Zbornik 16. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2013

Zvezek A

Proceedings of the 16th International Multiconference

INFORMATION SOCIETY – IS 2013

Volume A







Uredili / Edited by

Matjaž Gams, Rok Piltaver, Dunja Mladenić, Marko Grobelnik, Franc Novak, Bojan Blažica, Ciril Bohak, Luka Čehovin, Marjan Heričko, Urban Kordeš, Zala Kurinčič, Katarina Marjanovič, Toma Strle, Vladimir A. Fomichov, Olga S. Fomichova, Vladislav Rajkovič, Tanja Urbančič, Mojca Bernik, Andrej Brodnik

7.–11. oktober 2013 / October 7th–11th, 2013
Ljubljana, Slovenia

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Interakcija človek-računalnik v informacijski družbi
Sodelovanje, programska oprema in storitve v informacijski družbi
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Kognitonika
Vzgoja in izobraževanje v informacijski družbi
Srednjeevropska konferenca o uporabnem teoretičnem računalništvu (MATCOS 2013)

Intelligent Systems
Data Mining and Data Warehouses (SiKDD 2013)
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http://is.ijs.si

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Uredniki:

prof. dr. Matjaž Gams
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prof. dr. Dunja Mladenić
Marko Grobelnik

prof. dr. Franc Novak
Bojan Blažica
Ciril Bohak
Luka Čehovin

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Katarina Marjanovič
Toma Strle

prof. dr. Vladimir A. Fomichov
prof. dr. Olga S. Fomichova

prof. dr. Vladislav Rajkovič
prof. dr. Tanja Urbančič
dr. Mojca Bernik

prof. dr. Andrej Brodnik

Založnik: Institut »Jožef Stefan«, Ljubljana
Priprava zbornika: Vedrana Vidulin, Mitja Lasič, Vesna Lasič
Oblikovanje naslovnice: Vesna Lasič, Mitja Lasič, Mitja Luštrek

Dostop do e-publikacije:
http://library.ijs.si/Stacks/Proceedings/InformationSociety/IS2013_Volume_A.pdf

Ljubljana, oktober 2013

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

659.2:316.42(082)
659.2:004(082)
004.8(082)
37:659.2(082)

MEDNARODNA multikonferenca Informacijska družba (16 ; 2013 ; Ljubljana)
Zbornik 16. mednarodne multikonference Informacijska družba - IS 2013, 7.-11. oktober 2013, Ljubljana, Slovenia [Elektronski vir] : zvezek A = Proceedings of the 16th International Multiconference Information Society - IS 2013, October 7th-11th, 2013, [Ljubljana, Slovenia] : volume A / uredili, edited by Matjaž Gams ... [et al.]. - El. knjiga. - Ljubljana : Institut Jožef Stefan, 2013

Način dostopa (URL): http://library.ijs.si/Stacks/Proceedings/InformationSociety/IS2013_Volume_A.pdf. - Vsebina na nasl. str.: Inteligentni sistemi = Intelligent systems ; Izkopavanje znanja in podatkovna skladišča (SiKDD 2013) = Data mining and data warehouses (SiKDD 2013) ; Sodelovanje, programska oprema in storitve v informacijski družbi = Collaboration, software and services in information society ; Kognitivna znanost = Cognitive science ; Kognitonika = Cognitonics ; Vzgoja in izobraževanje v infomacijski družbi = Education in information society ; Srednjeevropska konferenca o uporabnem teoretičnem računalništvu (MATCOS 2013) = Middle-European Conference on Applied Theoretical Computer Science (MATCOS 2013)

ISBN 978-961-264-066-8 (pdf)
1. Dodat. nasl. 2. Gams, Matjaž, računalništvo
271584000

Preko 5000 let slovenske inovativnosti.

Spomladi leta 2002 je ekipa Inštituta za arheologijo na Ljubljanskem barju odkrila ostanke lesenega kolesa in osi. Z radiokarbonsko metodo so v VERA laboratoriju na Dunaju ugotovili, da kolo datira iz 3360-3080 pr.n.št., kar ga postavlja za najstarejše leseno kolo na svetu in ga uvršča v vrh svetovne dediščine.



More than 5000 years of Slovenian inovativeness.

In the spring of 2002, the team from the Institute of Archaeology at the Ljubljana Marshes discovered the remains of a wooden wheel and axle. The radiocarbon method in the VERA laboratory in Vienna found that wheel dating from 3360-3080 BC, which makes it the oldest wooden wheel in the world and one of the top world heritage.

PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2013

V svojem šestnajstem letu multikonferenca Informacijska družba (http://is.ijs.si) ostaja pomembna srednjeevropska konferenca na področju informacijske družbe. Informacijska družba, znanje in umetna inteligenca se razvijajo čedalje hitreje in nekoč utopične ideje Raya Kurtzweila, da se človeška družba približuje točki singularnosti, kjer bo preskočila v novo, najkvalitetnejše obdobje človeške civilizacije, so danes marsikje razumljene tako, da je časovni interval »točke singularnosti« že tu. V 2013 bomo prvič podelili nagrado za življenjske dosežke v čast Donalda Michija in Alana Turinga. Letos smo v multikonferenco povezali devet odličnih neodvisnih konferenc. Na multikonferenci predstavljamo, analiziramo in preverjamo nova odkritja in pripravljamo teren za njihovo praktično uporabo, saj je njen osnovni namen promocija raziskovalnih dosežkov in spodbujanje njihovega prenosa v prakso na različnih področjih informacijske družbe tako v Sloveniji kot tujini. Še bolj kot prejšnja leta smo prepričani, da sta stroka in vizija najpomembnejši za izhod iz stagnacije, v katero sta zašli Evropa in Slovenija.

Na vzporednih konferencah bo predstavljenih okoli 200 referatov, vključevala pa bo tudi okrogle mize in razprave. Referati so objavljeni v zbornikih multikonference, izbrani prispevki pa bodo izšli tudi v posebnih številkah dveh znanstvenih revij, od katerih je ena Informatica, ki se ponaša s 36-letno tradicijo odlične znanstvene revije.

Multikonferenco Informacijska družba 2013 sestavljajo naslednje samostojne konference:

- Inteligentni sistemi
- Rudarjenje podatkov in podatkovna skladišča
- Sodelovanje, programska oprema in storitve v informacijski družbi
- Soočanje z demografskimi izzivi
- Vzgoja in izobraževanje v informacijski družbi
- Kognitivna znanost
- Kognitonika
- Komunikacija človek-računalnik v informacijski dobi
- Srednjeevropska konferenca uporabno-teoretične računalniške znanosti.

Soorganizatorji in podporniki konference so različne raziskovalne institucije in združenja, med njimi tudi ACM Slovenija in SLAIS. V imenu organizatorjev konference se želimo posebej zahvaliti udeležencem za njihove dragocene prispevke in priložnost, da z nami delijo svoje izkušnje o informacijski družbi. Zahvaljujemo se tudi recenzentom za njihovo pomoč pri recenziranju.

V letu 2013 sta se programski in organizacijski odbor odločila, da bosta podelila posebno priznanje Slovencu ali Slovenki za izjemen življenjski prispevek k razvoju in promociji informacijske družbe v našem okolju. Z večino glasov je letošnje priznanje pripadlo dr. Dušanu Kodeku. Priznanje za dosežek leta je pripadlo dr. Marku Bajcu za dosežke na področju podatkovnih baz. V letu 2013 tretjič podeljujemo nagrado »informacijska limona« in »informacijska jagoda« za najbolj (ne)uspešne poteze v zvezi z informacijsko družbo. Limono je dobilo pretirano vladno varčevanje na področju informacijske družbe, jagodo pa raziskovalni portal Videolectures (podeljeno Mitji Jermolu). Čestitke nagrajencem!

Nikolaj Zimic, predsednik programskega odbora
Matjaž Gams, predsednik organizacijskega odbora

FOREWORD - INFORMATION SOCIETY 2013

In its 16th year, the Information Society Multiconference (http://is.ijs.si) remains one of the leading conferences in Central Europe devoted to information society. For 2013 and further, the award for life-long outstanding contributions will be delivered in memory of Donald Michie and Alan Turing. This year, we organized nine independent conferences forming the Multiconference, delivering a broad range of topics and the open academic environment fostering new ideas makes which our event unique among similar conferences, promoting key visions in interactive, innovative ways. According to the AI community, we are closer and closer to the Kurtzweil's singularity point, the starting point of a new, further advanced human civilization where the major boost comes from intelligent machines.

The major driving forces of the Multiconference are search and demand for new knowledge related to information, communication, and computer services. We present, analyze, and verify new discoveries in order to prepare the ground for their enrichment and development in practice. The main objective of the Multiconference is presentation and promotion of research results, to encourage their practical application in new ICT products and information services in Slovenia and also broader region. We are more confident than ever that science and vision are the two most important issues to break the stagnation of Europe and Slovenia.

The Multiconference is running in parallel sessions with 200 presentations of scientific papers. The papers are published in the conference proceedings, and in special issues of two journals. One of them is Informatica with its 36 years of tradition in excellent research publications.

The Information Society 2013 Multiconference consists of the following conferences:

- Intelligent Systems
- Cognitive Sciences
- Data Mining and Data Warehouses
- Collaboration, Software and Services in Information Society
- Demographic Challenges in Europe
- Cognitonics
- Cognitive Science
- Human-Computer Interaction in Information Society
- Middle-European Conference on Applied Theoretical Computer Science.

The Multiconference is co-organized and supported by several major research institutions and societies, among them ACM Slovenia, i.e. the Slovenian chapter of the ACM, and all the participants of the multiconference.

In 2013, the Programme and Organizing Committees decided to award one Slovenian for his/her life-long outstanding contribution to development and promotion of information society in our country. With the majority of votes, this honor went to Dr. Dušan Kodek. In addition, a reward for current achievements was pronounced to Dr. Marko Bajec for his research in the area of databases. The information strawberry is pronounced to the science portal Videolectures and delivered to Mitja Jermol, while the information lemon goes to lack of political support for information society activities, delivered to Jurij Bertok. Congratulations!

On behalf of the conference organizers we would like to thank all participants for their valuable contribution and their interest in this event, and particularly the reviewers for their thorough reviews.

Nikolaj Zimic, Programme Committee Chair
Matjaž Gams, Organizing Committee Chair

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Zbornik 16. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2013

Proceedings of the 16th International Multiconference

INFORMATION SOCIETY – IS 2013

Inteligentni sistemi

Intelligent Systems

Uredila / Edited by

Matjaž Gams, Rok Piltaver

http://is.ijs.si

8. in 9. oktober 2013 / October 8th and 9th 2013
Ljubljana, Slovenia

PREDGOVOR

Konferenca Inteligentni sistemi tudi letos, tako kot vsa pretekla leta od 1997 dalje, poteka v okviru multikonference Informacijska družba. Konferenca je posvečena pomembnim vidikom informacijske družbe: inteligentnim sistemom in inteligentnim storitvam. Ključna tema so programski sistemi v informacijski družbi oziroma konkretne tehnične rešitve v inteligentnih sistemih, možnosti njihove praktične uporabe, pa tudi trendi, perspektive, potrebni ukrepi, prednosti in slabosti, priložnosti in nevarnosti, ki jih v informacijsko družbo prinašajo inteligentni sistemi.

V 2013 beležimo nadaljnji nesluteni razvoj informacijske družbe in zlasti umetne inteligence. Nekoč utopične ideje Raya Kurtzweila o točki singularnosti in preskoku v novo človeško ero se tako zdijo čedalje bližje.

Tudi letos je konferenca Inteligentni sistemi sestavljena iz mednarodnega dela in delavnice; prispevki so tako v slovenskem kot angleškem jeziku. V letu 2013 je sprejetih preko 30 prispevkov, ki so bili recenzirani s strani vsaj dveh anonimnih recenzentov, avtorji pa so prispevke popravili glede na njihove pripombe. V ločeni sekciji so predstavljeni prispevki Delavnice Odseku za inteligentne sisteme Instituta Jožef Stefan, ki večinoma obravnavajo raziskovalne dosežke v odseku. Hkrati s predstavitvijo poteka tudi aktivna analiza prispevkov vsakega predavatelja in diskusija o bodočih raziskavah.

Rok Piltaver in Matjaž Gams, predsednika konference

PREFACE

The conference Intelligent Systems remains a traditional part of the multiconference Information Society since its beginnings in 1997. The conference addresses important aspects of information society: intelligent computer-based systems and the corresponding intelligent services. Specifically, it addresses technical aspects of intelligent systems, their practical applications, as well as trends, perspectives, advantage and disadvantages, opportunities and threats that are being brought into the information society by introduction of intelligent systems.

In 2013, the pace of progress in information society and intelligent systems increases further. Once regarded as utopist, the ideas of Ray Kurtzweil regarding the point of singularity where the human civilization will embrace a new, intelligent era, are thus becoming widely accepted.

As previously, the conference Intelligent Systems 2013 consists of an international event and a workshop, and presents over 30 papers written in both English and Slovenian language. The papers have been reviewed by at least two anonymous reviewers, and the authors have modified their papers according to the remarks. In the separate section, papers from the Workshop of Department of Intelligent Systems - Jožef Stefan Institute, Ljubljana, Slovenia are presented, discussing the research achievements of the department. Each presentation consists of the classical paper report, and further includes analysis of the researcher's achievements and future research plans of each presenter in the workshop manner.

Rok Piltaver and Matjaž Gams, Conference Chairs

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BENEFITS OF OPTIMAL PRINCIPLE COMPONENTS ANALYSIS TO MACHINE LEARNING

Cemil ALTIN[1], Mücella Ö. KARAKUŞ[2] Orhan ER[3]
Bozok University – Electrical and Electronics Engineering[1-3]
Bozok University – Computer Engineering[2]
e-mail: {cemil.altin, mucella.karakus, orhan.er}@bozok.edu.tr

ABSTRACT

This paper presents a machine learning application with one of the dimension reduction method Principal Component Analysis (PCA). Here, price prediction of a house will be made benefiting from 8 variables of the house by multilayer neural network. Firstly principle components of the input data set is obtained by principle component analysis. In the next step, input dataset is formed by using principle components and house variables data set (or raw dataset). In the application part, firstly input dataset which comprised with all principle components is used for the machine learning and the prediction accuracy is evaluated. Next, identification of the most important principal components is realized. Also the dependence of the response on the most important principal components is explained. Then the principle component columns which has maximum 1% and 10 % fraction of variance are removed respectively and output is compared with the output which all principle components are used.

1 INTRODUCTION

Generally data sets include millions of participants with thousands of variables. Datasets should be handled before using it for machine learning applications. Because, using too much variables in machine learning application causes complicacy. Therefore the variables which are not necessary should be omitted. Data mining is the analysis of large data sets to find unsuspected relationships and to summarize the data both understandable and useful [1]. Multicollinearity is a serious problem for machine learning because some of the variables can be correlated with each other. Therefore optimal number of variables should be determined. The optimal number of variable help to machine learning to interpret the relationship between input and output. Artificial neural networks (ANN) are used almost all of the arts. There are lots of advantage of using neural network like being fast, cheap and reliable. In this work house value prediction is made using ANN. Aim of our work is to predict house value using 8 variables belong to house. In machine learning the data which will be processed should be evaluated and rearranged. Because lack, poor or complex data will effect machine learning negatively. In order to get over such a negativity PCA will be used. PCA uses the correlation structure among the variables in order to realize;

- Reducing the variables to optimal amount
- Proving the attributes are independent

2 PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) is one of the most general purpose feature extraction methods [2]. PCA is used to overcome complexity of input variables and collinearity by reducing number of the input variables. PCA converts the input variables $X_1, X_2, \ldots, X_m$ into another set of column vectors $T_1, T_2, \ldots, T_m$. Here T vectors are the components of the original input data. The principal components represent a new matrix created by rotating the original data along the directions of maximum variability. T vectors contain all information (or most of its variance) of the original dataset. This transformation allows reduction of the complex input data to smaller number of dimensions, with low information loss, simply by ejecting some of the principal components. Each Principal Component is a linear combination of the original inputs and each PC is orthogonal, so collinearity problem is overcame [3]. Principal Component Analysis reveals the same information as much as in smaller dataset which is derived from original dataset.

PCA is useful in machine learning applications where;

- Input data has high dimension
- Long calculation time
- Lack of knowledge about input dataset

Before the data reduction standardization should be applied and mean for the each attribute is 0 and standard deviation for the each attribute is 1. Let each variable X_i represent an $n\,x\,1$ vector where n is the number of records. $Z_i = (X_i - \mu_i)/\sigma_{ii}$, Z_i is $n\,x\,1$ vector which stores standardized variable, μ_i is the mean of X_i and σ_{ii} is the standard deviation of X_i . In matrix notation $Z = \left(V^{\frac{1}{2}}\right)^{-1}(X - \mu)$ "-1" mean matrix inverse, $V^{\frac{1}{2}}$ is $m\,x\,m$ diagonal standard deviation matrix.

$$V^{\frac{1}{2}} = \begin{bmatrix} \sigma_{11} & 0 & \ldots & 0 \\ 0 & \sigma_{22} & \ldots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \ldots & \sigma_{mm} \end{bmatrix} \quad (1)$$

Symmetric covariance matrix is calculated by equation 2:

$$\sum = \begin{bmatrix} {\sigma_{11}}^2 & {\sigma_{12}}^2 & \dots & {\sigma_{1m}}^2 \\ {\sigma_{12}}^2 & {\sigma_{22}}^2 & \dots & {\sigma_{2m}}^2 \\ \vdots & \vdots & \ddots & \vdots \\ {\sigma_{1m}}^2 & {\sigma_{2m}}^2 & \dots & {\sigma_{mm}}^2 \end{bmatrix} \quad (2)$$

Here ${\sigma_{ij}}^2$ is covariance between X_i and X_j when $i \neq j$

$${\sigma_{ij}}^2 = \frac{\sum_{k-1}^{n}(x_{ki}-\mu_i)(x_{kj}-\mu_j)}{n} \quad (3)$$

Covariance shows the variation relationship between two variables. When the covariance is positive that means if one of the variable increase also the other variable tends to increase. When the covariance is negative that means if one of the variable increase, inversely the other variable tends to decrease. Covariance measure is not scaled, so that changing the units of measure would change the value of the covariance. The correlation coefficient r_{ij} avoids this difficulty by scaling the covariance by each of the standard deviations [4].

$$r_{ij} = \frac{{a_{ij}}^2}{a_{ii}a_{jj}} \quad (4)$$

Then the correlation matrix is denoted as ρ below

$$\rho = \begin{bmatrix} \frac{{\sigma_{11}}^2}{a_{11}a_{11}} & \frac{{\sigma_{11}}^2}{a_{11}a_{21}} & \dots & \frac{{\sigma_{1m}}^2}{a_{11}a_{mm}} \\ \frac{{\sigma_{12}}^2}{a_{11}a_{22}} & \frac{{\sigma_{22}}^2}{a_{22}a_{22}} & \dots & \frac{{\sigma_{2m}}^2}{a_{22}a_{mm}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{{\sigma_{1m}}^2}{a_{11}a_{mm}} & \frac{{\sigma_{2m}}^2}{a_{22}a_{mm}} & \dots & \frac{{\sigma_{mm}}^2}{a_{mm}a_{mm}} \end{bmatrix} \quad (5)$$

2.1 Applying PCA to the Data Set

The original data is gotten from the STATLIB repository. It consists of aggregated data from each of 20.640 (16.512 used for training) neighborhoods (1990 census block groups) in California. Relating this data $X_1 = median\ income$, $X_2 = housing\ median\ age$ $X_3 = average\ no\ rooms$ $X_4 = average\ no\ bedrooms$ $X_5 = population$ $X_6 = average\ occupancy$ $X_7 = latitude$ $X_8 = longitude$ m=8 and n=16512.

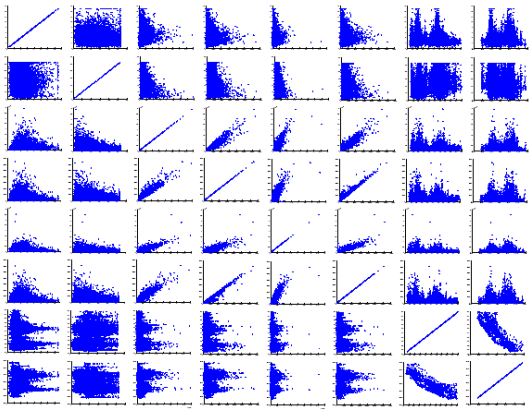


Figure 1: Matrix plot of the house variables

Matrix plot is very useful in order to see correlation among the variables. As seen in the matrix plot $X_3 = average\ no\ rooms$, $X_4 = average\ no\ bedrooms$, $X_5 = population$ and $X_6 = average\ occupancy$ are seem to be positively correlated but latitude and longitude seem to be negatively correlated. Also these evaluations can be made using correlation matrix.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	1	-0.12	0.19	-0.01	0.001	0.009	-0.08	-0.01
X_2	-0.12	1	-0.36	-0.31	-0.29	-0.3	0.01	-0.11
X_3	0.19	-0.36	1	0.92	0.85	0.91	-0.04	0.04
X_4	-0.01	-0.31	0.92	1	0.87	0.98	-0.07	0.07
X_5	0.001	-0.29	0.85	0.87	1	0.9	-0.11	0.1
X_6	0.009	-0.3	0.91	0.98	0.9	1	-0.07	0.06
X_7	-0.08	0.01	-0.04	-0.07	-0.11	-0.07	1	-0.92
X_8	-0.01	-0.11	0.04	0.07	0.1	0.06	-0.92	1

Table 1: Correlation matrix ρ

As seen in the Figure 1 and Table 1 total rooms, total bedrooms, population and average occupancy vary together. As seen correlation matrix and matrix plot give the same results.

Correlation matrix will be used in the next step for getting the components. If the principle component analysis is applied on correlation matrix, principal component coefficients (also known loadings) are acquired. This component matrix is P by P square matrix. Here P is number of components or number of variables belong to house. Each column in the component matrix contains coefficients for one principal component. The columns are in order of decreasing component variance.

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
X_1	0.04	0.03	-0.88	-0.41	-0.05	-0.06	-0.17	-0.03
X_2	-0.12	-0.01	0.40	-0.88	0.03	0.09	-0.04	-0.00
X_3	0.48	-0.07	-0.09	-0.11	0.30	0.56	0.55	0.13
X_4	0.49	-0.06	0.11	-0.06	0.37	-0.22	-0.22	-0.70
X_5	0.47	-0.02	0.11	-0.08	-0.85	0.10	-0.02	-0.12
X_6	0.49	-0.06	0.10	-0.09	0.15	-0.39	-0.29	0.68
X_7	-0.07	-0.70	-0.01	0.09	0.03	0.46	-0.52	0.04
X_8	0.081	0.70	0.05	0.07	0.09	0.47	-0.50	0.05

Table 2: Components matrix c

New input data set to the neural network will be generated from original data set by using components matrix. The new input data set is formed as below.

$$nds = c' * ods \quad (6)$$

Here nds=new data set, ods=standardized old data set, c' is inverse of component matrix. Dimension reduction process is made in equation 6 by reducing the number of components in components matrix. The relevant calculations are made in conclusion part of the paper.

2.2 How Many Variables Should be Extracted

As explained before the principal component analysis extracts the essential variables of the data set. As known the data set has 8 components and how many of them should be extracted. 8?, 4? or 2? there is a serious question. The

extracted data should be in a smaller dimension but should explain the data nearly like original data set. Because of that the number of the extracted variable is very important. There are some methods to overcome this question one of them is scree plot criterion.

Scree plot is a plot which eigenvalues on y axis and number of components on x axis.

component	eigenvalue	% fract. of variance	Cumulative%
1	3.9053	48.8166	48.8166
2	1.9039	23.7992	72.6158
3	1.0746	13.4323	86.0481
4	0.8212	10.2655	96.3136
5	0.1509	1.8857	98.1993
6	0.0825	1.0313	99.2306
7	0.0475	0.5937	99.8243
8	0.0140	0.1756	100

Table 3: Component specifications

As seen in Table 3: eigenvalues are aligned in decreasing order. Sum of the eigenvalues equal to number of components. For example here the first eigenvalue is 3.9053 and number of components is 8 or the sum of eigenvalues 8. Therefore the effect of the first component in the data set is calculated as 3.9053/8=0.488166≈49% means that the first component includes information about data set by ≈49%. Nearly the half of the information belong to data set is stored in first component and the other half of the information belong to data set stored in the rest of 7 components.

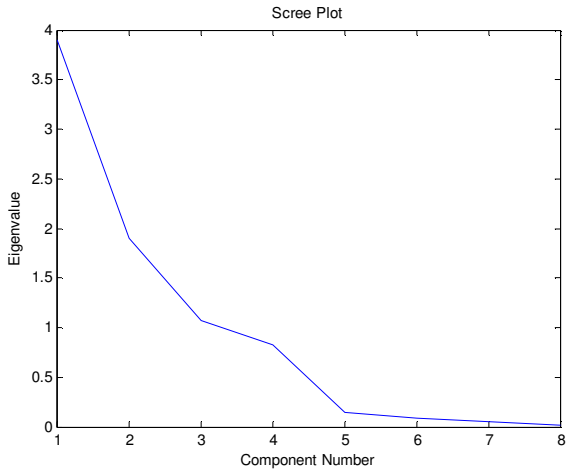


Figure 2: Scree plot

Interpreting the scree plot we can find the number of actual extracted components. As seen in figure 2 big changes occur until fifth component. After fifth component the change of the plot is very small. This mean, number 5, 6, 7, 8 components includes too few information about the dataset. Scree plot in figure 2 says not to extract more than four components.

3 MULTILAYER NEURAL NETWORK

The multilayer neural networks (MLNNs) have been successfully used in machine learning applications. In this study a multilayer neural network structure was used for estimation of the house value which depend on 8 variables.

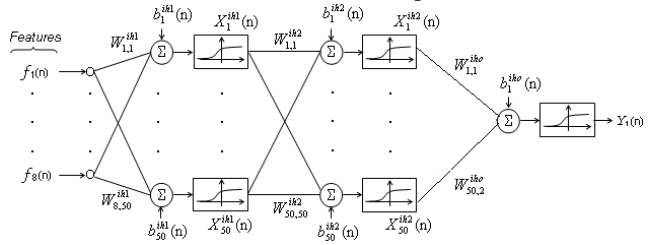


Figure 3: Multilayer neural network structure

Outputs of the first hidden layer neurons are,

$$\vec{X}^{ih1}(n) = 1 \Big/ \left(1 + \exp\left(W^{ih1}(n) * \vec{f}(n) + \vec{b}^{ih1}(n)\right)\right) \quad (7)$$

Outputs of the second hidden layer neurons are,

$$\vec{X}^{ih2}(n) = 1 \Big/ \left(1 + \exp\left(W^{ih2}(n) * \vec{X}^{ih1}(n) + \vec{b}^{ih2}(n)\right)\right) \quad (8)$$

Output of the network is

$$\vec{Y}(n) = 1 \Big/ \left(1 + \exp\left(W^{h0}(n) * \vec{X}^{ih2}(n) + \vec{b}^{h0}(n)\right)\right) \quad (9)$$

In figure 3, $W^{ih1}(n)$ are the weights from the input to the first hidden layer and $\vec{b}^{ih1}(n)$ are the biases of the first hidden layer, $W^{ih2}(n)$ are the weights from the first hidden layer to the second hidden layer and $\vec{b}^{ih2}(n)$ are the biases of the second hidden layer, $W^{h0}(n)$ the weights from the second hidden layer to the output layer and $\vec{b}^{h0}(n)$ are the biases of the output layer, $\vec{f}(n)$ number of the variables, $\vec{Y}(n)$ value of the output (house value) and n a training pattern index[5].

Levenberg-Marquardt algorithm is used in the work for the training of the multilayer neural network structure.

4 APPLICATION RESULTS

In the application part of the study firstly the principal components data set is used without extraction of any principal component second the components which have maximum fraction of variance smaller than 1% are removed and the data set rebuilt again and used. Last the components which have maximum fraction of variance smaller than 10% are removed and the data set rebuilt again and used. Data set dimension which formed by all components is 8x16512 for input and 1x16512 for house value. The half of participants used for training (8256) the one fourth of participants used for validation (4128) and the other one fourth of participants used for testing. The result plots are shown below:

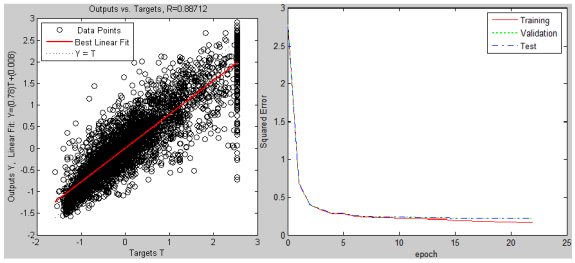


Figure 4: Result of application 1

Application 1: When all the components are used the training matrix dimension is 8x8256, squared error=0.2144, correlation between ANN output and test data 88.712%, the machine processing time is 4 minutes and 11 seconds.

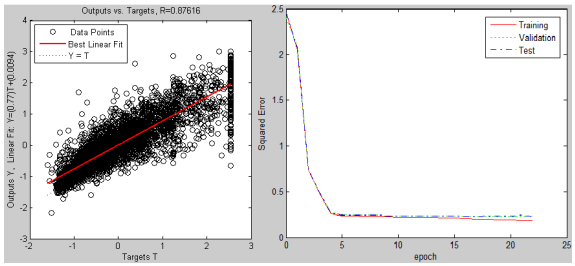


Figure 5: Result of application 2

Application 2: When the components whose maximum fraction of variance smaller than 1% are omitted. Training matrix dimension is 6x8256, squared error=0.2337, correlation between ANN output and test data 87.616%, the machine processing time is 3 minutes and 57 seconds.

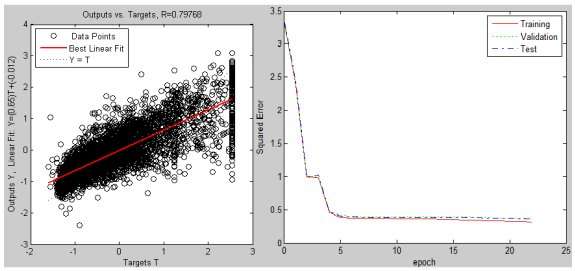


Figure 6: Result of application 3

Application 3: When the components whose maximum fraction of variance smaller than 10% are omitted. Training matrix dimension is 4x8256, squared error=0.3661, correlation between ANN output and test data 79.768%, the machine processing time is 3 minutes and 42 seconds.

5 CONCLUSION

When all results are evaluated and compared, the result of Application 1 and the result of Application 2 are so close (88.712%-87.616%). The results are so close but what about the matrix dimension and machine processing time. In Application 2 the matrix dimension is reduced with Principal Component Analysis from 8 components to most important 6 components. The reduction is made according to table 3. If components whose maximum fraction of variance smaller than 1% are omitted. Cumulative percentage of information used from all components 99.23% in table 3. In other words nearly all of the information of data set is being used despite dimension is reduced. As shown in table 3, 7th component (0.5937) and 8th component (0.1756) are ejected, in other words 2column of 8 column are ejected. Thus the new train (input) data dimension is from equation 6 (6x8)*(8x8256)=6x8256. This mean 25% of the dimension is reduced but the performance is the same with data which formed with all components. Also the machine processing time is decrease from 4 minutes and 11 seconds to 3 minutes and 57 seconds nearly 6% decreased.

On the other hand when the result of Application 1 and Application 3 are compared, the result of Application 3 is worse compare to Application 1 (88.712%-79.768%). The reason is that the data extraction made with Principal Component Analysis should be realized in an optimal level. The reduction is made according to table 3. If components whose maximum fraction of variance smaller than 10% are omitted. Cumulative percentage of information used from all components 96.3136% in table 3. In other words 96.3136% of the information belong to data set which formed with all components is being used despite dimension is reduced. As shown in table 3, 5th component (1.8857), 6th component (1.0313), 7th component (0.5937), 8th component (0.1756) are ejected, in other words 4 column of 8 column are ejected. In Application 3 the data dimension is reduced 50% this is excellent for human or machine but the output is worse approximately 10% compare to Application 1. Also the processing time is decrease from 4 minutes and 11 seconds to 3 minutes and 42 seconds nearly 12% decreased.

These results show that an optimal Principal Component Analysis reduces the data set dimension and eliminates unnecessary information from data set. This helps to fast learning and more stable learning. The effects of the Principal Component Analysis can seen more sharply when applied to the bigger data sets.

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DECISION SUPPORT MODEL FOR THE ASSESSMENT OF BANK REPUTATIONAL RISK

Marko Bohanec[1,*], *Giorgio Aprile*[3], *Maria Costante*[2], *Morena Foti*[2], *Nejc Trdin*[1],
[1] Jožef Stefan Institute, Department of Knowledge Technologies, Jamova 39, SI-1000 Ljubljana, Slovenia
[2] MPS, Risk Management Division, V.le Mazzini 23, Siena, Italy
[3] Aon, Principal Consultant, 8 DevonShire Square, London
[*] e-mail: marko.bohanec@ijs.si

ABSTRACT

This paper presents a decision support model aimed at the assessment of reputational risks associated with bank operation. The innovative aspect of the model is that it combines different types and sources of information: structured and unstructured, quantitative and qualitative, internal and external. Unstructured, qualitative and external aspects are represented by sentiment of news and blogs about bank counterpart organisations. The model is multi-attribute and hierarchical, and is composed of three modules: basic data processing, qualitative evaluation, aggregation; these are presented in detail. The paper also presents a prototype implementation of the model and illustrates its application on real-life data.

1 INTRODUCTION

The current financial crisis has dramatically changed the risk profile associated to the production and distribution of investment products and services by banks and other financial institutions. *Reputational risk* is defined as "the risk arising from negative perception on the part of customers, counterparties, shareholders, investors, debt-holders, market analysts, other relevant parties or regulators that can adversely affect a bank's ability to maintain existing, or establish new, business relationships and continued access to sources of funding " (Settlements, July 2009). It has become vital for banks to measure, monitor, assess and mitigate their reputational risks.

The *reputational risk model* (RIM for short) presented in this paper is aimed at estimating bank reputational risk as a means to supporting risk managers. The model builds on structured data, which is readily available in a bank, and supplements it with information extracted from external unstructured data, mostly blogs, online newspapers and financial documents available on the web. Specifically, external information is assessed in form of *sentiment*, that is, a positive or negative view, attitude, emotion or appraisal on the studied object from a document author or actor (Liu, 2010).

RIM has been developed in the context of the EU project FIRST (2010-2013). FIRST addresses the challenges of dealing in real-time with massive amounts of heterogeneous data and information in financial markets, and provides infrastructure for collecting and processing this data. One of the services developed in FIRST provides a daily sentiment related to a given financial organisation (FSS, 2013); RIM uses this service as one source of input data. The other source is composed of structured data, provided by a bank that carries out reputational risk analysis. In FIRST, the bank is represented by the project partner Banca Monte dei Paschi di Siena, Italy (MPS).

2 BASIC CONCEPTS

The basic operational scheme of RIM is shown in Figure 1. Input data consists of several time series, coming from two primary sources:

(1) sentiment data, provided by the FIRST infrastructure, based on an analysis of unstructured external data;
(2) data about financial product performance, provided by the bank, based on structured internal data.

All time series are typically sampled on a daily basis.

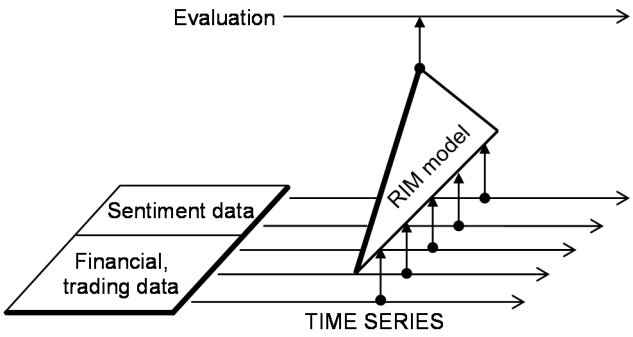


Figure 1: *Basic operational scheme of RIM.*

Time series data taken at a particular point in time represent a situation that has to be assessed for reputational risk. The assessment is carried out by a hierarchical multi-attribute model, which is denoted by a triangle in Figure 1 and described in detail in section 3.

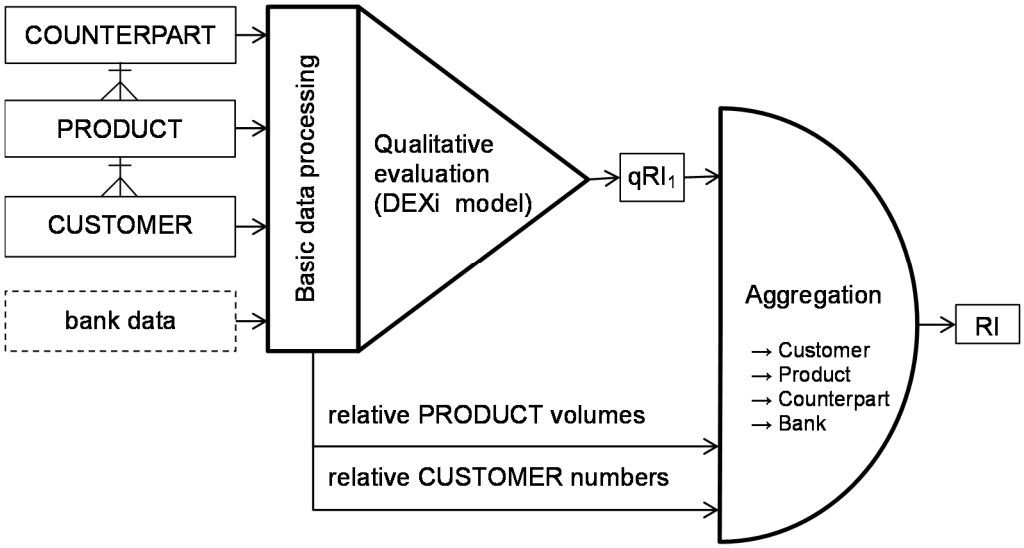


Figure 2: *Architecture and components of RIM.*

The result of evaluating a single situation is expressed in terms of *reputation risk index* (*RI*), a number from 1 to 5, where the higher number represents a higher risk. Applying the model in each time point, we obtain a time series of *RI*'s. In addition, since RIM is a hierarchical model and therefore contains internal variables, we also obtain time series of all internal variables; this is useful for the explanation of obtained results and aids model transparency.

3 MODEL STRUCTURE AND COMPONENTS

The basic function of RIM is to assess *RI* corresponding to a given *financial product* and a given *customer* at some given point in time. Therefore, the assessment is based on input data of two main entities: PRODUCT and CUSTOMER (Figure 2). The third entity is COUNTERPART, that is, a producer of PRODUCT, which is an object of sentiment assessment. The relations between COUNTERPARTs, PRODUCTs, and CUSTOMERs are all 'one-to-many': a COUNTERPART produces one or more PRODUCTs, and each PRODUCT can be sold to one or more CUSTOMERs of the bank.

Time series processed by RIM contain data about these three entities. The fourth data source is the bank itself (MPS), which provides data on volumes and benchmark performance of specific groups of products.

RIM processes this input data using three main components (Figure 2): (1) basic data processing, (2) qualitative evaluation, and (3) aggregation.

3.1 Basic Data Processing

The basic data processing part of RIM takes input data about PRODUCTs, CUSTOMERs and COUNTERPARTs and transforms them into a form suitable for further use in the qualitative evaluation and aggregation components. The following variables are produced by the module:

Sentiment indicator S: Sentiment measured on text sources referring to the counterpart. $S = w_{SP}S_{SP} + w_{LP}S_{LP}$, where S_{SP} and S_{LP} are short-term (last day) and long-term (30-days average) of counterpart's sentiment, and w_{SP} and w_{LP} are the associated weights, by default set to 30% and 70%, respectively. S_{SP} and S_{LP} are represented as numbers on the interval [–1,+1] and are obtained from FSS (2013).

Performance indicator P: A measure to which extent the financial product is performing in line with customer expectations. $P = PP + 0.1(PP - BP)$, where PP is an absolute product performance measured since the customer bought the product, and BP is benchmark performance of similar products. Both PP and BP are defined by the bank for each customer and product pair.

Mismatching indicator M: Defined as a difference between the risk profile of the customer and the risk profile of its portfolio for each product. This indicator measures the extent to which the customer's portfolio is still in line with their risk investment profile, which is defined in the contract between the bank and the customer. The risk profile of the product is a composite measure that is already in place in MPS.

Relative product and customer volumes: The higher the volume of some product held by some customer, and the higher the number of users holding some product, the higher the effect of this customer and product to potential reputational risk. For this purpose, the basic data processing module calculates a number of quantities representing relative shares of product volumes in total bank assets, and relative numbers of customers holding some product or group of products. These quantities typically serve as weights in further processing.

Discretized variables qS, qP, qM and qRV$_{1C}$: Finally, all numerical indicators that enter the qualitative evaluation (section 3.2), that is S, P, M and RV_{1C} (relative volumes of a given product in the total assets of customer C), are discretized according to rules defined by MPS reputational risk experts. For more details on discretization, the reader is referred to FIRST D6.3 (2013).

3.2 Qualitative Evaluation

The function of the qualitative evaluation model is to produce the value of qRI_1, i.e., qualitative assessment of RI for a given customer/product pair. This is achieved through qualitative aggregation of qS, qP, qM and qRV_{1C}, according to the hierarchical scheme presented in Figure 3.

Attribute	Scale
qRI1	***low***; ***medium-low***; medium; **high**; **very-high**
├qS	***neutral***; ***low-neg***; med-neg; **high-neg**; **very-neg**
├**qPM**	***in-line***; ***low***; medium; **high**; **very-high**
│├qP	***in-line***; ***low***; medium; **high**; **very-high**
│└qM	***in-line***; ***low***; medium; **high**; **very-high**
└qRV1c	***low***; ***medium-low***; medium; **high**; **very-high**

Figure 3: *Structure and scales of qualitative evaluation attributes.*

The aggregation is implemented as a qualitative multi-attribute model developed according to methodology DEX (Bohanec et al., 2013). This means that all variables in the model are discrete and can take values from small symbolic value scales (Figure 3), and that the aggregation of values in the model is carried out according to expert-defined decision rules. Figure 4 shows an example of rules that aggregate input attributes qP and qM into an internal attribute qPM. For all rules, see FIRST D6.3 (2013).

The final risk qRI_1 is expressed on the five-valued scale: low, medium-low, medium, high, very-high.

	qP	qM	qPM
1	<=***low***	***in-line***	***in-line***
2	***in-line***	***low***:medium	***low***
3	<=medium	***low***	***low***
4	medium	<=***low***	***low***
5	>=medium	***in-line***	***low***
6	***in-line***	**high**	medium
7	***low***:medium	medium	medium
8	>=**high**	***low***	medium
9	<=***low***	**very-high**	**high**
10	***low***	>=**high**	**high**
11	***low***:**high**	**high**	**high**
12	**high**	medium:**high**	**high**
13	>=**high**	medium	**high**
14	>=medium	**very-high**	**very-high**
15	**very-high**	>=**high**	**very-high**

Figure 4: *Rules for aggregating qP and qM into qPM.*

3.3 Aggregation

In the part described so far, RIM assesses reputational risk only for a given customer/product pair in a given point in time. The role of the aggregation component is to determine RI for groups of customers and/or products (in the same point in time). For each of the studied groups G (customers, products, counterparts, bank), the aggregation produces a corresponding reputational index RI_G, which is represented as a numerical value in the range [1,5]. The range corresponds to the five qualitative risk classes, therefore $RI = 1$ corresponds to the case without reputational risk, and $RI = 5$ denotes the highest risk.

The aggregation of RI is hierarchical by the levels: Customer → Product → Counterpart → Bank. This means that individual customers' assessments qRI_1 are first aggregated into product reputational indices RI_P for all products P. These are then grouped by counterparts T into RI_T, and finally aggregated into a single synthetic reputational index RI at the bank level.

Furthermore, RI reflects the fact that some products influence reputational risk more than others. Particularly important are products that have high volumes and are held by many bank customers. Therefore, a collective RI_G of some group G, whose individual indices are $RI_i, i = 1,2,\dots,g$, is defined as the weighted average:

$$RI_G = \frac{\sum_{i=1}^{g} w_i RI_i}{\sum_{i=1}^{g} w_i}$$

Each weight w_i consists of two components, $w_{V,i}$ and $w_{N,i}$, so that $w_i = 60w_{V,i} + 40w_{N,i}$. Both $w_{V,i}$ and $w_{N,i}$ depend on some group of products P_i and reflect the relative share of corresponding product volumes and customer numbers in the bank, respectively. Thus, $w_{V,i}$ is defined as the share of volumes of P_i in total assets TA of the bank:

$$w_{V,i} = \frac{1}{TA} \sum_{p \in P_i} V_p$$

Here, V_p represents the total volume of product p. Similarly, $w_{N,i}$ takes into account the number of customers holding P_i with respect to the total number of bank customers TN:

$$w_{N,i} = \frac{1}{TN} \sum_{p \in P_i} N_p$$

Here, N_p is the number of customers holding product p.

4 IMPLEMENTATION

At present, RIM is implemented as prototype software called RIMstream. At input, RIMstream takes time series of data provided by the bank, then it queries FSS (2013) for the corresponding sentiment data, calculates RI for all customer/product pairs in all given points in time, and performs the hierarchical aggregation of RI for products, counterparts and whole bank in the same points in time. At output, it generates a series of HTML reports for the user at all four levels of aggregation. RIMstream is implemented in Java and uses JDEXi (2012), an open-source Java library for the evaluation of DEX models.

5 EXAMPLE APPLICATION

Because of space limitations, we illustrate the application of RIMstream only with a single report (Figure 5). The report was obtained on a realistic and fairly big input data stream prepared by MPS, which contained about 1.9 million data items from the period April 13 to May 24, 2013, involving 11 counterparts, 985 products, 130565 customers and 327826 different customer/product pairs. At output, 997 reports were obtained for the bank, counterpart and product level. For more detailed examples of these, see FIRST D6.3 (2013).

The highest-level report is called the "bank-level report" (Figure 5) and presents an overall aggregation of reputational-risk analysis. The left hand side shows the reputational index on each date in terms of average (*RI*), discrete level, and the corresponding relative volume and number shares. It is evident that on most days *RI* was relatively low (1.05 or 1.08), with two exceptions on April 22 and 29, when the risk increased to 2.38 and 2.39, respectively. Reasons for this are partly revealed on the right hand side of Figure 5, which displays five counterparts and five products that contributed most to *RI*. It is apparent that high risks were induced due to problems with the reputation of counterpart "CTP 24". Lower-level reports (not shown here) provide further details to explain this assessment and reasons for it.

6 CONCLUSION

RIM is a novel reputational risk assessment model, whose distinguishing characteristic is that it combines internal structured information, which is readily available in banks, with sentiment assessments, obtained by analysis of external and unstructured text documents. The latter are provided through information infrastructure developed in the project FIRST. RIM is a multi-attribute and hierarchical model that contains both quantitative and qualitative evaluation components.

At present, RIM is implemented as prototype software, which still requires substantial verification and validation, particularly by financial experts, reputation risk managers and other end-users. In the future, the prototype will be upgraded into a fully-featured decision support system, containing a database and a suitable user interface supporting on-line analytical data processing.

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Date	RI	Level	RNp%	RVp%
2013-04-22	2.38	v-high	1.9753	0.3277
2013-04-23	1.08	low	1.9750	0.3277
2013-04-24	1.08	low	1.9755	0.3278
2013-04-25	1.08	low	1.9276	0.3253
2013-04-26	1.05	low	1.9283	0.3253
2013-04-29	2.39	v-high	1.8710	0.3302

Counterpart	RI	Contr%
CTP 24	2.43	37.36
CTP 33	1.13	25.02
CTP 06	1.06	16.05
CTP 25	1.11	12.68
CTP 32	1.06	7.04
CTP 24	1.22	37.35
CTP 33	1.13	25.01
CTP 06	1.06	16.04
CTP 25	1.11	12.67
CTP 32	1.06	7.04
CTP 24	1.22	37.34
CTP 33	1.13	25.01
CTP 06	1.06	16.03
CTP 25	1.11	12.68
CTP 32	1.06	7.05
CTP 24	1.22	37.80
CTP 33	1.13	23.70
CTP 06	1.06	16.26
CTP 25	1.11	13.07
CTP 32	1.06	7.24
CTP 24	1.20	37.79
CTP 33	1.13	23.71
CTP 06	1.06	16.26
CTP 25	1.11	13.06
CTP 32	1.07	7.24
CTP 24	2.43	38.32
CTP 33	1.14	27.37
CTP 06	1.07	13.90
CTP 25	1.10	13.18
CTP 32	1.07	5.29

Product	RI	Contr%
PROD 0435	2.63	4.09
PROD 0476	2.54	2.77
PROD 0479	2.49	2.18
PROD 0133	2.30	1.71
PROD 0478	2.55	1.66
PROD 0435	1.38	4.09
PROD 0476	1.00	2.77
PROD 0479	1.03	2.18
PROD 0133	1.39	1.71
PROD 0478	1.00	1.66
PROD 0435	1.38	4.09
PROD 0476	1.00	2.77
PROD 0479	1.03	2.18
PROD 0133	1.38	1.71
PROD 0478	1.00	1.66
PROD 0435	1.38	4.09
PROD 0476	1.00	2.77
PROD 0479	1.03	2.18
PROD 0133	1.39	1.71
PROD 0478	1.00	1.66
PROD 0435	1.23	4.09
PROD 0476	1.00	2.77
PROD 0479	1.01	2.18
PROD 0133	1.27	1.71
PROD 0478	1.00	1.66
PROD 0435	2.62	4.14
PROD 0476	2.54	2.78
PROD 0479	2.48	2.19
PROD 0133	2.36	1.77
PROD 0478	2.55	1.66

Figure 5: *Bank-level RIM report. Counterparts (CTP) and financial products (PROD) are anonymised.*

AN IMPROVED FIREFLY ALGORITHM FOR ENGINEERING DESIGN OPTIMIZATION: WELDED BEAM DESIGN PROBLEM

Yuksel CELIK

Karamanoglu Mehmetbey Unv., Department of Computer Programming, Karaman, Turkey
Tel: +90 532 7797413
e-mail: celik_yuksel@hotmail.com

ABSTRACT

There is a need for optimizing many problems used in engineering sciences and a lot of optimization algorithms have been developed to solve these engineering problems. Today, there are a number of meta-heuristic algorithms based on swarm intelligence and inspired by nature. Firefly algorithm (FA) suggested by Xing She Yang in 2008 is a meta-heuristic and swarm intelligence based algorithm inspired by the natural behaviors of fireflies. In this study, neighborhood method is adapted to Firefly Algorithm and an Improved Firefly Algorithm (IFA) is proposed. The proposed IFA is applied to Welded Beam Design problem, a well-known engineering problem, and the experiment results were compared with the results of other studies in literature using other optimization algorithms on the same problem. In conclusion, the proposed algorithm is seen to display a successful performance.

1 INTRODUCTION

Optimization algorithms aim to find the best solution for a given problem under certain conditions. There are many algorithms used in literature. These can be categorized as mathematical and meta-heuristic algorithms by their working principles. Mathematical-based algorithms are generally problem-specific and it takes longer to solve problems with large solution space. On the other hand, meta-heuristic algorithms are not problem-specific and they can solve even large problems with their heuristic methods or provide the closest results to solution [1]. Among metaheuristic optimization algorithms, there are many nature-inspired and swarm intelligence based algorithms. The main ones are Particle Swarm Optimization (PSO), Ant Colony Optimization, Artificial Bee Colony (ABC), Marriage in Honey-Bee Optimization (MBO) and Firefly Algorithm (FA). In the current study, Firefly algorithm is examined and improved. There are many studies previously carried out on Firefly algorithm, the major ones of which are summarized below. Lukasik and Zak (2009) improved the firefly algorithm for the continuous constrained optimization task [2]. Their experimental evaluation demonstrates the efficiency of the firefly algorithm. Yang et al. (2012) used firefly algorithm for solving Economic Dispatch (ED) problems containing 4 non-convex solution spaces [2]. According to their test results, the proposed FA algorithm is able to find more economical loads than those determined by other methods. Sayadi et al. (2013) proposed Discrete Firefly Algorithm (DFA) for discrete optimization problems [3]. They used DFA algorithm for six cell information problems and demonstrated that DFA has an effective potential in the solution of NP-hard problems. Yang (2013) proposed Firefly Multiobjective Firefly Algorithm (MOFA) for multiobjective optimization problems [3]. They applied the proposed MOFA to optimization design benchmark problems frequently used in industrial engineering and compared the test results with other algorithm and then showed the efficacy of the algorithm they proposed.

There are many optimization problems used for testing the performance of optimization algorithms. Industrial engineering design optimization problems are also frequently used in this regard. The IFA proposed in the current study is used for solving Welded Beam Design Problem one of the industrial engineering design problems frequently used in literature. A number of studies have been conducted for testing this problem. The major studies are briefly summarized below. Mahdavi et al. (2007) developed the Improved Harmony Search (HIS) algorithm based on Harmony Search (HS) algorithm [6]. They applied the proposed algorithm to tension/compression spring, pressure vessel design, and welded beam design problem among industrial engineering design problems. Amir et al. (2011) used Firefly algorithm on Welded beam design, Pressure vessel design, helical compression spring design, A reinforced concrete beam design, Stepped cantilever beam design and car side impact design problems, which are all most common engineering design problems [7]. They compared their experimental findings with the test results of other algorithms. Tomassetti and Cagnina (2013) improved the Particle Swarm Optimization (PSO) algorithm and proposed two versions as Simple Constrained Particle Swarm Optimization (SiCPSO) and Minimized Computational Effort Particle Swarm Optimization (MCEPSO). They applied both algorithms to welded beam design and pressure vessel design problems among industrial design problems and compared their test outcomes with the results of other optimization algorithms. They integrated a neighborhood search

algorithm to the improved firefly algorithm and thus increased its performance. In the current study, firefly optimization algorithm is examined and improved. The second part of the study is focused on detailed examination and improvement of welded beam design problem and firefly algorithm, while experimental studies and results are presented in the third part and the results are discussed and assessed in the fourth and last part.

2 MATERIAL AND METHOD

2.1 Welded beam design optimization problem

Welded beam design problem is an engineering problem and shown in Figure 1. The problem is to minimize the cost of buckling stress of a beam and bar welded on it.

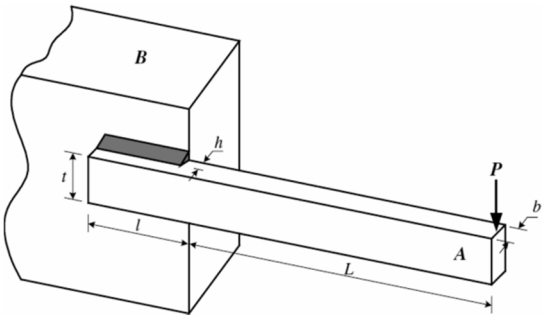


Figure 1. Welded Beam Design

As shown in Figure 1, it has 4 design variables, which are h, l, i and b. The design variables correspond to x_1, x_2, x_3 and x_4 parameters in the equation, respectively. The parameters of problem are τ: shear stress, σ: bending stress on beam and P_c: buckling stress on bar. Of the welded beam design problem to be minimized, minimization function is given in Equation 1 [4]:

Minimize:

$$f(\vec{x}) = 1.10471\, x_1^2 x_2 + 0.04811 x_3 x_4 (14.0 + x_2) \quad (1)$$

Best solution $f(x^*)$ =1.724852.

2.2 Firefly Algorithm (FA)

Firefly algorithm is a nature-inspired meta-heuristic and swarm intelligence based optimization algorithm, developed by Dr. Xin-She Yang in 2008 based on the social behaviors of fireflies in tropical zones [5]. The algorithm is inspired by the flashing behavior of firefly acting as a signal system to attract other fireflies. Although the details of biochemical process of flash formation and its true purpose are still debated in the science world, many researchers are of the opinion that flashing help firefly to find its friends, attract preys and protect itself from predators.

In firefly algorithm, the objective function of an optimization problem given to yield optimal solutions is related to flashing or light intensity that helps firefly swarm to go brighter and more attractive places. The algorithm is based on the fact that all fireflies are accepted unisexual and thus they can be attracted by each other. The brighter one firefly, it becomes more attractive to other fireflies. A firefly will be attracted by the brighter one [6]. The pseudo code of algorithm is given in Figure 2.

Objective function f(x), $x=(x_1,\ldots,x_d)^T$
Generate initial population of fireflies x_i (i=1,2,…,n)
Light intensity Ii at xi is determined by $f(x_i)$
Define light absorption coefficient γ
***While** (t<MaxGeneration)*
For *i=1:n all n fireflies*
  For *j=1: n all n fireflies (inner loop)*
    If *(I_i<I_j), Move firefly I towards j;* **End If**
  Vary attractiveness with distance r via exp[-γr]
  Evaluate new solutions and update light intensity
  End For *j*
End For *i*
rank the fireflies and find the current global best ***g****
End While
Postprocess results and visualization

Figure 2: Firefly Algorithm [5]

In order to improve the efficacy of Firefly algorithm, Akay (2009) developed a solution by applying neighborhood structure as in Equation 2 below [7].

$$x_{ij} = x_{ij} + (x_{ij} - x_{gj})\, rand(0,1) \quad (2)$$

Here, each solution in the current population is defined by x_i, and randomly selected item from solution set is represented by j. The global minimum is show with x_g. The difference between the randomly selected solution (x_{ji}) and global minimum (x_{gi}) is multiplied by a random value between 0 and 1, and the obtained result is included to current solution for improvement. The proposed IFA is given in Figure 3.

Objective function f(x), $x=(x_1,\ldots,x_d)^T$
Generate initial population of fireflies x_i (i=1,2,…,n)
Light intensity Ii at xi is determined by $f(x_i)$
Define light absorption coefficient γ
***While** (t<MaxGeneration*
For *i=1:n all n fireflies*
For *j=1: n all n fireflies (inner loop)*
  If *(I_i<I_j), Move firefly I towards j;* **End If**
  Vary attractiveness with distance r via exp [-γr]
  Evaluate new solutions and update light intensity
End For *j*
End For *i*
for *i=1:n all n fireflies*
Improved select random a value by Equation (2)
End For *i*
rank the fireflies and find the current global best ***g****
End While
Postprocess results and visualization

Figure 3: Improved Firefly Algorithm [5]

3 EMPIRICAL STUDIES

The experimental studies were made with 40 repetitions for both original FA and the proposed IFA. The best, average and worst results and their parameters obtained in the experimental studies are summarized in Table 1. In addition, the best, average

and worst results and standard deviations obtained with FA in literature as well as FA and IFA algorithms used in the present study are presented in Table 2.

Algorithm		Cost	Error Rate%
FA	Best	1.726148	0.075
	Mean	1.791697	3.875
	Worst	2.006609	16.335
IFA	Best	1.725458	0.035
	Mean	1.763528	2.242
	Worst	1.856885	7.655

Table 1: The best, average and worst results and their parameters obtained with FA and IFA algorithms. Repetition=40

When the test results for FA and IFA given in Table 1 are examined, IFA gives better results in terms of all the best, average and worst values. In Table 2, it is seen that FA and IFA results obtained in the present study are better than the FA results in literature.

Researches	Algorithm	Best	Mean	Worst	SD	No. fireflies
Gandomi et al. [6]	FA	1.731	1.878	2.345	0.2678	25
Present Study	FA	1.726	1.791	2.006	0.0669	25
Present Study	IFA	1.725	1.763	1.857	0.0358	25

Table 2: Comparison of the results obtained with FA and IFA Optimization Algorithms. SD= Standard Deviation.

Similarly, considering the standard deviations in Table 2, IFA provided a smaller value, which indicates that it works more stable than FA. In order to examine the success of IFA, a comparison with the results obtained for the same problem with other optimization algorithms in literature is given in Table 3.

Algorithm	h (x1)	l (x2)	t (x3)	b (x4)	Cost	Error Rate %	No. evaluation
GA [11]	0.2088	3.4205	8.9975	0.2100	1.7483	1.36	N.A.
SA [12]	0.2444	6.2175	8.2915	0.2444	2.3810	38.04	N.A.
SA-GA [13]	0.2231	1.5815	12.8468	0.2245	2.2500	30.45	26.466
PSO [14]	0.2444	6.2175	8.2915	0.2444	2.3810	38.04	30.000
HS [15]	0.2057	3.4705	9.0366	0.2057	1.7248	0.00	200.000
RA [16]	0.2444	6.2819	8.2915	0.2444	2.3815	38.07	N.A.
SBM [17]	0.2407	6.4851	8.2399	0.2497	2.4426	41.61	19.259
SCA [18]	0.2444	6.2380	8.2886	0.2446	2.3854	38.30	33.095
BFO [19]	0.2536	7.1410	7.1044	0.2536	2.3398	35.65	N.A.
DE [20]	0.2444	6.2175	8.2915	0.2444	2.3810	38.04	24.000
FA [6]	0.2015	3.562	9.0414	0.2057	1.73121	0.37	50.000
ABC [22]	0.205730	3.470489	9.036624	0.205730	1.724852	0.00	30.000
SiCPSO [8]	NA	NA	NA	NA	1.724852	0.00	30.000
MHS [23]	0.206704	3.252355	8.9759952	0.208518	1.707009	1,0344	50.000
IFA	0.205348	3.478881	9.036993	0.20573	1.725458	0.04	32.000

Table 3: Welded beam problem: comparison of IFA best results with literature.

Table 3 shows that IFA performs worse than 4 out of 14 optimization algorithms in comparison and gives better results than the rest.

4 CONCLUSION AND DISCUSSION

At present, optimization algorithms are used to solve many real-life problems. Among them, heuristic optimization algorithms are the primary ones. Firefly algorithm developed by Xing She Yang in 2008 is a nature-inspired, swarm intelligence based and metaheuristic algorithm. In this study, a neighborhood method is integrated to the current FA, and thus IFA is proposed.

The proposed algorithm is expected to have a good performance. According to the well-accepted approach, it is more important to determine with which problems an optimization algorithm performs better rather than expecting that each one of the proposed optimization algorithms shows a good performance with all problems. Therefore, in order to observe the performance of both FA and IFA, they were tested on Welded Beam Design problem, a common engineering design problem in literature.

The performances of IFA and FA were compared according to the experimental test results, and IFA was concluded to perform better. Furthermore, in order to observe the performance improvement of the proposed algorithm, a comparison was made with the results of other optimization algorithms applied on the same problem in literature. In this comparison made with 14 optimization algorithms in literature, the algorithm proposed in this study was found to perform worse than 4 algorithms and better than 10 algorithms.

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HYBRID RECOMMENDER SYSTEM FOR PERSONALIZED POI SELECTION

Božidara Cvetković[1, 2], Boštjan Kaluža[1, 2], Hristijan Gjoreski[1, 2], Mitja Luštrek[1, 2]
Jožef Stefan Institute – Department of Intelligent Systems[1]
Jamova cesta 39, 1000 Ljubljana, Slovenia
International postgraduate School Jožef Stefan[2]
Jamova cesta 39, 1000 Ljubljana, Slovenia
e-mail: {boza.cvetkovic, bostjan.kaluza, hristijan.gjoreski, mitja.lustrek}@ijs.si

ABSTRACT

An important phase of trip planning is the selection of relevant points of interest. Many recommender systems have been developed to assist in travel planning, but only few of them take into account user's preferences. This paper presents preliminary results of the hybrid recommender system which first, filters out the points of interest according to user preferences and second, predicts the attractiveness of unrated points of interest using a combination of expert rate, knowledge-based and collaborative filtering recommendation approach.

1 INTRODUCTION

The tourism industry in the European Union (EU) has increased its economic importance in the last 50 years [1]. It has become one of the most significant financial contributor to the budget (4 -11% GDP) of the EU and also individual countries. The recent statistics show that the crisis did not have an impact on holiday trips, but on number of days spent at one location [2]. This indicated that for the higher financial turnover, it is important to offer and provide information about the relevant attractions, the points of interest (POI) at certain location to the user.

The users usually spend a lot of time researching the travel guides and the web for places they would like to visit and things they would like to do and see before going on a trip. To facilitate the search and assist the user in creating suitable trip plan and choosing the relevant POIs, various trip planning web sites and services have been developed over the years [3-5]. Mostly, these sites contain a lot of helpful information about the POIs, but don't automatically recommend them according to the user's preferences. The recommendations are focused on choosing the appropriate flight or providing the list of the best rated POIs, hotels or restaurants according to the user's budget.

The effective way to overcome manual selection and reduce search complexity is by using recommender systems. The recommender systems are very popular in various domains such as book, news, music, movies etc. recommendation [6]. Main advantage of the recommender systems is the possibility of personalisation of search for each individual user. Personalisation involves matching the context in sense of the user specifics, preferences and history to infer on the selection procedure and provide relevant results.

There are various approaches to recommendations. In this paper we will overview the three major categories [6]: (i) the content-based approach; (ii) the collaborative filtering approach; and (iii) knowledge base approach. The content-based approach assumes that the user's behaviour is repeated under similar circumstances. The learner builds a model of user interests according to the users past behaviour. In domain of tourism this means, the predicted rate of POI will be influenced by the rates given by the user to similar POIs. The collaborative filtering is based on behaviour of groups of people under similar circumstances. In tourism, the rate of POI will be influenced by other like-minded people. There are two major categories of collaborative filtering: (i) memory-based collaborative filtering and (ii) model-based collaborative filtering. The memory-based collaborative filtering uses the nearest neighbour algorithm to determine similarity among the users. The neighbours' preferences influence the predicted rate of the new user. The model-based collaborative filtering uses a machine-learning algorithm to learn the model of ratings for known users. This model is afterwards used to predict the rates for the new user. The knowledge-based approach is based on some functional knowledge, such as expert rules, on how a certain item fits the needs of the type of user under certain circumstances.

Using recommender systems in tourism has become a popular research domain. There are many recommender systems focused on selecting the most suitable POIs. For example, the Traveller by Schiaffino et al. [7] uses collaborative filtering, demographic information and the content-based approach to make recommendation. The demographic information is used within collaborative filtering to determine similarity between two users. The rate is influenced by the previous rating of the similar users. The Huang et al. [8] uses tourism ontology and content-based approach based on Bayesian networks, thus using the past behaviour of the current user and other users. The Sepa system by Garcia-Crespo et al. [9] requires the user to explicitly define the preferences, interests and the type of places he/she likes to visit. The system connects to the

user's social network and utilizes the social information. It also uses real-time location via GPS as a feature in the recommender system. The user profile is built upon the information explicitly provided by the user and semantic information obtained from the social network. The user and the services are expressed in ontology like structures which allow the application of feature based similarity algorithms to be used. The recommender system algorithm is a combination of knowledge-based approach and content-based approach.

This paper presents the preliminary results of the hybrid recommender system used in the e-Turist project for selection of the most suitable POIs according to the user's specifics and preferences. The recommender system first, filters the POIs according to users' constraints and second, uses combination of expert rate, knowledge-based approach and memory-based collaborative filtering approach to predict the rate of the POI.

The rest of the paper is structured as follows. Section 2 presents the modules of the recommender system, Section 3 presents the experimental results and Section 4 concludes the paper.

2 HYBRID RECOMMENDER SYSTEM

The purpose of the e-Turist application is to provide a trip plan composed of the most suitable POIs according to the user's preferences and specifics. To obtain the demographic information of the user the user is asked to register before using the application; the preferences for the current trip plan are inserted before each plan creation as shown in Figure 1.

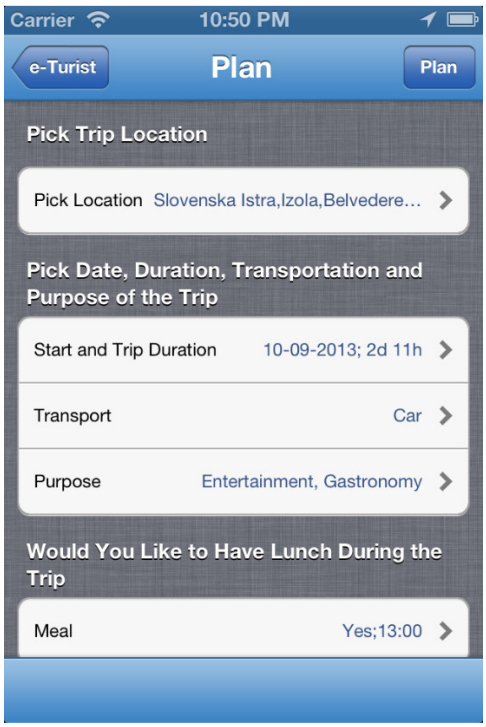


Figure 1: e-Turist application asking the user to specify the preferences of the tip.

The e-Turist recommender system is composed of three modules shown on Figure 2: (i) the constraints filtering module; (ii) the knowledge-based module based on knowledge-based approach; and (iii) collaborative filtering module based on memory-based collaborative filtering approach.

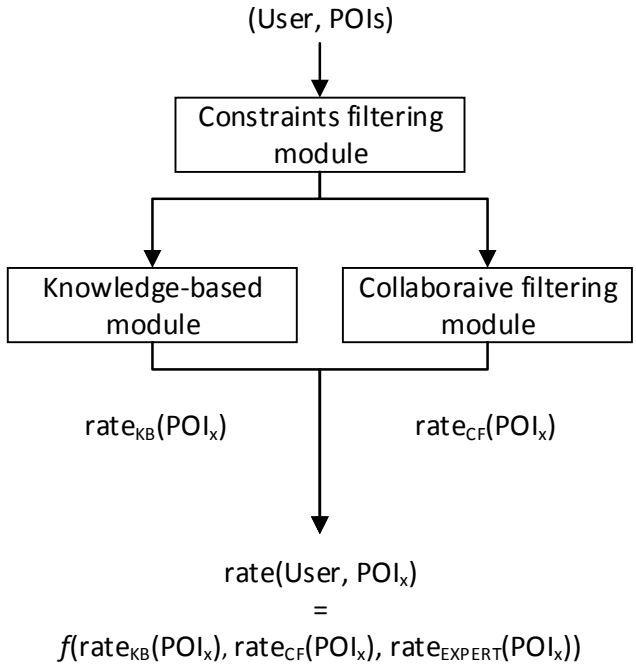


Figure 2: Workflow of the hybrid recommender system.

The final rate of hybrid recommender system is weighted sum of rates provided by the knowledge-based module, collaborative filtering module and expert rate provided by the experts for each POI. The expert rate is a constant.

2.1 The constraints filtering module

The constraints filtering module utilises "hard" constraints to keep only those POIs that satisfy the user's limitations. The hard constraints are: (i) the location; (ii) the purpose of the trip (active tourism, cultural heritage, gastronomy and entertainment); (iii) the working hours; and (iv) the mobility limitation of the user. The constraints filtering module returns POIs on a specified location that are open during the specified start of the trip and duration. The module filters out those POIs that are not categorised into purposes preferred by the user. In case the user has mobility limitations, the module filters out POIs that are not easily accessible.

2.2 The knowledge-based module

The knowledge-based module is based on knowledge-based approach. The approach is composed of expert rules that evaluate how a certain POI fits the needs of the type of user under certain circumstances.

The experts defined four sets of stereotypes that are important for the evaluation: (i) the age group; (ii) the education, (iii) the country of residence; and (iv) the budget. There are five age groups: (i) age up to 26; (ii) 27 to 36; (iii)

37 to 45; (iv) 46 to 55; and (v) 56 and higher. The education groups are three: (i) primary; (ii) secondary; and; (iii) tertiary. The budget groups are three: (i) low; (ii) medium and (iii) high. Each POI is categorised into one or more age groups, one or more education groups, one or more country and can have only one budget value. To evaluate the suitability the Euclidian distance is calculated between the user and POI characteristics. The final rate $rate_{KB}$ of the knowledge-based module is calculated using equation 1.

$$rate_{KB} = \frac{rate_{age}+rate_{edu}+rate_{country}+rate_{budget}}{4} \quad (1)$$

2.3 Collaborative filtering module

The collaborative filtering is based on memory-based collaborative filtering approach. We used k-nearest neighbour algorithm [11] to find k similar users. Each instance represents one user. The feature vector is composed of rates per POI given by the individual user. In case the user did not rate the POI the value is defined as a missing value. The final rate for individual POI is an average value of rates per POI for the k-nearest neighbours.

3 EXPERIMENTAL SETUP AND RESULTS

To perform the experiment we collected data of 24 users with different age and background. The users were given a list of 90 POIs from Slovenian Istria, which are used by the e-Turist application. They were asked to rate given POIs they are familiar with from 1 to 5 stars. The data was used to evaluate each module separately and to define the final weights of the equation.

The goal of each module is to accurately predict the rate of POI as would be given by the current user. Result of each module was evaluated by mean absolute error (MAE) as defined by equation 2.

$$MAE = \frac{\sum_{i=0}^{n}(|rate_{true}-rate_{predicted}|)}{n} \quad (2)$$

First, we evaluated the knowledge-based module. We used the demographic data and budget preference to predict the rate for each POI using the expert rules. An example of the expert rule for rating the suitability of POI according to budget is as follows:

IF $user_{budget}$ *notDefined:*

$$rate_{budget} = 0.5$$

ELSE IF $user_{budget} >= poi_{budget}$*:*

$$rate_{budget} = 1$$

ELSE:

$$rate_{budget} = 1 - \frac{abs(poi_{budget}- user_{budget})}{3}$$

If the budget is not defined than the rate is 50% suitable otherwise the rate is normalised calculation of Euclidian distance between the budget specified by the user and the budget specified for the POI. The MAE of the knowledge-based module was 0.98 rate. The error can be translated into prediction accuracy of 75%.

Second, we evaluated the collaborative filtering module. The collaborative filtering is based on k-nearest neighbour algorithm. Before evaluation we had to define the number of neighbours that will be used by the algorithm. We tested the algorithm for k=1 to k=10. The results are shown in a graph in Figure 3. We can observe that higher the number of neighbours the lower the error. However, since we had data of only 24 users we had to limit the number of neighbours to the number from 1 to 5. The best results were obtained when k was set to 4.

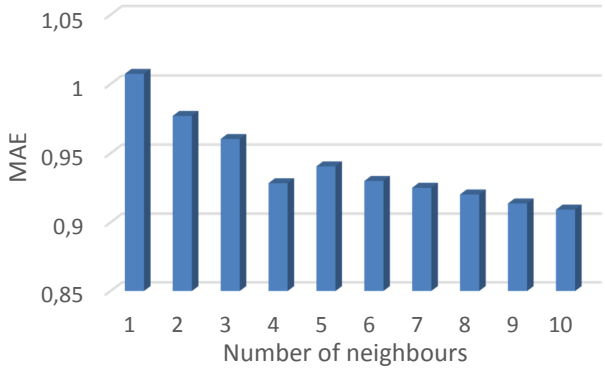


Figure 3: Number of neighbours and MAE of the collaborative filtering module.

The result of the collaborative filtering module using 4-nearest neighbours algorithm is MAE was 0.87 rate. The error can be translated into prediction accuracy of 78%.

The final result of the recommender system is calculated as a weighted sum of predictions of both modules and the expert value. The equation for the final result is presented as equation 3.

$$rate = w_1 * rate_{KB} + w_2 * rate_{CF} + w_3 * rate_{expert} \quad (3)$$

The weights for each rate prediction were set based on the MAE for both modules and MAE of rate defined by the experts. The results are presented in Table 1.

Rate	MAE
Rate knowledge-based module	0.98
Rate collaborative filtering module	0.87
Expert rate	0.99

Table 1: Mean absolute error of knowledge-based, collaborative filtering module and expert rate.

We can observe that both modules perform with lower error as if the rate would be set equal to expert rate.

Therefore, the weights of both modules w_1 and w_2 should be set higher than the weight of the expert rate w_3. For the preliminary results, we decided the values of weights w_1 and w_2 should be equal and the weight w_3 lower. The results of the experiment defined the final algorithm and equations as follows:

IF $rate_{Expert}$ *notDefined:*

$$rate = 0.5 * rate_{KB} + 0.5 * rate_{CF}$$

ELSE:

$$rate = 0.4 * rate_{KB} + 0.4 * rate_{CF} + 0.2 * rate_{expert}$$

The result of the above equation was compared to a baseline approach. The baseline approach rates all POIs with rate 3, which is a medium rate. The results of all experiments are presented in MAE value and can be observed in Figure 4. The MAE value of the baseline approach is 1.05 rate and the MAE of the final rate is 0.86 rate, which is lower than MAE of both modules and the expert rate.

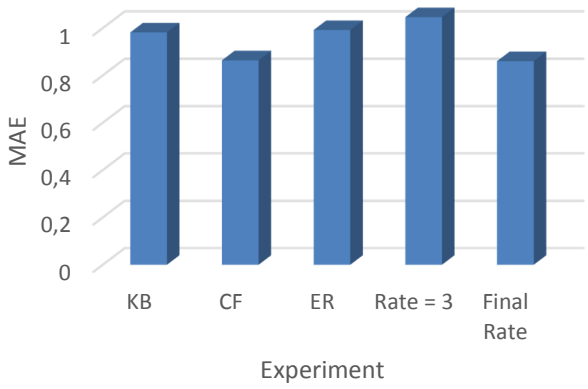


Figure 4: MAE value per each experiment the knowledge-based module (KB), the collaborative filtering module (CF), the expert rate (ER), the baseline approach, if rate is always equal to 3 (Rate=3) and the final rate calculated by the algorithm and equation above.

The result of the recommender system, the list of the most suitable POIs for the current user and the predicted rates, are afterwards processed with module for route planning, which is not a focus of this paper.

4 CONCLUSION

The paper presented hybrid recommender system consisting of knowledge-based module, collaborative filtering module and expert rate. The recommender system was used to predict the rates of tourist attractions or points of interest for individual user. The paper also presented the preliminary results of the recommendations. The experiments were performed on real users and data comprised from points of interest located in Slovenian Istria.

The results show that the collaborative filtering performs with lowest mean absolute error value compared to the other approaches. When the results of the three approaches (knowledge-based module, collaborative filtering module and expert rate) were combined, the mean absolute error of the predicted rate became a bit lower. The MAE of the final rate was 0.86 rate. Which can be translated into prediction accuracy of 79%.

Acknowledgement

This work was supported by Slovenian ministry of education, science and sport: call for proposals for co-funding of projects developing e-services and mobile applications for public and private non-profit organizations. The authors would like to thank Vito Janko, Maja Somrak and Andrej Tratnik for the help provided in the system implementation and programming part.

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DETEKCIJA ZNAČILNIH TOČK NA SLIKI

Erik Čuk[1,2]
[1]LOTRIČ meroslovje d.o.o
[2]Odsek za inteligentne sisteme, Inštitut Jožef Stefan
e-mail: erik.cuk@ijs.si
e-mail: erik.cuk@lotric.si

POVZETEK:

Članek opisuje detekcijo lokalnih značilnih točk. Za primerjavo detekcije sta bila uporabljena detektorja MSER in SIFT. Za preverjanje stopnje invariantnosti in s tem preverjanje kvalitete omenjenih detektorjev pri detekciji lokalnih točk na sliki vizitke je bila slika vizitke najprej postopoma zamegljena, vizitki se je postopoma dodajalo šum, zatem pa je bila opravljena translacija, pomanjšava, rotacija in strig slike vizitke.

1 UVOD:

Detekcija lokalnih značilnih točk je termin, ki se uporablja na področju računalniškega vida in se nanaša na detekcijo značilnih lokalnih točk potrebnih za nadaljno obdelavo slikovnega materiala [1]. Detekcija lokalnih značilnih točk se je izkazala za zelo uporabno tehniko detekcije in ekstrakcije značilk tudi na področju obdelave slik.

Za namen detekcije lokalnih značilnih točk obstaja veliko različnih oblik detektorjev (Harris corner detector, Harris–Laplace, SURF - Speeded Up Robust Features, SIFT - Scale Invariant Feature Transform, MSER - Maximally stable extremal regions in drugi), ki se pojavljajo v aplikacijah kjer so pomembne detekcija, klasifikacija [2], ujemanje in razpoznavanje objektov [3].

Lokalna značilna točka je točka na sliki ki je:
- jasno, matematično definirana
- ima natančno določeno mesto v slikovnemu prostoru
- lokalna strukture slike okoli značilne točke je bogata v smislu lokalnih vsebinskih informacij s čimer se poenostavi nadaljna obdelava slikovnega materiala
- je lokalno in globalno stabilna točka [1].

2 DETEKTOR MSER

Metoda maksimalno stabilnih ekstremnih območij je bila zasnovana za detekcijo množice točk iste barve, za iskanje ujemanja med elementi slik, zajetih iz različnih zornih kotov. Iskanje značilnih elementov slike poteka preko določanja maksimalno stabilnih območij na sliki, ki so definirana z intenzitetno funkcijo.

Postopek iskanja stabilnih območij izvedemo z zaporednimi upragovljanji slike s postopnim spreminjanjem vrednosti praga. Pri tem opazujemo spreminjanje velikosti posameznih povezanih regij slike, kjer so črne vrednosti intenzitet slikovnih elementov regije pod trenutnim pragom ali bele vrednosti intenzitet slikovnih elementov regije nad trenutnim pragom. Stabilnost območij je določena s stopnjo spreminjanja njihovih velikosti preko več različnih vrednosti pragov. Za stabilna območja proglasimo tista območja, ki se ohranijo skozi daljše zaporedje pragov. Maksimume predstavljajo svetlejša področja na temnejšem ozadju. [4,5]

3 DETEKTOR SIFT

Metoda SIFT je algoritem, ki detektira in opiše lokalne značilnosti na sliki. Metoda se uporablja za razpoznavanje objektov, 3D modeliranje, razpoznavanje gest, video nadzor itd [6].

V prvem delu poteka iskanje značilnih točk s prepoznavanjem območij, ki jih je mogoče ponovljivo zaznati na različnih slikah. Zaznavanje stabilnih območij je možno z uporabo iskanja ekstremov Gaussovih diferenc. Rezultirajoča slika L(x, y, σ) je definirana kot konvolucija Gaussovega filtra G (x, y, σ) in originalne slike I(x, y):

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y).$$

Zatem razliko različnih skalirnih prostorov slike D (x, y, σ) dobimo s konvolucijo slike z Gaussovimi diferencami (DoG) z dvema bližnjima skalama, ki sta oddaljeni za faktor k:

$$D(x, y, \sigma) = L(x, y, k\sigma) - L(x, y, k) = \big(G(x, y, k\sigma) - G(x, y, \sigma)\big) * I(x, y)$$

DoG slika je razlika dveh slik, zglajenih z Gaussovima filtroma, katerih σ se razlikuje za faktor k. Originalno sliko zaporedno konvoluiramo z Gaussovimi filtri. Tako dobimo slike v skalirnem prostoru, ki se razlikujejo za faktor k. Slike razdelimo v 'oktave'. Znotraj ene oktave se vrednost σ podvoji. Ključne točke predstavljajo minime ali maksime DoG slik, ki se pojavljajo na več različnih skalah.

Minime in maksime najdemo s primerjavo slikovnih elementov slike DoG in sicer z osmimi sosedi na isti DoG skali in po devet sosedov na sosednjih dveh DoG skalah. Če je izbran slikovni element večji ali manjši od vseh primerjanih sosedov, je kandidat za ključno točko. Ko smo poiskali vse minime in maksime v eni oktavi, generiramo naslednjo oktavo.

V sliki, ki je zglajena z Gaussovim filtrom, vzamemo le vsak drug slikovni element v vsaki vrstici in stolpcu ter postopek ponovimo. S tem ne izgubimo nobene informacije o sliki, medtem ko se računska zahtevnost s tem občutno zmanjša.

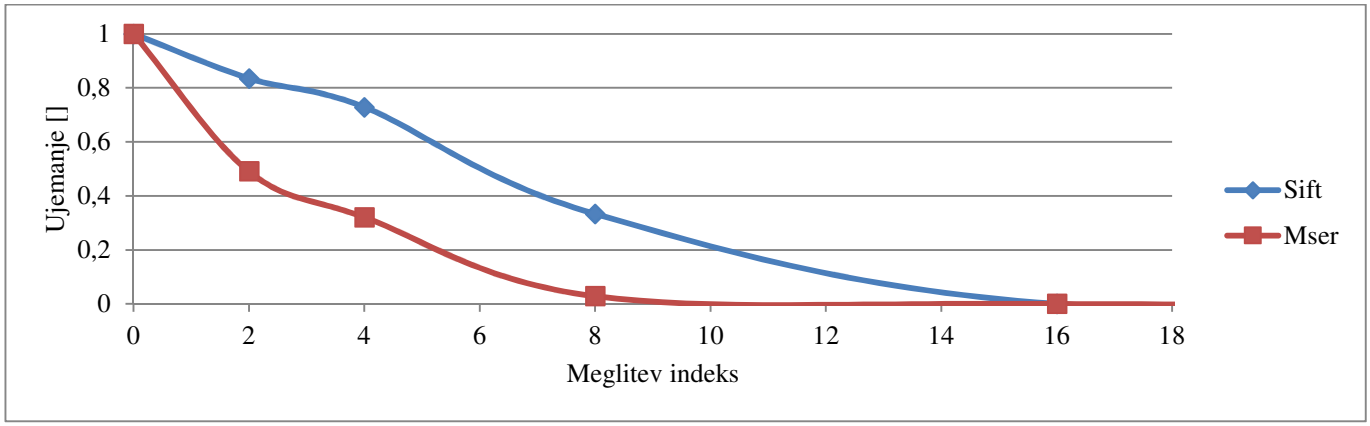
Ko je kandidatka za ključno točko s primerjanjem s sosednjimi slikovnimi elementi najdena, sledi korak v katerem naredimo podrobno ujemanje na bližnje točke za lokacijo in skalo. Ta informacija omogoča, da izločimo bodisi nestabilne točke z nizkim kontrastom (občutljive na šum) ali pa slabo lokalizacijo vzdolž robu. Na podlagi pridobljenih informacij izmed vseh kandidatk izberemo le stabilne ključne točke [6,7,8].

4 ANALIZA STABILNOSTI IN PRIKAZ REZULTATOV

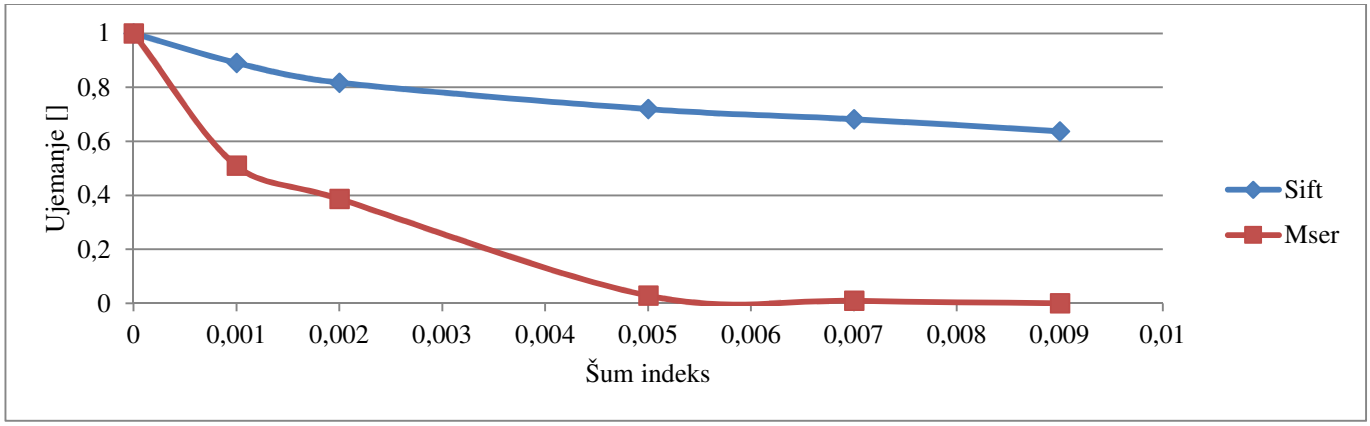
Za določanje značilnih točk sta bili uporabljeni MATLAB implementaciji metod SIFT in MSER [9]. Pri izbiri detektorjev je najpomembnejša ponovljivost, ki ponazarja koliko točk je stabilnih v različnih slikovnih sekvencah. Za študijo ponovljivosti so bile na izbrani vizitki narejene različne transformacije. Osnovno sliko se je najprej postopoma zamegljevalo (glej sliko 1) z Gaussovim filtrom. Zatem se je postopoma dodajal Gaussov šum (glej sliko 2), prav tako pa je bila slika podvržena afinim preslikavam (translacija-glej sliko 3, pomanjšava-glej sliko 4, rotacija-glej sliko 5, strig-glej sliko 6). Ponovljivost je bila merjena z Evklidsko razdaljo z vrednostjo 2.

$$d(x,y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$

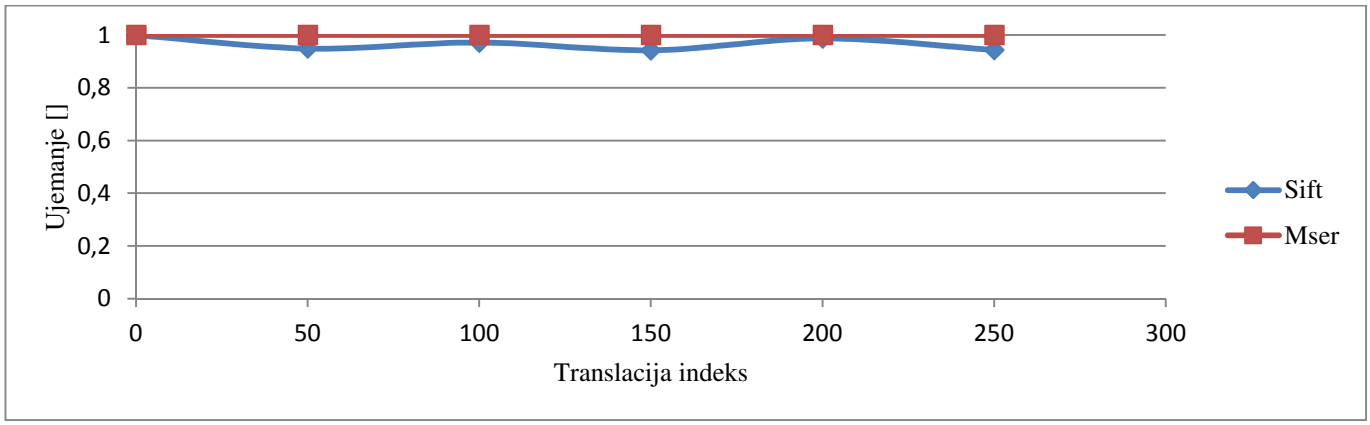
Grafi rezultatov posameznih načinov deformacije originalne slike so podani kot ujemanja števila lokalnih značilnih točk s točkami na deformirani sliki v odvisnosti od parametra posamezne transformacije:



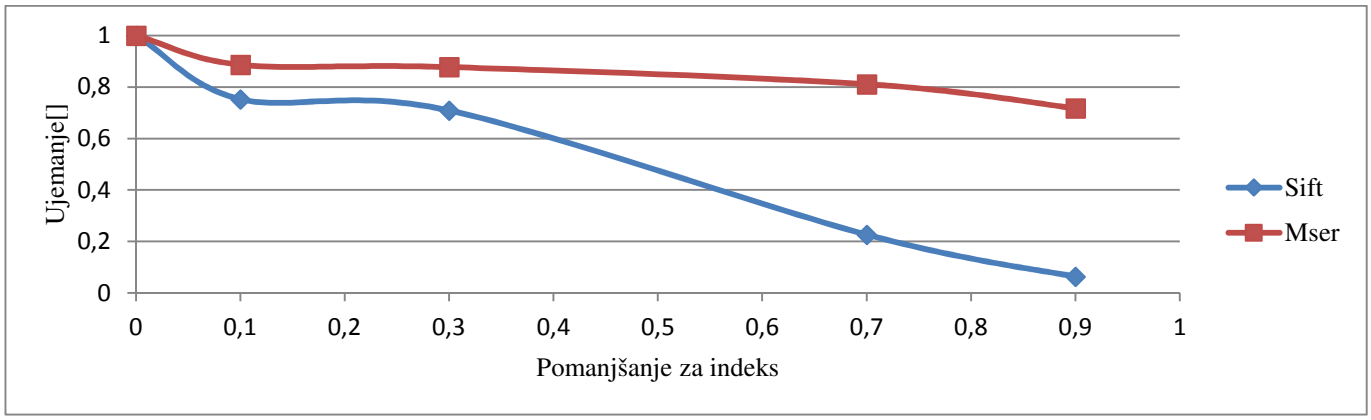
Slika 1: Meglenje slike vizitke



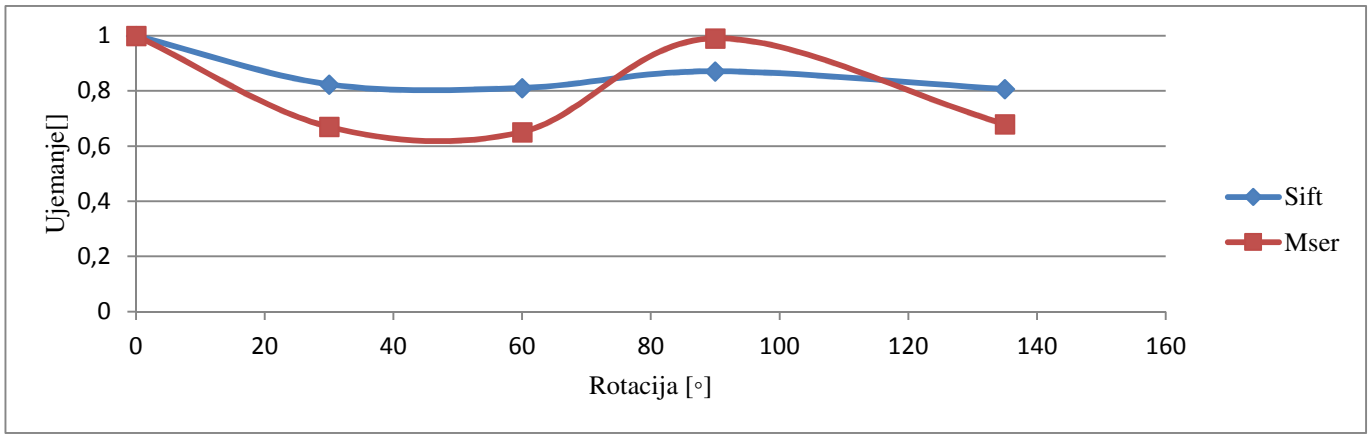
Slika 2. Dodajanje Gaussovega šuma vizitke



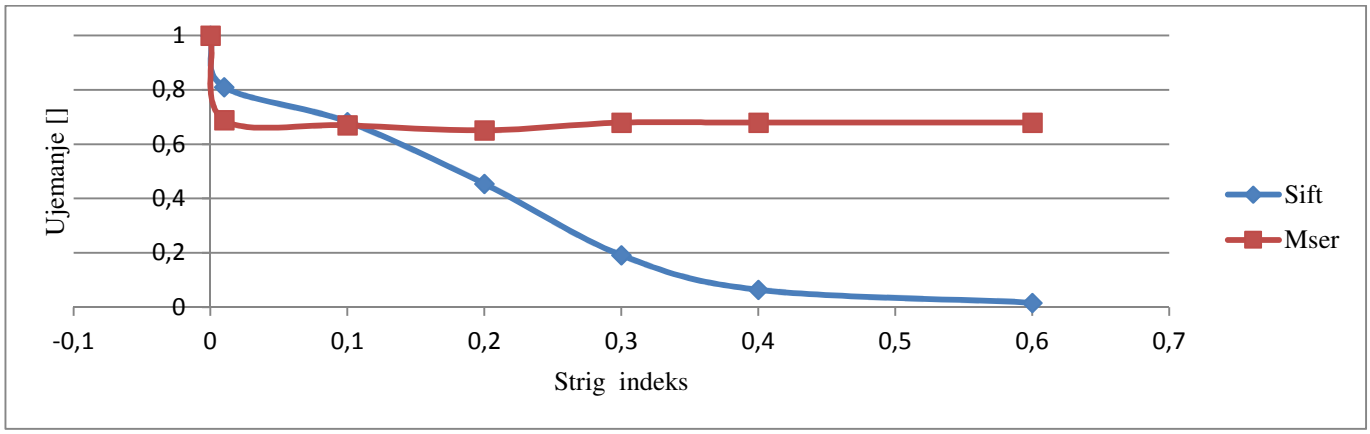
Slika 3: Translacija slike vizitke



Slika 4: Pomanjšanje slike vizitke



Slika 5: Rotacija slike vizitke



Slika 6: Strig slike vizitke

ZAKLJUČEK

S primerjavo rezultatov lahko ugotovimo nekatere skupne lastnosti metode SIFT in MSER. Obe metodi izkazujeta invariantnost na translacijo. Pri rotaciji se izkaže, da za zasuk slike za π/2 dosežemo dobro stabilnost za oba detektorja. Pri večanju zasuka od 0 od π/4 stabilnost točk pada, doseže minimum in z večanjem zasuka proti π/2 zopet narašča. Pri meglitvi slike opazimo hitro izgubljanje značilnih točk. Pri strigu in pomanjšavi se bolje odreže MSER, medtem ko pri dodajanju šuma prednjači detektor SIFT.

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REDUCING THE USE OF CHEMICALS IN AGRICULTURE USING SMART TOOLS

Yusuf Dilay[1], *Adem Özkan*[1]
[1]Karamanoğlu Mehmetbey University
Vocational School of Technical Sciences Machine Dept.
e-mail: ydilay@kmu.edu.tr

ABSTRACT

Today one of the most important problems of the world is fast growing of the population. According to the FAO reports, people need 15-20 million ton food materials per year. The area of the world is always same, not changed though population is growing every day. Because of that, producing of the food is not enough to live well in the world. In order to produce much more, agricultural products are not to accept discarding for using in the fields. Besides high usage of chemicals in agriculture, is very dangerous for human health. The goal is to develop smart, easy, efficient and open-ended adjustment tools on sprayer machines.
Key Word: Smart tools, chemical, agriculture.

1 INTRODUCTION

Insects, herbicide, fungicides and rodenticides are called as pesticide which includes all using chemicals.
The pesticides have been used for a long time. On a papyrus which is in BC 1500 was found the records about preparing the insecticides for insects and bees. Inorganic pesticides were used for the pests in 19 century. After 1940s, organic chemistry was derived at producing pesticide.
Besides, because of using pesticide unconsciously and intensively, you can find the pesticide parts on the soil, air and water. The negative effects can be seen on other organisms and people who weren't target, the importance of the pesticide parts were understood in 1948 and 1951 with being found the remains of organics and chlorine pesticides on the body of human. While some of the pesticides are not pestilent, it is found that some are very pestilent for our health such as toxic, affecting of nervous system and even contracting the mutation. The most important source of the remains of pesticides is foods. So, FAO and WHO founded the Pesticide Remains Codex organization in 1960 and in the end of these organization studies, some definitions, dealing with this subject, were done. According to the scientific research data's, permitted maximum remains chemical on the foods were found.
This study was taken from the report presented by ICT-AGRI project. The ICT-AGRI project is funded by the European Commission's ERA-NET scheme under the 7th Framework Programme for Research.

2 EFFECTS OF THE PESTICIDES ON PEOPLE

Because there are some toxics on everywhere that effected people, all people working in this area must be protected from the negatives affects of them. As people expose the pesticides, poisoning and health problem are occurred on body.

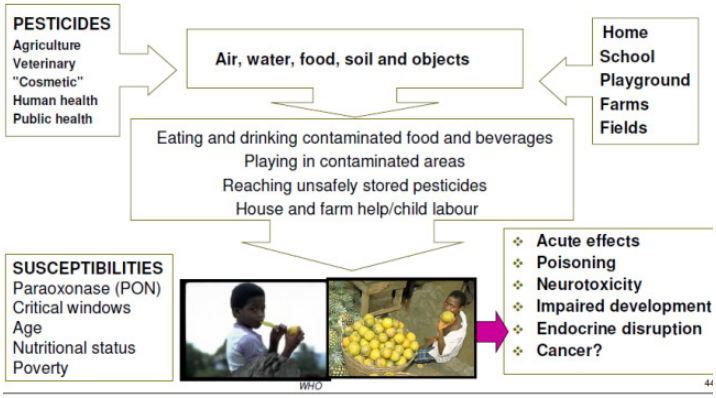


Figure 1: *Pesticides in children's complex environment [1].*

These summary slide shows the complexity of the issues related to children's environmental exposure to pesticides and the effects on their health. Pesticides used in agriculture were found at the treatment of animals, on lawns

("cosmetic") and for protection of human and public health may enter the air, food, water and soil in the places where children spend most of their time (e.g. at home, at school, in playgrounds, on farms and in fields) and may also contaminate their toys, floors, carpets and materials in their playgrounds. Children become exposed by:

•Eating and drinking contaminated food and beverages
•Playing in contaminated areas
•Gaining access to unsafely stored pesticides, or pesticides stored in attractive, colorful containers

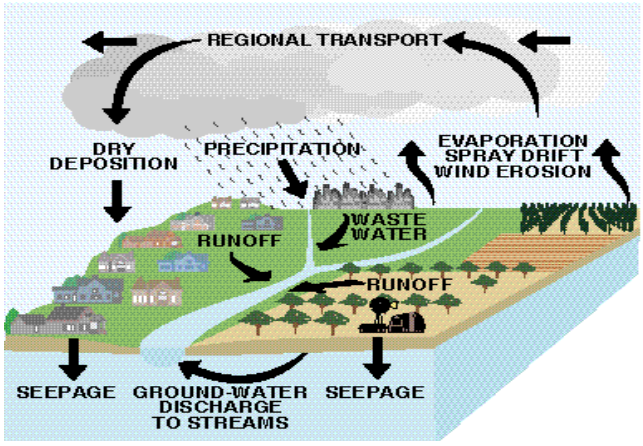


Figure 2: *Pesticides in the atmosphere and water[1].*

Pesticides are considered an important environmental threat to people's health in rural, especially, areas. This is because:

•Helping in the house and on the farm or as child labor
•Contact with clothing or shoes of working parents

3 EFFECTS ON ENVIRONMENT

The US Geological Survey (USGS) monitors ground and surface water for 76 pesticides and seven pesticide breakdown products. A recent survey found that 90% of streams and 50% of wells tested were positive for at least one pesticide.

- A large variety of chemicals and mixtures are used as pesticides.
- Many pesticides are used at the same time in the same place (agricultural regions).
- They are ubiquitous in the environment and in individual environments (microenvironments) of people there may be several sources of exposure by same or a different chemical.
- Multiple exposures may occur from the preconception period throughout the child's growth into adolescence and adulthood. Pesticides may also be heavily used indoors in urban areas, so this is not solely a rural issue.

4 RESULTS AND DISCUSSION

"***What recommendations can be given?***"

1- **Drifting:** Drifting reduced the affects of the insecticide. And then, repeating the applying insecticide causes economical losses. In addition that, as a result of these applications, plants on the target, increases amount of the remains.

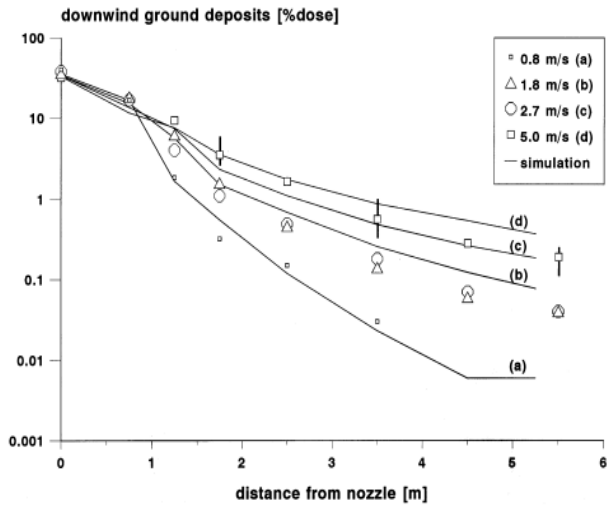


Figure 3: *Drops of different diameters vary depending on wind speeds measured drift the distances [2].*

Finally, food is coming to the unused position or it treats consumers seriously. In order to solve these problems, these problems can be decreased with machines used in the field and with knowing the techniques of using. Machines must be done calibration regularly. Operating pressure and drop diameter selected is affecting way for drift. While thin and medium size drops on insecticide and Fungusit operations are being worked with, larger drops are preferred to the Herbisit operations. Drops which are 200 mЦ-sizes are the easiest drifting. If the diameter is bigger than we want, drop cannot be hanged on the target.

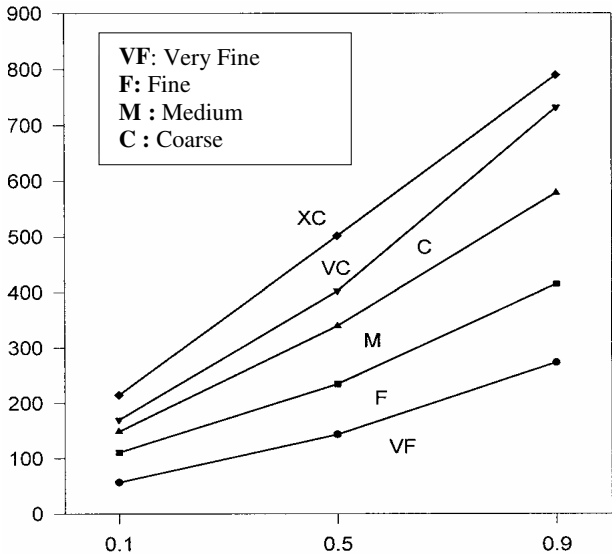


Figure 4: *Drops of spray nozzles according to the classification ranges [3].*

2- **Smart Systems: C**hemicals usage can be decreased with using smart system on pesticides. Height can be controlled with ultrasonic sensors. As a result of this, amount of the pesticides applicated equally to every plant. If there is no plant, there is no pesticide. So there is no risk for health. With the smart system we can use little pesticide to the small leaf and more pesticide for large leaf. So its not only increased productivity but also decreased the using of the pesticides.

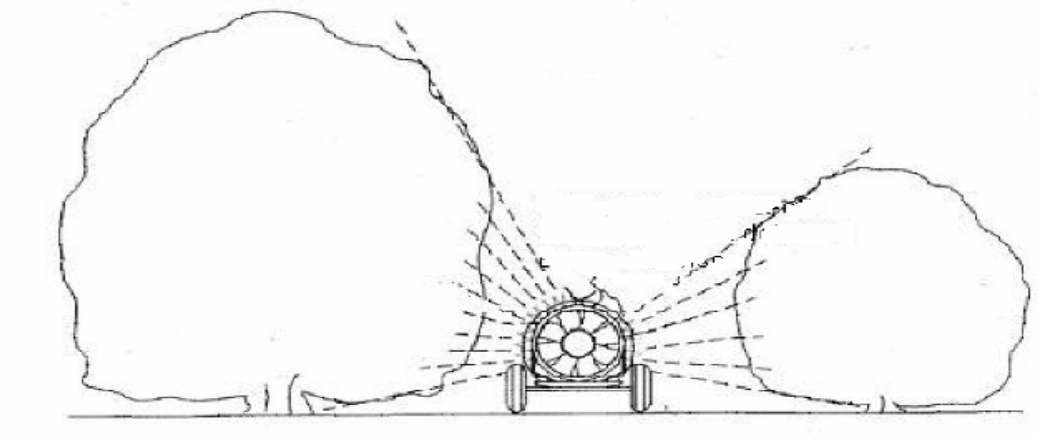


Figure 5: *Spraying machine is equipped with sensors detected the area of plant and activates the corresponding nozzles [4].*

3- **Precision Farming:** GPS and DGPS are used on the precision farming. In this systems, we don't need to pesticide on the same area and there won't be any area without pesticiding.

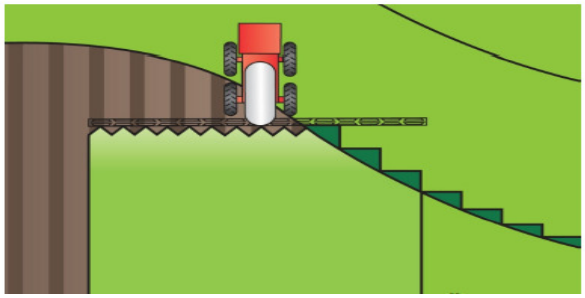




Figure 6: *Flow control unit and schematic appearance during operation [4].*

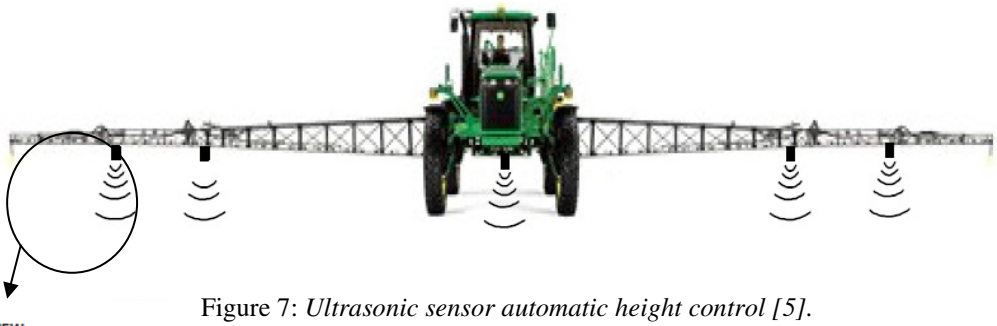
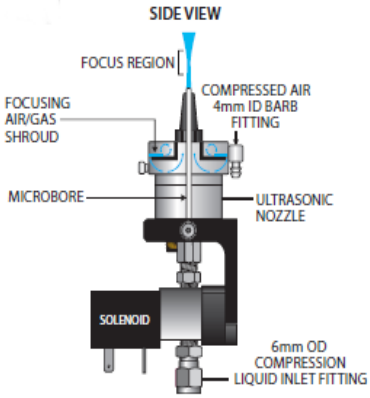


Figure 7: *Ultrasonic sensor automatic height control [5].*



4- **Low Drifts:** Low drifts are used on the machines used for pesticides.

The two main areas of focus are residue and drift reduction. While we continue working to reduce residues, cisgenesis technology is being developed that don't need as many pesticides. Once this technology is accepted we can move on to other challenges, but in the mean time we will still need to spray for the foreseeable future. The issues that are going to shape sprayers of the future are:

- Public perception
- Deposition efficacy
- Environmental contamination
- Operator safety

If we assume that the average orchard sprayer sprays about 20 ha a year and average spray costs are about £1100 per ha, then the average sprayer is used to apply about £22,000 worth of product a year [6].

5- **Educated Farmers:** We should tell the advantages and disadvantages of the pesticides and how to use the machines very effectively.

5 CONCLUSIONS

This study was carried out to evaluate reducing the use of chemicals in agriculture using smart tools. The following results can be drawn from the study:

-Chemical consumption has been significantly reduced using smart tools.

-Smart tools used in agricultural production are increased.

-Governmental policies should be focused on research and development of new technologies, extension and encouraging farmers to apply conservation agriculture practices.

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ANALIZA MOŽNOSTI NADGRADNJE OBSTOJEČIH SISTEMOV ZA KALIBRACIJO NAPRAV Z INTELIGENTNIMI METODAMI ZA NAPOVEDOVANJE ROKOV KALIBRACIJE

Erik Dovgan, Damjan Kužnar, Matjaž Gams
Odsek za inteligentne sisteme
Institut "Jožef Stefan"
Jamova cesta 39, 1000 Ljubljana, Slovenija
Tel: +386 1 4773393; fax: +386 1 4773131
e-mail: erik.dovgan@ijs.si

POVZETEK

Prispevek analizira možnosti vključitve inteligentnih metod za napovedovanje rokov kalibracij v obstoječe sisteme za kalibracijo naprav. Pri napovedovanju rokov kalibracij je najpomembnejši korak natančno in pravilno napovedovanje bodočega delovanja naprav, na podlagi katerega se nato določi čas, ko bo delovanje naprave signifikantno odstopalo od pravilnega delovanja. Poleg napovedovanja rokov kalibracij je možno obstoječe sisteme nadgraditi tudi z različnimi grafičnimi prikazi bodočega delovanja naprav, ki so namenjeni nestrokovnjakom, na podlagi katerih se lahko lastniki naprav odločijo, kdaj bodo naprave kalibrirali.

1 UVOD

Kalibracija naprav zagotavlja pravilno delovanje naprav in zmanjšuje verjetnost okvar. Roki kalibracije so bodisi določeni zakonsko, s standardi, ali pa se jih določi na podlagi priporočil strokovnjakov na področju kalibracije. Zadnji primer je z raziskovalnega vidika najbolj zanimiv, saj lahko z inteligentnimi metodami svetujemo strokovnjakom, kar izboljša napovedovanje rokov kalibracije in omogoča nadgrajevanje znanja strokovnjakov. Pri implementaciji inteligentnih metod za napovedovanje rokov kalibracije je potrebno upoštevati množico podatkov, kot so priporočila, standardi, zakonski predpisi, izkušnje strokovnjakov ter preteklo delovanje naprav.

V tem prispevku bomo analizirali podatke, ki jih obstoječi sistemi za kalibracijo naprav shranjujejo. Ti podatki so predvsem odvisni od tipa kalibriranih naprav. Naprave so lahko enostavne, npr., termometri, katerih delovanje se ne spreminja, lahko pa so kompleksne, npr., hladilne komore, katerih delovanje se spreminja (npr. temperatura niha). Drugi del prispevka vsebuje opis obstoječih metod za napovedovanje rokov kalibracij. Poleg tega vsebuje tudi seznam mednarodnih projektov, sorodnih s področjem kalibracije naprav. Zadnji del vsebuje priporočila, kako obstoječe sisteme za kalibracijo naprav nadgraditi z inteligentnimi metodami za napovedovanje rokov kalibracij.

2 OBSTOJEČI SISTEMI ZA KALIBRACIJO NAPRAV

Obstoječi sistemi za kalibracijo naprav za vsako kalibracijo shranjujejo množico podatkov. Tipični podatki, ki jih sistemi shranjujejo, so:

1. Nazivna vrednost, torej vrednost, ki bi jo idealno delujoča naprava izmerila;
2. Izmerjena vrednost, torej vrednost, ki jo kalibrirana naprava dejansko izmeri;
3. Pogrešek;
4. Največji dovoljeni pogrešek;
5. Negotovost, ki je odvisna tako od naprave kot od pogojev v prostoru, kjer se kalibracija izvaja.

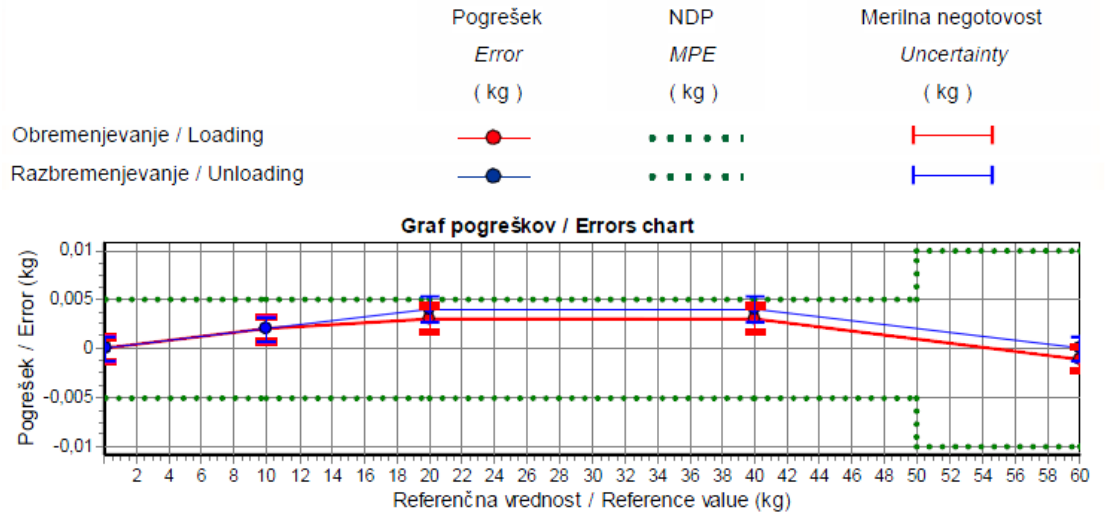
Ti podatki se lahko shranjujejo ob različnih stanjih naprav. Na primer, pri tehtnicah se shranjujejo podatki ob obremenjevanju tehtnice in ob razbremenjevanju tehtnice.

V nadaljevanju so opisani postopki kalibracij dveh tipov naprav:

1. Naprave, katerih stanje se ne spreminja tekom kalibracije, npr. tehtnice in termometri;
2. Naprave, katerih stanje se spreminja tekom kalibracije, npr. hladilniki in sterilizatorji.

2.1 Naprave, katerih stanje se ne spreminja tekom kalibracije

Naprave, katerih stanje se ne spreminja tekom kalibracije, so relativno enostavne naprave z vidika analize podatkov kalibracije. Primeri takih naprav so tehtnice in termometri. Vsako izmed naprav se kalibrira pri več različnih vrednostih in pogojih, npr., tehtnico pri več različnih utežeh ob obremenitvi in razbremenitvi. Poleg tega se vsako meritev večkrat ponovi. Nato se izračuna povprečno vrednost meritve, povprečno napako (pogrešek) in merilno negotovost. Merilna negotovost vsebuje vpliv postopka merjenja (fiksna vrednost), vpliv okolja (vpliv temperature okolja itd.) in vpliv naprave (npr. standardni odklon meritev). Vsaki meritvi se pripiše tudi največji dovoljeni



Slika 1: *Grafični prikaz podatkov o kalibraciji tehtnice.*

pogrešek (NDP). Slika 1 prikazuje grafični pogled na podatke o kalibraciji tehtnice.

2.2 Naprave, katerih stanje se spreminja tekom kalibracije

Naprave, katerih stanje se spreminja tekom kalibracije, so kompleksnejše naprave z vidika analize podatkov kalibracije. Primer takih naprav je hladilnik, ki stalno vzdržuje notranjo temperaturo znotraj dovoljenih odstopanj. Za potrebe kalibracije takih naprav je potrebno namestiti tipično več senzorjev na/v napravo. Vsak senzor opravi več meritev, pri čem so meritve opravljene z določeno frekvenco (npr. enkrat na minuto). Ob zaključku merjenja se izračuna minimalna, maksimalna in povprečna vrednost za vsak senzor. Za vsak senzor se shranjuje tudi mersko enoto podatkov (temperatura, vlaga itd.) in dovoljeno odstopanje, če je le-to vnaprej določeno.
Slika 2 prikazuje primere meritev senzorjev med kalibracijami naprav. Pri določenih meritvah lahko opazimo spreminjanje vrednosti podatkov z določeno frekvenco. Poleg tega lahko opazimo odstopanja pri določenih meritvah in sicer dveh vrst:

- Odstopanja vseh senzorjev istočasno. V takem primeru je lahko prišlo do zunanje motnje, kar je povzročilo spremembe v meritvah vseh senzorjev.
- Odstopanja le enega senzorja. V takem primeru je verjetno prišlo do napake pri izvedbi meritve. To posebej drži, če imamo več istovrstnih senzorjev enega blizu drugega. V tem primeru je prišlo do napake, saj v nasprotnem primeru bi tudi ostali senzorji zaznali odstopanje.

Metode za napovedovanje rokov kalibracij morajo biti sposobne zaznati takšna odstopanja in jih zanemariti, če so irelevantna. Poleg tega se lahko uporabi posebne metode za predprocesiranje podatkov za namene odstranjevanja irelevantnih odstopanj in uporabe prečiščenih podatkov pri napovedovanju bodočih rokov kalibracij.
Poleg merjenja podatkov ob običajnem delovanju naprav se pri določenih napravah izvaja tudi meritve ob neobičajnem delovanju. Primeri neobičajnega delovanja so:

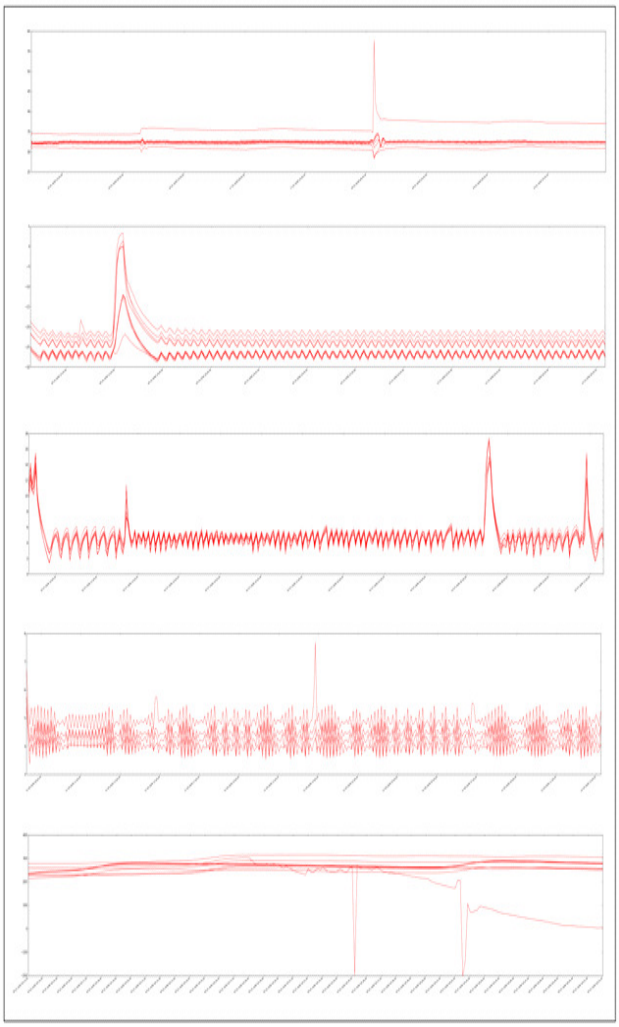
1. Test odpiranja vrat npr. hladilnika: vrata naprave se pusti odprta za nekaj ur, nato se jih zapre in meri obnašanje naprave naslednjih nekaj ur.
2. Test izklopa naprave, npr. hladilne komore: napravo se izklopi in meri njeno obnašanje nekaj ur/dni.

3 NAPOVEDOVANJE BODOČIH ROKOV KALIBRACIJ

Za namene napovedovanja bodočih rokov kalibracij je potrebno pravilno napovedati bodoče delovanje naprav. Metode, ki napovedujejo bodoče delovanj naprav, so npr. metode strojnega učenja in metode za analizo časovnih vrst. Inteligentne metode omogočajo tudi odkrivanje odstopanj v delovanju, odkrivanje negativnih trendov ter ugotavljanje, kdaj bo odstopanje delovanja naprav preveliko in bo potrebno ponovno kalibrirati napravo.

3.1 Metode in algoritmi za napovedovanje bodočih rokov kalibracij

Podpoglavje opisuje metode in algoritme, ki se jih uporablja za napovedovanje bodočega delovanja naprav in bodočih rokov kalibracij. Poleg tega opisuje potrebne vhodne podatke, ki jih potrebujejo metode in algoritmi za uspešno napovedovanje delovanja naprav in rokov kalibracij.
Prvi korak pri napovedovanju bodočih rokov kalibracij je gradnja modela delovanja naprav. Model se zgradi na podlagi trenutnega stanja naprave med kalibracijo, preteklega obnašanja naprave, referenčnega obnašanja podobnih naprav itd. Za gradnjo modela delovanja se lahko



Slika 2: *Primeri meritev senzorjev med kalibracijo naprave.*

uporabi metode strojnega učenja, metode za analizo časovnih vrst (analiza preteklega delovanja, primer metode je v [4]), metode za gručenje podobnih naprav [1], itd.
Naslednji korak je napovedovanje bodočih rokov kalibracij. Napovedovanje se izvede s pomočjo predhodno zgrajenega modela delovanja naprav, ki simulira bodoče delovanje ter napove najbolj verjeten datum okvare oziroma začetka nepravilnega delovanja naprav. Pri tem je treba upoštevati dovoljena odstopanja v delovanju naprav (npr. dovoljena temperaturna odstopanja hladilnika).
Raziskovalni pristopi in metode, ki se jih uporablja za napovedovanje bodočih rokov kalibracij, so predvsem metode strojnega učenja. Primer metod strojnega učenja so metode za odkrivanje zakonitosti v časovnih vrstah npr. s sistemi diferencialnih enačb. Naučen model lahko uporabimo za simulacijo delovanja naprav, napovedovanje bodočega obnašanja naprav, napovedovanje okvar naprav itd.
Poleg analize časovnih vrst lahko za analizo delovanja naprav uporabimo tudi gručenje. Gručenje se uporabi za določitev skupin naprav, ki se podobno obnašajo, kljub temu, da so zelo različne med seboj. Na primer, podobno obnašanje lahko pričakujemo od večine naprav z grelci. Zato se pri analizi obnašanja naprave upošteva tudi znanje o napravah v skupini, kateri opazovana naprava pripada.
Metode strojnega učenja so opisane npr. v [2], [7], [10] in [3]. Primeri uporabe metod strojnega učenja za preverjanje pravilnosti delovanja naprav in napovedovanja bodočih rokov kalibracij so opisani v člankih [6], [8], [5] in [9].

3.2 Projekti na področju kalibracije naprav

Številni mednarodni projekti delujejo in so delovali na področju analize delovanja naprav, napovedovanja odstopanja od pravilnega delovanja in napovedovanja odpovedi naprav. Primeri mednarodnih projektov so:
Intelligent Monitoring System based on Acoustic Emissions Sensing for Plant Condition Monitoring and Preventative Maintenance (tip projekta: EU FP7-SME). V projektu uporabljajo podatke iz brezžičnih senzorjev za ugotavljanje dejanskega stanja naprav in napovedovanje potreb po vzdrževanju.
Predictive Maintenance System for Industrial Machinery based on Induction Motor Current Analysis, Wireless and Self-Power Technologies (tip projekta: EU FP6-SME). V projektu razširjajo nadzor na dele industrijskih sistemov, ki trenutno še niso nadzorovani. Za to uporabljajo nizkocenovno brezžično tehnologijo. Cilj nazorovanja je napovedovanje potreb po vzdrževanju.
Sustainable Predictive Maintenance for Manufacturing Equipment (tip projekta: EU FP7-NMP). Cilji projekta so razvoj novih orodij za procesiranje podatkov iz senzorjev na napravah, napovedovanje potreb po vzdrževanju, učenje vzorcev obnašanja ob odpovedi naprav, delovanje teh orodij v realnem času itd.
Predictive Integrated System for the Maintenance of a Rotating Machinery Prisma (tip projekta: EU BRITE/EURAM 1). V projektu so nadzirali delovanje opazovanega sistema in ugotavljali tipe odpovedi le-tega. Pridobljeno znanje so uporabili za napovedovanje bodočih odpovedi sistema.
Modelling of Induction Machines for Monitoring and Diagnostics (tip projekta: EU FP4-TMR). Cilj projekta je razvoj modela motorja za namene nadzorovanja in analize delovanja motorja, simuliranja odpovedi in časovne analize podatkov ob odpovedi.

3.3 Nadgradnja obstoječih sistemov z inteligentnimi metodami

Obstoječi sistemi za kalibracijo naprav shranjujejo relativno malo podatkov o napravah. Na primer, kalibracije se izvajajo do nekajkrat na leto. V vmesnem času med dvema kalibracijama sistemi nimajo nobenih podatkov o delovanju naprav. Količina podatkov o delovanju naprav je zato relativno majhna. To dejstvo pogojuje izbiro inteligentnih metod za napovedovanje bodočih kalibracij. Mnogo inteligentnih metod namreč potrebuje veliko podatkov o

preteklem delovanju naprav, da zgradi model delovanja naprav ter napove bodoče delovanje in potrebe po kalibracijah.

Poleg tega ob prvih nekaj kalibracijah naprave sistemi še nimajo dovolj podatkov, da bi kakovostno ocenili bodoče delovanje naprav in bodoče roke kalibracij. V tem primeru je potrebno upoštevati metapodatke o napravah, na podlagi katerih se določi referenčni model delovanja naprav. Model se nato uporabi pri napovedovanju bodočih rokov kalibracij. Obstoječi sistemi ponavadi shranjujejo le manjšo podmnožico metapodatkov o napravah. Za uspešno napovedovanje bodočih rokov kalibracij je potrebno shranjevati tudi ostale metapodatke o napravah. Seznam metapodatkov, ki jih je treba shranjevati, je odvisen od izbrane inteligentne metode za napovedovanje rokov kalibracij.

Napovedovanje rokov kalibracij se lahko uporabi tudi za grafični prikaz bodočega delovanja naprave. Na podlagi jasnega in razumljivega grafičnega prikaza bodočega delovanja bi se lahko uporabniki, predvsem naročniki kalibracij, sami odločili, kdaj bodo kalibrirali naprave. Prikaz bi lahko vseboval tudi finančno analizo bodočega delovanja in kalibriranja naprav. Takšen prikaz bi lahko doprinesel bistveno dodano vrednost obstoječim sistemom za kalibracijo naprav.

4 ZAKLJUČEK

Prispevek vsebuje opis podatkov, ki se shranjujejo v obstoječih sistemih za kalibracijo naprav. Poleg tega vsebuje tudi opis inteligentnih metod in mednarodnih projektov, ki se uporabljajo/delujejo na področju napovedovanja bodočega delovanja naprav ter napovedovanja odpovedi naprav in bodočih rokov kalibracije. Prispevek se zaključi z opisom možnosti vključitve inteligentih metod za napovedovanje rokov kalibracij naprav v obstoječe sisteme za kalibracijo naprav.

V bodoče bomo implementirali metode za napovedovanje rokov kalibracije. Poleg tega bomo zasnovali in implementirali jasen in razumljiv grafični prikaz bodočega delovanja naprav na podlagi obstoječih podatkov in dodatnih metapodatkov o napravah.

Zahvala

To delo je nastalo v okviru projekta "Industrijske raziskave na področju inteligentnih metod za napovedovanje rokov kalibracije", ki so ga na osnovi izbora na Javnem razpisu raziskovalni vavčer 2012 sofinancirali Republika Slovenija, Ministrstvo za izobraževanje, znanost in šport, Evropska unija, Evropski sklad za regionalni razvoj, in LOTRIČ Meroslovje d.o.o.

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AN OVERVIEW OF MULTIAGENT PLATFORMS

Ondřej Fikar[1], Boštjan Kaluža[2], Matjaž Gams[2]
Czech Technical University - Faculty of Electrical Engineering[1]
Institut Jožef Stefan - Intelligent Systems Department[2]
email: fikar.ondrej@gmail.com, {bostjan.kaluza, matjaz.gams}@ijs.si

ABSTRACT

Multiagent system are gaining importance in design of complex, decentralized and autonomous systems. This paper provides an overview of major multiagent platforms, focusing on communication ability of the frameworks and ability to build hierarchical structures.

1 INTRODUCTION

Multiagent systems are of a great importance both in the artificial intelligence and the software engineering fields. During the time, frameworks for building such systems emerged to reduce an overhead of researchers and engineers. They are able to model autonomy, local views, decentralization, self-organization and self-steering. As such, they have been used e.g. for optimization, distributed computation, control engineering and modeling of various systems ranging from crowds to markets to disaster response. The goal of this paper is to study, which multiagent framework can be used as an underpinning pillar in a smart city platform for connecting urban subsystems. The platform is required to support existing autonomous subsystems, asynchronous communication, hierarchical structure, self-organization, mixed-reality and simulation.

This paper hence provides an overview of four major multiagent frameworks: JADE, Jadex, OSGi[1] and Repast Simphony. Each of the frameworks was made for a different reason and therefore has different strong points. We try to provide a general overview of these strengths, but also the abovementioned platform requirements.

The rest of the paper is organized as follows: Section 2 reviews surveys on similar topic. Section 3 discusses the selected frameworks in detail. Subsection 3.5 briefly mentions others interesting projects. Section 4 concludes the paper with discussion and conclusions.

2 RELATED WORK

To our knowledge, there are not many surveys evaluating different multiagent platforms. Bordini et al. [10] provide a survey of several multiagent platforms including JADE. Apart from the general programming languages frameworks, they also included specialized multiagent programming languages and development environments. The discussed projects were chosen regarding to the extent to which European researchers contributed to them.

Railsback et al. [26] reviewed agent based simulation platforms. This paper focuses on simulation, especially from point of view of a scientist lacking the software expertise. Among the others, it covers NetLogo and Repast. To compare the platforms, the authors implemented several example models in every platform and they taught the platforms to mathematics and ecology students. Besides that, the authors give recommendations for the future development of the multiagent software.

Arunachalam et al. [7] studied multiagent tools with focus on environment and agent-environment interaction. For the purpose of comparison they implemented social simulation model and executed it on platforms as Mason and Repast.

Serenko at al. [27] downloaded and trial used 20 agent toolkits and evaluated online questionnaires in order to provide general comparison of the toolkits, and to find the toolkits suitable for education.

Usually, the papers focus entirely on tools for instrumenting intelligent multiagent systems or on tools for agent-based simulation. In this paper, we try to provide a broader view and include both categories of agent-based frameworks.

3 FRAMEWORKS OVERVIEW

This section first describes four selected multiagent frameworks, namely JADE, Jadex, OSGi and Repast, and then briefly mentions other interesting projects, especially the works, which try to combine the discussed frameworks. Table 1 summarizes the framework properties.

3.1 JADE

JADE (Java Agent DEvelopment Framework) [2] is a middleware written in Java, which aims to make development of multiagent systems easier. Its basic features include the agent lifecycle management and provision of message encoding and transport mechanisms, which are fully compliant with FIPA standards [8]. It is a free software distributed under the terms of LGPL license.

The framework is built upon the peer-to-peer paradigm and allows agents to communicate and negotiate directly [8]. Every agent runs in a separate thread and possess a separate message queue [2]. The agents are designed to be autonomous and pro-active, which means they not only react to the incoming messages and actions, but they are also able to initialize such actions. The communication between agents is asynchronous,

[1] Strictly speaking, OSGi is not a multiagent framework but it can be used to add multiagent-like features to a software.

so there are only few constraint for the reaction time to the incoming messages. Agents can react at the time, which is most suitable for them or even not react at all [8]. JADE also provides mechanisms to structure complex tasks by grouping simple actions to behaviors and allows agents to schedule cooperative behaviors [2].

The framework provides tools to build ontologies and share them between agents, while it is also possible to import ontologies created within other tools such as Protege [13].

The system can be distributed between several machines and the agents can even move from machine to another during the operation. Apart from FIPA compliant messages JADE can also transmit serialized Java objects [2]. Security features are provided to avoid abuse of these abilities. For example, an application can verify the identity of the message sender and the messages may be encrypted [9].

The framework comprises a set of graphical tools for debugging and agent management to make it easier to use. The whole framework is designed with a "pay as you go" philosophy in mind. This means that the user is not forced to use features she does not need at the time and can add them to her instantiated program application gradually. This makes the adoption of the framework easier for newcomers [8].

3.2 Jadex

Historically, Jadex started as an extension of JADE [11]. The most recent Jadex implementation uses its own platform as an underlying mechanism. But the higher level Jadex functionality, such as BDI, does not depend on the underlying technology therefore, JADE or even a different platform may be still used [24].

Jadex is based on *service component architecture* (SCA), which is a model following *service oriented architecture* principle (SOA) and makes use of an actor model [3]. This basically means that the application built with Jadex is a set of interconnected loosely coupled services.

A service is a piece of a software, which provides a well defined and self-contained functionality. It is regarded as a black box by other services and potentially even by the application designer. Services communicate by sending messages, which can be transferred by various mechanisms, especially on a network. The services may be discovered dynamically and used on demand [29]. This architecture resemble the object-oriented model, but on a different scale. The services are executed asynchronously by default [3].

SOA allows decomposition of complex software systems to smaller well, manageable pieces. In Jadex, it is possible to create composite components by grouping components together, which leads to a hierarchical architecture [12]. The form of the service can range from purely reactive to autonomous agent performing complex behavior. For the later, Jadex provides built-in belief-desire-intention (BDI) ability [3].

The running application can be reconfigured dynamically. Services may be started, terminated or swapped. Jadex can even download a Maven artifact[2] automatically and start a component from it [3].

Simulations are also supported in Jadex. It is designed to be simulation transparent, which means the running application can not distinguish whether it is part of the simulation or whether it is running in the real world settings. This allows easy deployment of the application from test to production environment [3]. Moreover, there is an environment model called EnvSupport for simulating 2D/3D extending Jadex multiagent simulation capabilities [3].

3.3 OSGi

OSGi – The Dynamic Module System for Java – is a specification for a service platform, which allows to build modular dynamic software from in house or off the shelf components [5].

This means OSGi is not a multiagent system framework in the usual meaning of the term. But it can give some capabilities of such systems to the software incorporating it, which in many cases may be sufficient solution with lower overhead.

A component in OSGi framework is called bundle. Bundle provides services to other bundles and once running it may also perform a behavior on its own. The services are described by Java interfaces. When a bundle wants to use a service, it requests the framework for an object implementing the given interface. The returned objects are used as regular Java objects, except they should not stored for a long time [5, 17].

Internally, bundle is a JAR file. The JAR must contain bundle manifest, interfaces of the provided services, classes, which implements them, and other classes, which are used by framework to make the bundle work as a part of the application. The bundle manifest is a text file, which contains information about the bundle including the list of provided services [17].

Bundles may be installed, started, stopped and uninstalled dynamically as they are needed by the application. This makes it possible to add new functionality to a running application or update bundles on the fly. For example, it may reflect the situation that the application is connected to a physical device. The service representing the device change its availability in the same way the physical device does [5].

Also with OSGi it is easier to solve dependency problems, because the system allows to have a different versions of the same library at the same time in one application. This is possible because the library is encapsulated in a bundle [5].

There exist many implementations of the OSGi standard. At the time of writing seven of these implementations are officially certified by OSGi alliance. The full list may be reviewed in [5]. As an example, we mention Eclipse Equinox, which is an OSGi implementation used by Eclipse IDE and Apache Felix Framework.

3.4 Repast Simphony

Repast stands for the Recursive Porous Agent Simulation Toolkit [6]. Unlike the other listed frameworks, Repast main goal is modeling and simulation. It was originally written to be used for social science research, but it could be used for any kind of agent simulation. It is inspired by the framework Swarm. Repast Simphony is distributed under the terms of BSD license [6, 21].

[2] Apache Maven is a software project tool for managing builds, reporting and documentation (http://maven.apache.org/).

	JADE	Jadex	OSGi	Repast
Communication	FIPA	method call (assynchronous possible)	method call (assynchronous possible)	method call
Ontologies	yes	yes	no	no
Distributed	yes	yes	yes	possible
Hierarchical structure	no	yes	no	yes
Simulation tools	no	yes	no	yes
BDI support	no	yes	no (or Self-OSGi)	no
Dynamic reconfiguration	yes	yes	yes	limited
Open source	yes	yes	available	yes
License	LGPL	LGPL (closed source license possible)	various	BSD

Table 1: *Summary of the frameworks features. Absence of some feature does not mean the framework can not be used for that purpose, but an extra effort will be probably necessary.*

There are three versions of Repast. RepastJ is implemented in Java, Repast.NET is implemented in Microsoft .NET and RepastPy is a RAD Python scripting tool. Models may be also written in ReLogo, which is language inspired by NetLogo and based on Groovy, and a graphical editor may be used [21, 22].

Repast Simphony is re-implemented successor of the Repast 3. The new implementation was written in modular, easy to extend architecture and strong separation of layers, e.g. model from visualization in mind [21].

The core of the framework provides basic simulation functions, such as discrete scheduler, behavior activation, random number generation etc. The other modules then add extensive logging and graphing abilities, the functions connected with social systems, network simulations, genetic algorithms, game theory, GIS, system dynamics and others. There is also a built-in support for various environments for the agents, e.g. 2D discrete and continuous grids, spheres and tori, 3D environments and even networks [21, 22].

The layer separation makes the simulation itself independent of the visualization. Different visualizations may be used for the same simulation regarding to the actual needs of the user. It is even possible to employ more of them at the same time [21].

Repast is able to checkpoint or serialize a simulation, stop it, and resume it later. The parameters could be exported to and imported from XML or table format. This makes it easy to change the parameters during the simulation. Also, the simulations could be ran automatically in a batch mode with an automatic parameter settings. The 3rd party tools (e.g. R or Weka) can be used to process the data [21].

Eclipse was chosen as the main Repast IDE. A set of plugins for Eclipse is provided to make development, execution and debugging of the simulations easier. It also allows to prepare self-contained installers for the simulation models [21].

Repast agents may be nested into named containers. These containers can contain any type of Java object in particular agents and other containers. This allows to create hierarchical structures, which means that the model component present in a container is also present in every parent containers [21]. As an example of Repast application we mention simulation of cities described in [20].

3.5 Other frameworks

There are many other frameworks and for more exhaustive list we refer reader to [10, 15, 26, 27]. Here we briefly mention three other frameworks we consider promising for the future investigation.

Mason is multiagent simulation platform written in Java. It is lightweight and fast. It provides visualization ability independent of the model itself and models, which are self contained and portable [18, 23].

JRep is a project, which combines abilities of JADE and Repast by providing intermediate level between the JADE and Repast classes [16].

Self-OSGi is a framework, which brings BDI ability and the notion of *self* (configuring, optimizing, healing etc.) into OSGi component and service model [14].

At this point, we would also like to mention that there was work done to combine JADE and OSGi. More precisely to make JADE available as an OSGi bundle and to allow JADE agents to utilize OSGi services [25].

4 DISCUSSION AND CONCLUSION

We have discussed frameworks for multiagent systems. The list is by no means exhaustive. There are many multiagent frameworks, which are developed today and new frameworks come to existence, while some old are being abandoned. The frameworks we mentioned here were chosen because they are interesting for smart city platform and they were given a high credit in a research community [7, 10, 15, 26, 27].

Obviously, there is no clear winner and we can not recommend one framework, which would fit all the needs. If the agent communication is of high interest we, recommend JADE or Jadex, regarding to the task complexity the agents should perform. If the simulation and visualization is the main concern, we recommend Repast. OSGi might provide functionality similar to agents in projects, which could take advantage of this approach, but are not really of a multiagent nature.

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SIGHTSEEING ROUTE PLANNING

Hristijan Gjoreski, Božidara Cvetković, Boštjan Kaluža, Mitja Luštrek
Department of Intelligent Systems, Jožef Stefan Institute,
Jožef Stefan International Postgraduate School,
e-mail: {hristijan.gjoreski, boza.cvetkovic, bostjan.kaluza, mitja.lustrek}@ijs.si

ABSTRACT

Route planning is a challenging task because it is a combination of theoretically well-defined computational problems on one side, and everyday-life decisions and constraints on the other side. This paper presents an approach to sightseeing route planning using theory of computation. In particular, in this paper we discuss the combination of two well-known computational problems: knapsack and travelling salesman, and their practical implementation in everyday life task – route planning. The algorithms are adapted in such way that they find near optimal solution with minimum delay, almost in real-time. The final result of the algorithms is a suggested list of tourist attractions ordered by their location and attractiveness.

1 INTRODUCTION

Tourism is very important branch for the economy of a country. Its impact is not only economic, it also promotes a country abroad and raises the awareness of our cultural and natural heritage at home. In order to improve the tourism branch in a country, tourists need information on the places of visit delivered in an efficient and attractive fashion. This is often a difficult task, since such information is scattered across various publications and websites. One of the main objectives of the e-Turist project [3] is collecting all the useful touristic information in one place and extracting useful touristic information in order to help the tourists to plan their trip. This information is presented using web and smartphone applications and mainly consists of recommendations of tourist attractions and suggestions of near optimal routes in order to visit all the selected tourist attractions in the time frame available.

This paper presents an approach to sightseeing route planning, which is a key component in the e-Turist project. Route planning in general is a challenging task because it is a combination of theoretically well-defined computational problems on one side, and everyday-life decisions and constraints on the other side. In particular, in this paper we discuss two well-known problems: knapsack problem and travelling salesman problem, and their practical implementation in everyday life task – route planning.

2 PROBLEM DESCRIPTION

The problem discussed in this paper addresses the question: "How to plan your sightseeing route, once you have a list of tourist attractions?". In other words, our solution tries to find the near optimal sightseeing route, given the points of interest and the time available for sightseeing.

To explain the basic concept, let us consider the following example, shown in Figure 1. Each of the small boxes represents a point of interest (POI). Additionally, each POI has two features: a fixed visit time duration (the average time a tourist spends at the POI) marked with W_i, and an POI evaluation mark (a number from 1 to 5), representing the attractiveness of the POI) marked with V_i. On the other hand, there is a tourist, who is limited by time, W_{max}, and has only 7 hours for sightseeing. The problem here is how to find the best route (combination of POIs) given the tourist's time limit and the list of the POIs.

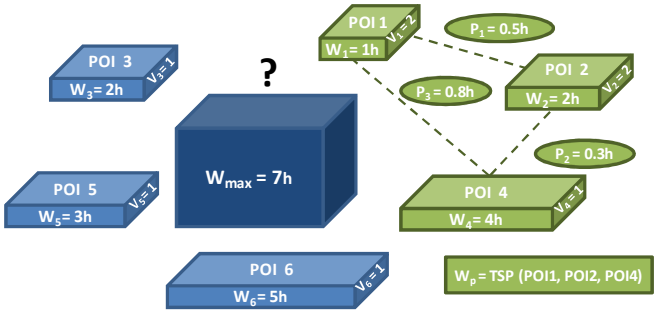


Figure 1: Modified knapsack problem.

Current description of the problem reminds of the known knapsack problem [5], with the following parameters: weight – POI visit duration (W_i), and a value – POI evaluation (V_i). The tourist's time limit is the maximum weight that the knapsack can hold (W_{max}). The optimal solution for the example shown in Figure 1 is marked with green color; POI number: 1, 2 and 4. It has a total value of 5 ($V_1 + V_2 + V_4$) and total weight of 7 hours ($W_{total} = W_1 + W_2 + W_4$), which is also the maximum time that the tourist has for his/hers sightseeing route. With this definition, the problem can be solved in a pseudo-polynomial time with dynamic programming [2]. However, this definition does not include the path duration (duration needed to visit all the POIs). In the example shown in Figure 1, that is the path duration to visit POI 1, POI 2 and POI 4. If we assume that

the path duration is symmetric (the same duration stands for POI1→POI2 and PO2→POI1), there are three different path combinations:

- POI1→POI2→POI4
- POI1→POI4→POI2
- POI2→POI1→POI4

It is easy to check that the best (minimum duration) path is POI1→POI2→POI4, which lasts for 0.7 hours ($W_p = P_1 + P_2$). If this path duration is added to the previous total time (W_{total}) the new total weight is 7.7 hours which is more than the tourist's maximum time of 7 hours (W_{max}). Therefore, this solution should be discarded.

The path duration estimation problem opens a new sub-problem inside the knapsack problem, i.e., how to find the path route with minimum duration, given the POIs. This sub-problem is also a known problem in the theory of computation, called travelling salesman problem (TSP) [7]. In the following sections our proposed solution is explained and the final implementation is presented.

3 ALGORITHM

As described in the previous section, we try to find a solution to a knapsack problem, where the weight value changes dynamically (with each algorithm iteration) and it depends on the "boxes" (POIs) chosen. Additionally, the path estimation is computationally expensive process, because it requires solving an NP-hard problem, i.e., TSP. Moreover, the final algorithm execution time should be in the range of several seconds, because it will be used in a real-time POI recommendation application, where the user needs instant feedback from the system. Because of these reasons, several simplifications were proposed: greedy approach for knapsack problem (POIs ordered by value), adapted TSP for path duration estimation (finds near optimal solution).

The first step in our algorithm is the estimation of the importance of a POI (how good a POI is – POI value). For this reason we created a special mathematical definition that considers three factors:

(1) POI's evaluation value
(2) POI's visit duration
(3) POI's local reachability duration

The first factor is a value that varies from 1 to 5 and it represents rough estimation of how interesting a POI is, based on several aspects: the attractiveness, sustainability, visit price, etc. The next factor, the POI's visit duration, represents the average time that a tourist needs in order to see the POI. This is also hardcoded by a domain expert. The final factor, the POI's reachability duration, is a variable that represents how far a POI is from its nearest neighbors. In other words, if a POI is far from the rest of the POIs, the value for this variable would be greater compared to the reachability duration of the rest POIs. Using this information the POIs that are "outliers" (far from the rest of the POIs) are "punished". For the estimation of this variable we used partial implementation of the Local Outlier Detection (LOF) algorithm [1]. In particular, we used the local reachability distance (*lrd*) metric in order to estimate how far a POI is from its neighbors. The LOF algorithm and its mathematical definitions are described by Breunig et al. in their paper, which is also provided in the reference list.

The mathematical definition of the POI importance, which includes all the three factors, is given below.

$$V^* = \alpha * V + (1 - \alpha) * (1 - P^*_{\text{norm}}) * V \quad (1)$$

The variable V is the POI's evaluation value, which varies from 1 to 5. The variable P^*_{norm}, represents the normalized value (from 0 to 1) of the P^*, which is a sum of the POI's visit duration (*Vd*) and the POI's local reachability distance (*lrd*):

$$P^* = Vd + lrd \quad (2)$$

Because the idea is to "punish" the POIs which visit lasts longer and the ones that are far away, the normalized P^* is subtracted from 1. The bigger the value of P^*_{norm} is, the less important the POI is. The α is a parameter regulating the importance of the evaluation value (V) on one side, and the POI's visit duration and POI's local reachability distance (P^*) on the other side. The empirical analysis of the data showed that 0.5 is a reasonable tradeoff value for α. This way, both sides of the equation are equally weighted in the final importance value – V^*.

To summarize, a part of the value V (the fraction alpha) is considered as it is, while the rest (the fraction 1 - alpha) is reduced by the factor corresponding to the time needed for the visit (1 - P^*_{norm}).

In the next step of the algorithm, all the POIs are ordered by the importance value, i.e., V^*. Next, using a greedy strategy, the algorithm adds items (POIs) in the knapsack until the limit is reached. With each POI added, the weight of the knapsack is checked – if the weight (time duration) of the chosen POI combination is below the maximum weight (total available time of the tourist). In addition with each added POI, a TSP algorithm estimates the path duration, which is also checked with the time limit of the tourist. This way, a near optimal combination of POIs is found.

Once the combination of POIs is found, in the next step it is checked if the user prefers to start from the nearest POI. If this is the case, the order of the POIs is recalculated with a modified version of the original TSP which creates a path using a fixed start POI.

In the final step of the algorithm, it is checked if the tourist has chosen multiple days for sightseeing. In the case of multiple-days visit, the POIs are segmented into groups, each group corresponding to one day of the trip. Additionally, it is checked if the user plans a meal in a particular hour of the day. If this is the case and there are restaurant-POIs in the list of POIs, the best (according to the evaluation value) restaurant is chosen. That day's route

is modified in such a way that the tourist is near the restaurant during the previously chosen meal-time.

3.1 Travelling Salesman Problem

In this section the TSP solution algorithm is discussed. As mentioned earlier, the TSP solves a sub-problem in the general knapsack problem. Therefore, its execution time needed to be in the range of several milliseconds. Because the TSP is a NP-hard problem, finding an optimal solution sometimes may be very difficult and computationally expensive. Therefore, for its implementation, we considered an open source algorithm [8], which finds a near optimal solution. It is a greedy approach with additional optimization mechanism. The empirical tests showed that for our scenario (up to 200 POIs) it almost always finds the optimal solution, and also the execution time is acceptable i.e., several milliseconds.

The original algorithm implementation does not take into account a start and end POI. It just connects POIs until a complete path connecting all the POIs is completed. However, in our implementation in some cases, fixed start and end POIs were needed. For this reason two modified versions of the original algorithm were implemented. The first one considers only a start POI and finds the appropriate path using the start POI constraint. This implementation is used in the case the tourist wants to start the sightseeing in the nearest POI. The nearest POI is calculated using the GPS signal of the tourist's smartphone. The second modified version considers not only the start POI, but also the end POI. This version is used in the case of a selected meal-time. In this case the path is divided into two parts: before and after lunch. In the first part the end POI is fixed, which is the restaurant. In the second part, the start POI is fixed, again the restaurant POI.

3.2 Algorithm Implementation Optimizations

Once the algorithms were implemented and the number of POIs increased in the range of a 100, few time-related problems emerged.

The first problem was related to the computation of the distance and duration between each of the POIs. To accurately compute the distance and the duration between the POIs, we used the Google maps distance matrix API [5]. Because the API calls are limited, we decided to save the distances into a database. An update of the distances is triggered only when new POI is entered into the database. However, the problem with too many database calls still existed. For each TSP execution, a new distance matrix was computed and therefore too many database calls were executed. That means if 20 POIs are analyzed, then the matrix has size of 20 x 20, which results in 400 database calls. To speed up this process, we decide to save a matrix that contains all the POIs distances into the RAM memory. This way, every time a distance is required, the result is taken out of RAM instead of calling a database. This solution, significantly decreased the time execution.

The second problem that appeared was related to the calls to the TSP algorithm. As mentioned earlier, the TSP problem is NP-hard and thus its execution is computationally expensive process. Therefore, we had to limit the calls to this algorithm. In our first implementation, the TSP was called every time a new POI was added to the solution list. This resulted into too many calls, especially when the number of POIs increased up to 100. Therefore, a solution that limits the calls to the TSP algorithm was suggested. This solution, calls the TSP algorithm only when the time needed to visit all the POIs reached a predefined threshold of 80% of the total available time. In other words, when the time needed to visit the POIs reaches 80% of the total available time, the TSP is called to estimate the exact path duration. Otherwise, every time a POI is added, the path is estimated simply by adding the path duration to the nearest POI.

4 IMPLEMENTATION

The sightseeing route planning algorithm was implemented in a more general trip planning application – e-Turist [4]. The general idea of this application is to provide a help to tourists which plan to visit Slovenia. The help consists of a POIs recommendation and organization, route planning, etc. An example of a sightseeing route planning is shown in Figure 2. The figure shows a 2-day trip plan with 11 POIs. The POIs are ordered by their location and the order of visiting is marked with consecutive letters from the alphabet. The POIs marked with yellow color are alternative POIs, which were excluded from the final solution because of the user's time-constraints. However, the user can still decide to visit these alternative POIs. Also a time duration estimation is provided for each day. The estimation is based on the POIs visit durations and the path duration time.

5 CONCLUSION

The paper presented an approach to sightseeing route planning. Our task was combining theoretically well-defined computational problems on one side, and everyday-life decisions and constraints on the other side. In particular, in this paper we discussed two well-known problems: knapsack and travelling salesman problem, and their practical implementation in everyday life task – route planning. The algorithms were adapted in such way that they find near optimal solution in with minimum delay, almost in real-time. The final result is a list of tourist attractions ordered by their location and attractiveness.

Acknowledgement

This work was supported by Slovenian ministry of education, science and sport: call for proposals for co-funding of projects developing e-services and mobile applications for public and private non-profit organizations. The authors would like to thank Andrej Tratnik, Vito Janko and Maja Somrak for the help provided in the system implementation and programming part.

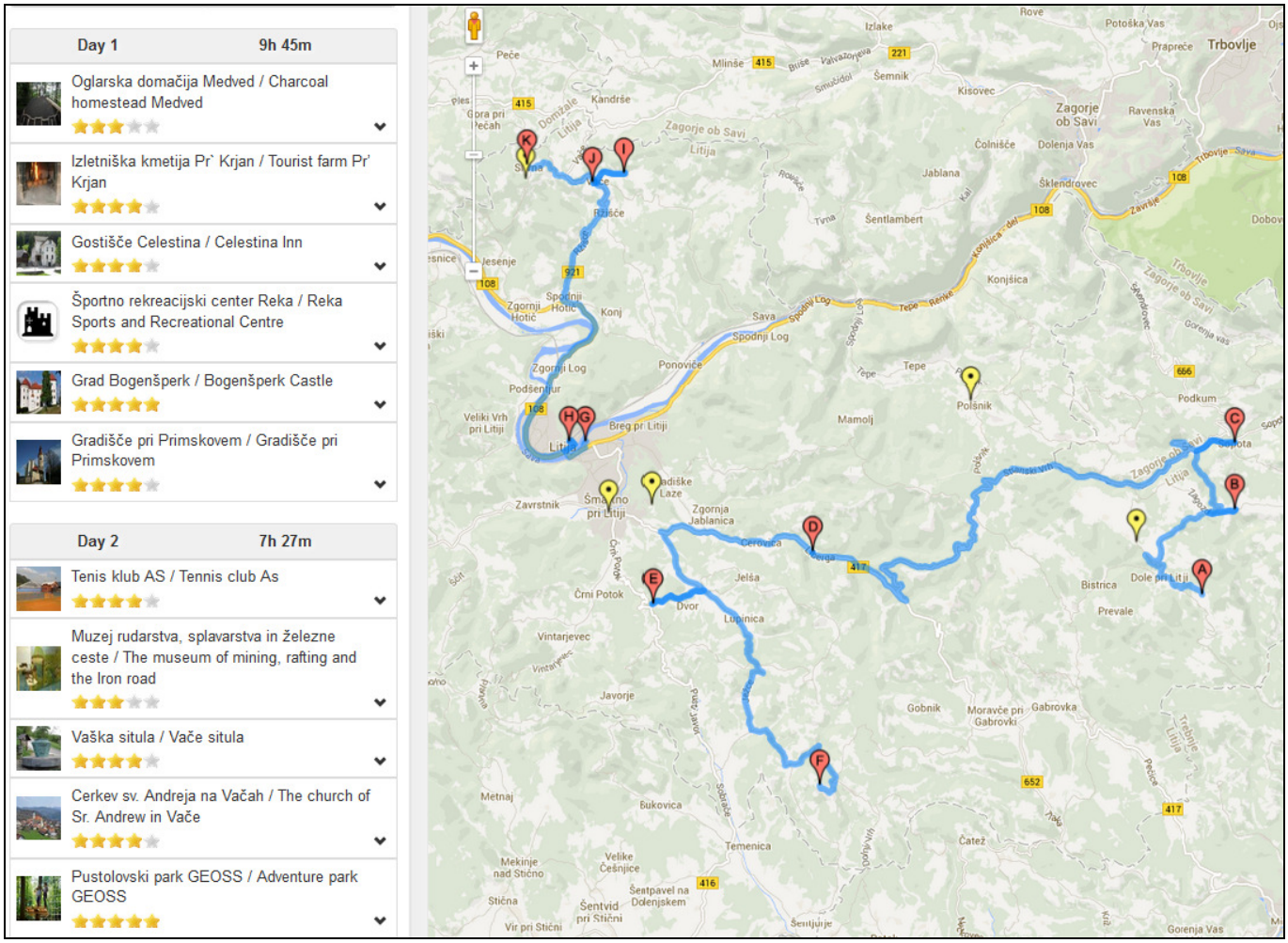


Figure 2: Example of sightseeing suggested route for two-day trip.

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PREDICTING THE ARRIVAL AND THE DEPARTURE TIME OF AN EMPLOYEE

Martin Gjoreski[2], *Hristijan Gjoreski*[1,3], *Rok Piltaver*[1,3], *Matjaž Gams*[1,3]
[1]Department of Intelligent Systems, Jožef Stefan Institute,
[2] Faculty of Computer Science and Engineering - Skopje
[3]Jožef Stefan International Postgraduate School,
e-mail: martin.gjoreski@gmail.com, {hristijan.gjoreski, rok.piltaver, matjaz.gams}@ijs.si

ABSTRACT

The paper presents an approach to predicting the time of arrival and departure to and from work of an employee. The methodology is based on learning a regression model using two types of information: employee's past work-attendance schedule and outside weather conditions. The main hypothesis is that by extraction of relevant attributes from both types of information, an accurate regression model can be learned in order to predict the employee's time of arrival and departure to and from work. Three data processing techniques and nine regression learning algorithms are analyzed. The results show that the learned regression model improves the prediction performance compared to a naive baseline approach. The improvements over the baseline approach are varying from 6% to 50% for the arrival time, and from 2% to 32% for the departure time. The results also show that the prediction performance mainly depends on the regularity of the employee's schedule: the more regular the smaller prediction error is.

1 INTRODUCTION

Energy-efficient households has been a hot topic in recent years. Technological advancements have allowed us to live more comfortable lives, but as a result we consume increased amounts of energy. As past work shows, neither programmable thermostats nor a remote control solve the problem of reducing energy consumption of temperature control systems. As an alternative, we now turn to automated approaches [1]. Many research and commercial attempts were made and it was shown that homes equipped with intelligent devices, that know how to communicate with each other, can sufficiently increase the energy-efficiency. Predicting the arrival and departure time of a person in his/hers home, work-place, etc., is potentially useful in this domain. An intelligent system having this information, can adapt the house or the work-place according to the user's needs before his arrival or departure. For example, if a house is equipped with such smart system, then the accurate prediction of user's arrival can result in preparing the house for the specific user before his/hers arrival. This means, adapting the house according to the user's needs, e.g., adapting the ambient temperature, heating the water, etc.

In this paper, an approach for prediction of a person's arrival and departure time to and from work is described. The main hypothesis is that it is possible to learn a model of user's arrival and departure times, using the past arrival and departure data and weather information. The proposed methodology, uses a machine learning regression algorithms applied on dozens of attributes, which are computed from the user's past work attendance information and weather context information, such as: what is the weather like in the morning, what season is it, what day of the week it is, etc. The approach is tested on the arrival and the departure data of 7 people for approximately 2 years time duration.

2 DATA PREPARATION

Two types of data were used: data from employees work attendance tracking system and data from weather tracking system. The attendance data is provided by the Time and Space system installed at the Institut Jožef Stefan (IJS). This data is voluntarily provided by 7 IJS employees for approximately 2 years. Please note that the employees do not have a fixed working time, thus they are more or less free to come and go based on their own preferences. The meteorological data was taken from the National Meteorological Service of Slovenia, which provides statistics about the weather in Slovenia in the last several decades [2]. The data from these two sources was additionally processed and synchronized on daily basis. This means that for each day for each user, beside the attendance information, the weather data is also available.

3 METHODOLOGY

The methodology is based on employee-specific regression model learning in order to predict the employee's time of arrival and departure. This means that data for each employee is analyzed separately and therefore the model is learned for each employee individually using only the data from that particular employee. The rationale behind this is that each employee has different habits and therefore the model should be able to adapt to the specific employee.

The regression learning algorithms were applied on specially constructed attributes. The attributes are computed using the user's past work attendance information and weather context information. The list of attributes was created after thorough discussions about what may influence a person arrival or departure times. The result is the following 18 attributes:

- day in the week (Monday, Tuesday, etc.),
- month (January, February, etc.),
- sum of actual working hours minus expected working hours for the current month,
- yesterday's arrival time,
- arrival time 7 days ago,
- average arrival time of the last 5 working days,
- average arrival time of 7, 14, 21 and 28 days ago,
- number of days until the next non-working day,
- number of consecutive non-working days after this day,
- number of consecutive non-working days before this day,
- previous day departure time,
- timestamp – enumeration of the instances,
- temperature at 7:00 am,
- wind speed at 7:00 am,
- today's cloud percentage,
- today's precipitation quantity,
- harsh weather (if there is storm or stormy wind or heavy rain or heavy snow than harsh weather = YES, else NO),
- quantity of new fallen snow of yesterday plus today

For predicting the departure time, 20 attributes are calculated. They are similar as the attributes for predicting the arrival time. The difference is that for calculating the attributes time of departure is used instead of the time of arrival. Furthermore two more attributes are added: the time of today's arrival and today's sun duration.

Three different techniques for learning models are tested with several different algorithms. The techniques that are tested are: sliding window techniques, expanding window technique and filtered expanding window.

3.1 Sliding window technique

The first technique that is used for learning regression models is sliding window technique. The word window here is referring to the number of data samples (instances) that are used as a training set for each model. The size of the window is determined empirically. Experiments started with window size of 15 instances and increased up to 80 instances. By increasing the window size the mean absolute error (MAE) was decreasing. After window size of 40 instances there was not much of improvement of the MAE so it was decided that window of 40 instances is reasonable.

3.1.1 Learning a model with sliding window technique

For each employee's dataset, all instances are ordered with respect to the date. The first 40 instances are taken as train instances, a model is learned and tested on the 41st instance. Then the window of instances "slides" for one instance. This means that the instance with oldest date is excluded from the training set and the instance that was used as a test instance in the previous step is included. The new model is tested on the instance that follows the last training instance. This is repeated until the last instance in the complete data set (instance with newest date in the complete data set for one employee) is used as a test instance. After that MAE is calculated for all the test instances.

3.2 Expanding window technique

With the expanding window technique, the starting size of the window is determined empirically. The tests showed that 40 instances is a reasonable staring size of the window.

3.2.1 Learning a model – expanding window technique

This technique is similar to the sliding window technique. At first the instances belonging to a single employee are ordered by the date. For each next model none of the previous instances is excluded from the new training set, just the test instance from the previous step is included. This means the first 40 instances are taken as training instances, a model is learned and tested on the 41st instance. Then the window of train instances "expands" for one more instance. The test instance from the previous step is included in the training set, new model is learned on the expanded training set and tested on the 42nd instance, and so on. This is repeated until the last instance (instance with newest date) from the complete dataset for one employee is used as a test instance. Than MAE is calculated on all test instances.

3.3 Filtered expanding window technique

This technique consists of two phases. In the first phase the data is filtered and in the second phase the model is learned on the filtered data. First, in the filtering phase expanding window technique is used to predict the value of every instance from 41st to the last. If the (*predicted value – true value*) > *threshold* then the instance is removed from the data set. In the learning phase expanding window technique is reapplied on the filtered data. Then MAE is calculated on all test instances.

This technique was implemented because on some days a person can come to work unusually early or late and these days are actually exceptions from person's regular schedule and cause our system to make prediction errors. With the described outlier pre-processing we are excluding those exceptions from the training and testing data set.

3.4 Baseline naive approach

A naive approach to predict the arrival time is to take the mean of the time of coming to work of the previous few days, weeks or months. The same holds for predicting the time of departure from work. This simple approach was used as a baseline for comparison.

4 EXPERIMENTAL SETUP

The experimental dataset consists of data for 7 employees. In the next subsections, the results for each of the both tasks are presented.

4.1 Predicting the arrival time of an employee

The experiments started with the sliding window technique. Regression learning algorithms that were used are: kNN, SVM, Linnear Regression, M5Rules, REPTree, Gaussian Processes, M5P, Bagging and Random Sub-Space Three of them, kNN[3], Gaussian Processes**Error! Reference source not found.** and Random Sub-Space[5], with the smallest MAE were chosen for further experiments with the other two techniques.

4.1.1 Sliding window

The results for the models learned with k-NN, Gaussian Processes (GP) and Random Sub-Space are shown in Figure 1. The MAE value is shown on the y-axis and is represented in minutes. It should be noted that the MAE varies from 10 minutes for employee 2 to 60 minutes for employee 3. The smaller the MAE is, the more regular schedule the employee has. However, the baseline approach has a reasonably good performance, sometimes even better than some of the regression models.

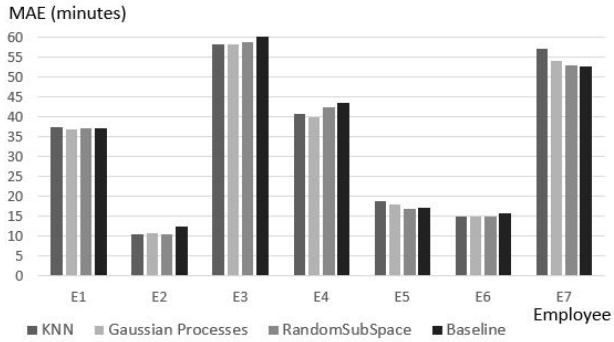


Figure 1: MAE for k-NN, GP, Random Sub-Space and Baseline for the 7 employees- Sliding Window.

Figure 2 shows the results for the models with the three approaches k-NN, Gaussian Processes and Random Sub-Space compared to the baseline approach for each of the 7 employees. Compared to the baseline approach for employees 1 to 4 and employee 6 we have improvement from 1% to 11%. For employees 5 and 7 the baseline approach is better.

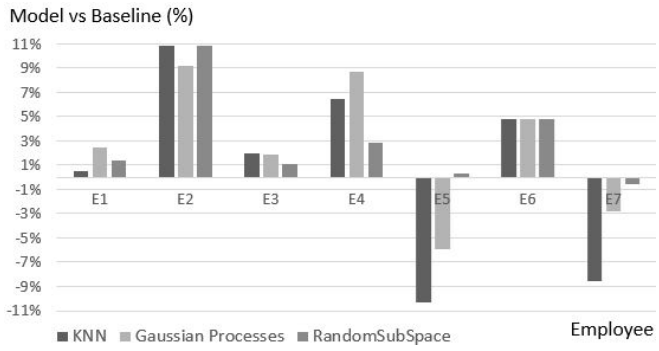


Figure 2: MAE for k-NN, GP and Random Sub-Space compared to Baseline employees- Sliding Window.

4.1.2 Expanding window

The results for the second technique, i.e., expanding window, are shown in Figure 3. The results are shown for the models learned with the three approaches: k-NN, Gaussian Processes and Random Sub-Space compared to the baseline approach for each of the 7 employees.

The results show significant improvement for the prediction performance for employee no 6. Using the sliding window technique, the regression model had the same MAE as the baseline approach (Figure 2.), however, using the expanding window technique the MAE of the regression model is 50% better. Additionally, one can note that for employee no. 6 this approach is quite good, but for employee no. 5 this approach is worse than the baseline approach for 23%. Therefore, further improvements should be proposed.

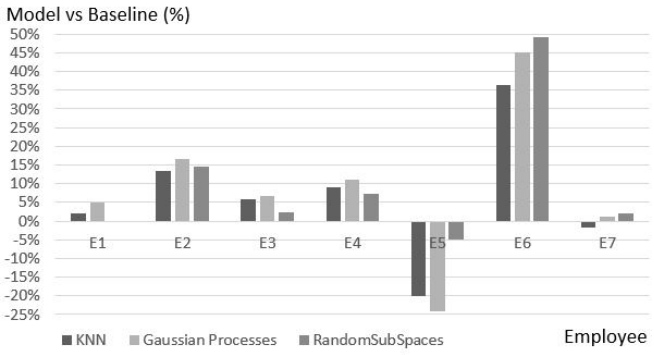


Figure 3: MAE improvement for k-NN, Gaussian Processes and Random Sub-Space compared to Baseline for 7 employees – Expanding Window Technique.

4.1.3 Filtered expanding window

The third tested technique is expanding window technique combined with outlier pre-processing. The results are shown in Figure 4. The results show the improvements in the MAE values with the three approaches k-NN, Gaussian Processes and Random Sub-Space compared to the baseline approach for each of the 7 employees. If we consider the models learned with Gaussian Processes technique we can see that the improvement in the MAE compared to the baseline approach varies from 0% to 50% for different employees.

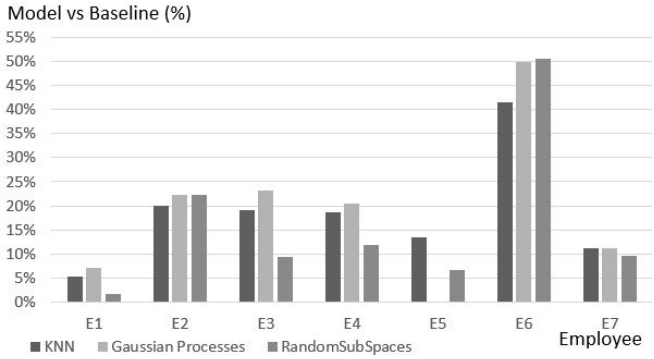


Figure 4: MAE improvement for Knn, Gaussian Processes and Random Sub-Space compared to Baseline for 7 employees – Filtered Expanding Window Technique.

Compared to the other two techniques filtered expanding window technique is the best because each model learned with this technique has a lower MAE than the baseline approach. The only exception of this is the model learned with Gaussian Processes for employee 5 which has the same MAE as the baseline approach. On the other hand if we consider the MAE for the same employee (Figure 1) we can see that it is only 10-15 minutes which means that this employee has a very regular schedule and that is the reason why the baseline approach has low MAE that is difficult to improve.

4.2 Predicting the departure time of an employee

Predicting the arrival time and the departure time of an employee are two problems that are similar in nature. Because of that similar approaches are used. First, models are learned with the sliding window technique, than with the expanding window technique and finally with the filtered expanding window technique. With the first two techniques we tried several different regression learning approaches of which 3 (k-NN, Gaussian Processes and Random Sub-Space) with the smallest MAE were chosen for further experiments. The results are quite similar as with the previous problem (predicting the arrival time). The models learned with the first two techniques have similar or in some cases even worse MAE that the baseline approach.

In Figure 5 we can see the MAE for the models learned with k-NN, Gaussian Processes and Random Sub-Space with sliding window technique. The MAE value is shown on the y-axis and is represented in minutes. We can see that it varies from 40 minutes for employee 2 to 80 minutes for employee 3 and 4. This values are higher than those for MAE for predicting the time of arrival shown in Figure 1. This means that for each employee there is more irregularities in the departure time that in the arrival time.

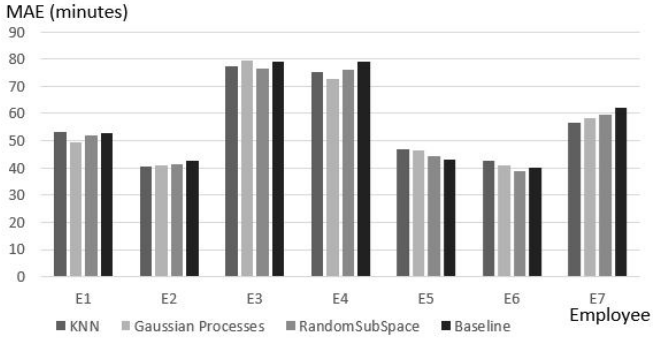


Figure 5: MAE for k-NN, GP, Random Sub-Space and Baseline for the 7 employees - Sliding Window Technique.

For predicting the departure time of an employee the best results are achieved with the filtered expanding window technique. There is an improvement in MAE compared to the baseline approach.

In Figure 6 we can see the results for the models learned with the three approaches k-NN, Gaussian Processes and Random Sub-Space for each of the 7 employees. The only model that is better than the baseline approach for all employee is Random Sub-Space. But if we compare Random Sub-Space with k-NN and Gaussian Processes there are cases where one of the other two models is much better. For example for employee 4 Gaussian Processes is better than Random Sub-Spaces for 80%.

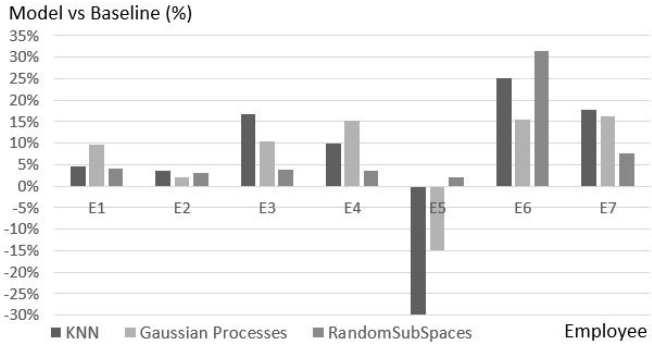


Figure 6: Knn, GP and Random Sub-Space compared to Baseline for 7 employees – Filtered Expanding Window.

5 CONCLUSIONS

The paper presented an approach to predicting the arrival and departure time of an employee. Three techniques for selecting the learning data were implemented and tested. The results showed that the best performing technique is the filtered expanding window technique. Additional analysis for finding the most suitable regression learning algorithms showed that k-NN, Gaussian Processes and Random Sub-Space perform the best according to the MAE value.

The results for the arrival time prediction showed improvements in the MAE values compared to the baseline naïve approach. The improvements vary from 6% to 50% depending on the employee. The results for the departure time prediction also showed improvements and vary from 2% to 32% depending on the employee.

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COMPARISON BETWEEN GAUSSIAN PROCESS REGRESSION AND SUPPORT VECTOR MACHINES REGRESSION

Luka Goljevšček[1], *Juš Kocijan*[2,3]
[1]Jozef Stefan International Postgraduate School, Ljubljana, Slovenia
[2]Jozef Stefan Institute, Ljubljana, Slovenia
[3]University of Nova Gorica, Nova Gorica, Slovenia
e-mail: luka.goljevscek@gen-i.com

ABSTRACT

This paper briefly presents two methods for regression analysis that are frequently met in recent literature dealing with modelling from data. These are Gaussian process models and support vector machines. An illustrative example with one dimensional data set is used to present some differences between models obtained with the used methods.

1. INTRODUCTION

Regression is one of most often used techniques in the continuous and functional data analysis and is present in all science fields.

In this paper two different approaches to regression are briefly presented and compared on a case study. The first regression method is based on Gaussian processes and fitted using Gaussian process regression (GPR) and the second method is based on better known non-Bayesian approach using function space basis and fitted using support vector machines (SVM). The purpose of this paper is only a preliminary investigation on differences between GPR and SVM. More comprehensive comparison can be found in, e.g., [5].

The structure of the paper is as follows. Gaussian process regression is presented in Section 2. Regression with support vector machines is given in Section 3. Section 4 contains an illustrative regression example and comparison between methods based on the example. Conclusions are given in the last section.

2. GAUSSIAN PROCESS REGRESSION

GPR model [2,5] is based on the stochastic process. One can think of Gaussian or any other stochastic process as a generalization of random vector to a random function. The process is Gaussian if any finite sample of values of this "random function" is multivariate normal random variable.

Distribution of the univariate normal random variable is usually presented as $X \sim \mathcal{N}(\mu, \sigma^2)$, where number μ is mean and σ^2 is variance. Similarly for multivariate normal random variable $X = (X_1, \ldots, X_n) \sim \mathcal{N}(\boldsymbol{\mu}, \boldsymbol{\Sigma})$ where vector $\boldsymbol{\mu}$ is mean vector and $\boldsymbol{\Sigma}$ is covariance matrix. Similarly for Gaussian process $G \sim \mathcal{GP}(\mu, \mathbf{K})$, where μ is mean function and $\mathbf{K}$ is the covariance matrix function. Similarly, if Gaussian process is observed in finite and fixed number of points, the Gaussian process values in the observed points are multivariate normal random variable.

The Gaussian process regression model [5] on the data set $\mathcal{D} = \{(\mathbf{x}_i, y_i), i = 1, 2 \ldots, n\}$ is given as $y_i = f(\mathbf{x}_i) + \varepsilon_i$ and $f(\cdot) \sim \mathcal{GP}(\boldsymbol{\mu}(\cdot), \mathbf{K})$ where elements of matrix $\mathbf{K}$ are calculated as covariance function on the elements of the input, also known as design or learning, set $\mathbf{K}_{ij} = k(\mathbf{x}_i, \mathbf{x}_j)$. This model yields a function. This function is average of realizations of the stochastic process.

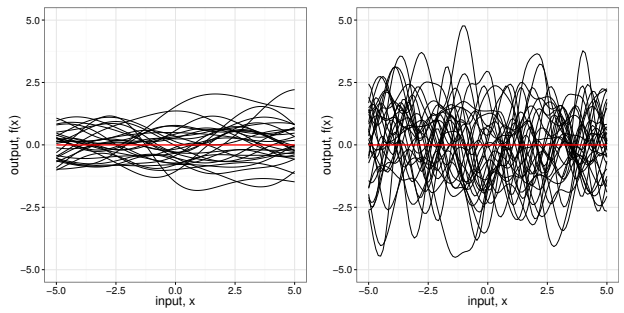
The mean function μ defines the mean value of the process. For instance, if one is doing GPR of August daily average temperatures, then mean function would be constant 22 degrees Celsius based on some historical observations or our best expectations. For theoretical and practical purposes, the mean function is often set to zero ($\mu(x) = 0$). Technically instead of modelling $f \sim \mathcal{GP}(\mu, \mathbf{K})$ one models $f - \mu \sim \mathcal{GP}(0, \mathbf{K})$.

The covariance function k is defining the values in the process covariance matrix function and thus the relation of function values among the points in which the process is observed. Therefore the covariance function must be positive-definite and symmetric function to ensure that matrix $\mathbf{K}$ can be covariance matrix of a Gaussian process.

The most commonly used covariance function is Squared Exponential (SE) covariance [7], defined by

$$k(\mathbf{x}, \mathbf{x}'; m, l) = m \exp(\frac{1}{2l} \|\mathbf{x} - \mathbf{x}'\|^2), \qquad (1)$$

where additional parameters m and l are used to control the magnitude and length-scale of the process. The process realization using SE covariance functions are continuous and differentiable, which is very often the desired property of regression models. The effects of changing m and l are illustrated in the Figure 1.



(a) $m = 0.5$ and $l = 2$ (b) $m = 2$ and $l = 0.5$

Figure 1: Gaussian process realizations using SE covariance. Realizations on the left have smaller magnitude and greater length-scale.

Only our expectations and previously measured data were used and encapsulated into the process mean and covariance function. At this point, any result i.e. will fulfil the expectations, but will yield random function as result, as illustrated in Figure 2.

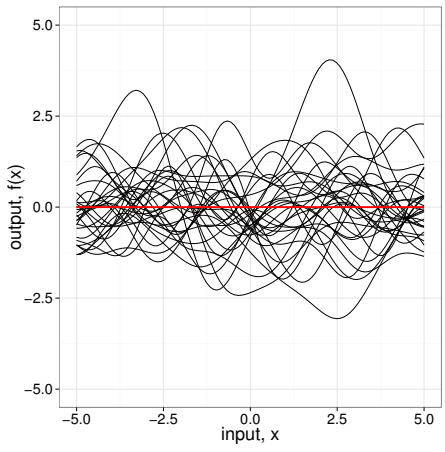


Figure 2: All process realizations have the same mean and covariance function but fulfilling expectations of the observed process

Looking at some new data, process realizations are fitted or updated to those observed values as it is illustrated in Figure 3.

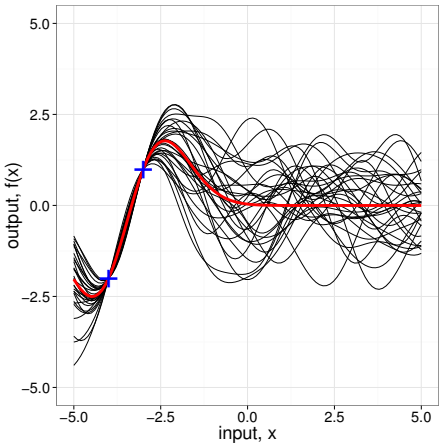


Figure 3: After some data is measured the process realizations are fixed in these points. Measured points are marked by blue plus.

The Bayesian approach to inference is by our experience best illustrated by Figures 2 and 3. In Figure 2, all realizations were done out of the probability distribution that is result of only the expectations of the model. In Figure 3, the probability distribution used for process realizations is more concentrated on the measured data values.

3. REGRESSION USING SUPPORT VECTOR MACHINES

SVM [6, 9] is perhaps more popular and easier to understand, but less intuitive once the Bayesian concept is understood properly. The main idea of non-Bayesian approach can be summarized as: one first defines the function space basis for the functional data that is being modelled and then model is fit to the data $\mathcal{D}$ minimizing loss function. This is also known as weight-space view, while Bayesian approach is known as functional-space view [5].

The linear regression model for dataset $\mathcal{D} = \{(\mathbf{x}_i, y_i), i \in \{1, 2 \ldots, n\}$ is written as $f(\mathbf{x}) = \mathbf{w}^T \mathbf{g}(\mathbf{x})$, simply a linear combination of functional space basis that is formed by collection of functions $\mathbf{g} : X \mapsto \mathbb{R}$.

Since relation among data is often non-linear, kernel methods became popular as opposite to non-linear models that did not work very well [6, 8]. The main idea is that one can define abstract distance among data instances and use already well established approaches, e.g. linear models, algorithms, that model non-linear relationship using kernel transformations. This approach results in very similar model $f(\mathbf{x}) = \mathbf{w}^T \phi(\mathbf{x})$, however the map ϕ is abstract and the model is not used, nor evaluated, in this form. The kernel trick [6] and Reproducing Kernel Hilbert Space expansion [1] rather yield model in form $f(\cdot) = \sum \boldsymbol{\alpha}_i \kappa(\cdot, \mathbf{x}_i)$, where κ is the kernel

function. More detail on this can be found in [1,6,8].

In case of SVM, very popular kernel function is Gaussian kernel, known also as radial basis kernel or radial basis function (RBF), Equation (2) which is similar to SE covariance function.

$$\kappa(\mathbf{x}_i, \mathbf{x}_j) = exp(-\sigma\|\mathbf{x}_i - \mathbf{x}_j\|^2) \quad (2)$$

Figure 4 probably best illustrates the main concepts of how SVM regression is done using ε-insensitive loss function, avoiding most mathematical details.

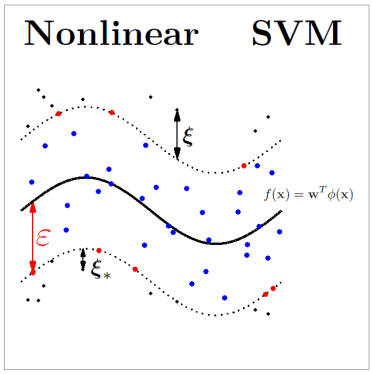


Figure 4: The main idea is to find a function that is as flat as possible and minimizes the sum of ξ and ξ_*

The interesting thing from GP point of view is the similarity of requirements of kernel function and kernel matrix of SVM to covariance function and covariance matrix of GP model and the fact, that both are evaluated only on the pairs of instances of the learning set and later against new instances of data.

4. ILLUSTRATIVE EXAMPLE

4.1. Example of GPR Using SE Covariance

To illustrate how GPR is used, model of average daily temperatures is built as an example of GPR model in practice. The model assumptions are:

- Temperature is continuous function of time
- Daily temperature is not very likely to move more than 5 degrees from average
- length-scale is not too short.

Based on these assumptions, model is set with mean function $\mu = 0$ and SE covariance with parameters $m = 10$, $l = 12$ to fulfil other expectations - but no data is used yet. Result of such model is function $f = 0$. The model is updated with historical temperature data, but hyperparameters are in our case not optimised or changed from prior values. This is illustrated in Figure 5. The gray area are individual process realizations. They are all equally likely and give good estimation of the quality of the model.

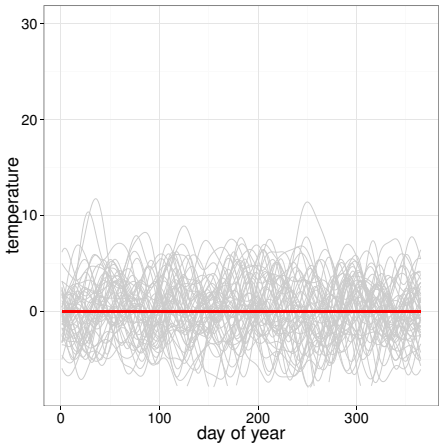
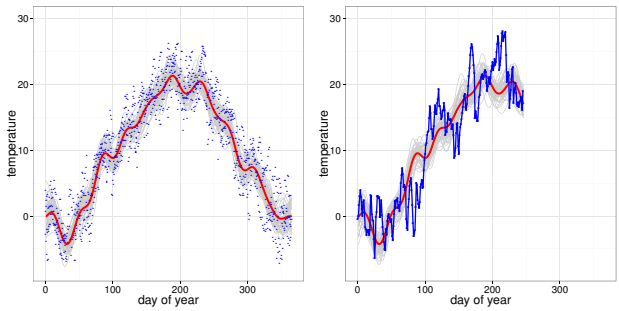


Figure 5: Assumptions about the daily average temperature model: a process with zero mean and SE covariance parameters are $m = 10$ and $l = 12$

The data used to update model is historical daily temperatures from years 2010 to 2012 in Slovenia. To test the model result, available data from 2013 is used. Model results and actual data for 2013 are shown in Figure 6. The model is not really good, but also temperatures in 2013 were not very similar to the corresponding historical ones.



(a) Model is updated using historical data (blue dots).

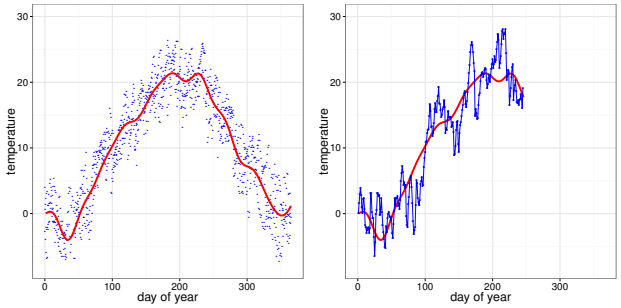
(b) This year temperatures used as the test set

Figure 6: Result obtained using GPR and this year temperatures

4.2. The Example of SVM Regression Using Gaussian Kernel

The illustrated SVM regression is straight-forward example of machine learning approach. First the training or learning set is defined and the model is built from the data. For the learning set, historical temperatures from 2010-2012 are used. Thus obtained function is tested on yet unseen temperature data from year 2013. The used data is the same as data in GPR case.

The ε-insensitive SVM regression [3, 4] is used. Thus obtained results are presented Figure 7.



(a) Historical data that is used to train the model. The resulting function is red

(b) SVM result (red) and this year temperatures (blue)

Figure 7: Regression results using SVM regression, RBF parameter σ was 16 and $\varepsilon = 0.5$

The one thing that is noticeable from the SVM regression is unusual behaviour of the result at the end of the year, where the solution is starting to increase rapidly while data values are not. This is problem that occurs when assigning weights to high degree polynomial basis of function space - which is exactly what SVM regression using Gaussian kernel is doing [6].

4.3. Comparison

Both methods provide satisfactory solution to the quite simple regression problem presented here. The dataset for this problem is big enough and this is the reason for good performance in regard to training data. Probably the most important advantage of GPR approach is that prediction confidence interval can be estimated easily from the model. The comparisons of both models are presented in Figure 8.

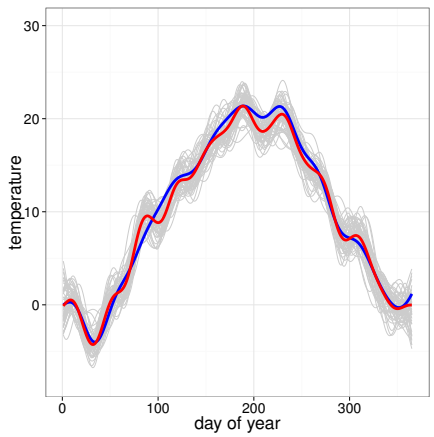


Figure 8: Comparison of GPR-model predictions, red, and SVM predictions, blue, on the same data

The result from SVM regression is well within rough estimate of confidence interval of GPR result. The difference between GPR and SVM prediction results are due to different methods of model and parameter selection.

On the other hand, SVM approach is easier to use, mainly due to amount of ready available software at this point [3].

5. CONCLUSION

Two different approaches to regression problems were illustrated and tested on the same dataset, both giving satisfactory and correct results. However further research is planned in regard to more scarce data or missing data where GPR approach could perform much better. Also there are implementations of GPR where one does not need exact values of data but just their improved estimates and GP model can be updated with those estimates [5].

Acknowledgement

This work has been supported partially by the Slovenian Research Agency, grants P2-0001 and L2-5475.

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UPORABA INTELIGENTNIH MOBILNIH NAPRAV ZA INDIVIDUALNO MEDICINSKO DIAGNOSTIKO

Anton Gradišek[1,2], Matjaž Gams[2]
[1]Odsek za fiziko trdne snovi
[2]Odsek za inteligentne sisteme
Institut »Jožef Stefan«
Jamova cesta 39, 1000 Ljubljana, Slovenija
Tel: +386 1 477 3967; fax: +386 1 477 3131
e-mail: {anton.gradisek, matjaz.gams}@ijs.si

POVZETEK

Pametni telefon vsebuje množico vgrajenih senzorjev, močno procesorsko enoto ter vrsto brezžičnih povezav. Kot tak je idealno orodje za spremljanje zdravstvenih parametrov posameznika in kot prvi indikator, če pride do poslabšanja zdravstvenega stanja. V prispevku predstavimo trenutno stanje na področju uporabe pametnih telefonov za medicinske aplikacije ter nakažemo, v katero smer se bo razvoj tovrstnih medicinskih aplikacij nadaljeval.

1 UVOD

V zadnjih letih smo priča bliskovitemu razvoju tehnologije na področju pametnih telefonov. Tipičen pametni telefon je opremljen z množico že vgrajenih senzorjev (mikrofon, kamera, senzorji dotika, pospeškov, magnetnega polja, giroskop), bliskavico, zvočnikom, različnimi brezžičnimi sprejemniki in oddajniki ter z močno procesorsko enoto. Taka konfiguracija ustreza klasičnemu računalniku s kopico dodatnih senzorjev. Tehnološki prodor na področju pametnih telefonov zato omogoča uvajanje nove generacije raziskav in aplikacij. Raziskovalni problemi realnega sveta npr. v domačem zdravstvu, ki so bili praktično nerešljivi zaradi previsoke cene ali nefunkcionalnih (pretežkih in neprenosnih) naprav, so sedaj na dosegu modernih raziskav. Razvija se novo raziskovalno področje, mobilna senzorika, ki se osredotoča na merjenje vrste parametrov z uporabo izključno vgrajenih senzorjev v mobilnem telefonu oz. s pomočjo enostavnih povezljivih senzoričnih naprav. Vendar pa obstoječe mobilne senzorične rešitve počasi prodirajo - predvsem zato, ker so zasnovane na »klasičnih pristopih« brez upoštevanja integrirane procesorske in senzorske moči pametnih telefonov [1] ter pomanjkanje metod umetne inteligence.

Problem obstoječih naprav in aplikacij je, da so relativno ozko usmerjene in le na omejen način izkoriščajo nove možnosti. Vsaka naprava je namenjena le spremljanju določenega parametra, za preliminarno diagnozo bolezenskega stanja pa je pogosto potrebnih več parametrov. Do veliko večje količine informacij lahko pridemo z integracijo podatkov različnih senzorjev ter z analizo teh podatkov s pametnimi algoritmi. Podobno kot lahko zdravnik le z upoštevanjem integralnih podatkov naredi zaključek, je velika teža na inteligentnem sistemu, ki zbrane podatke procesira na mnogotere načine, se »zaveda« pacientove zgodovine in trenutnega stanja in naredi primerne zaključke.

Na področju zdravstvenih aplikacij poteka hiter razvoj, ki ga podpira tudi zainteresirana industrija. Leta 2012 je konzorcij Qualcomm razpisal natečaj Qualcomm Tricorder XPRIZE [2] z nagradnim skladom 10 milijonov dolarjev za razvoj naprave, ki bo sposobna spremljati določene vitalne znake posameznika ter iz njihove analize napovedati nekaj najbolj pogostih bolezenskih stanj.

V nadaljevanju predstavimo podrobnosti tega natečaja, ki verjetno najbolj natančno nakazuje smernice, v katero smer bo razvoj potekal. Predstavimo tudi nekaj že obstoječih aplikacij in naprav, ki so na različnih stopnjah razvoja.

2 NATEČAJ QUALCOMM TRICORDER XPRIZE

Tehnološki konzorcij Qualcomm je leta 2012 razpisal natečaj, cilj katerega je razvoj naprave, »trikorderja«, ki bo bo sposobna spremljati zdravstveno stanje posameznika. Izraz »trikorder« je izposojen iz znanstvenofantastične serije *Zvezdne steze* (*Star Trek*), v kateri je zdravnik s pomočjo take naprave hitro in nekontaktno razbral vse bistvene informacije in si na ta način zlahka ustvaril sliko o zdravstvenem stanju pacienta [3].

Naprava, katere razvoj predvideva natečaj, naj bi bila sposobna konstantnega spremljanja petih vitalnih znakov posameznika. Gre za krvni pritisk, EKG, telesno temperaturo, hitrost dihanja in nasičenost krvi s kisikom. Za vsakega od teh parametrov trenutno uporabljamo specifično napravo. Krvni tlak merimo s sfigmomanometrom. Na nadlaket pacienta zdravnik namesti manšeto, v katero načrpa toliko zraka, da zaustavi pretok krvi v brahialni arteriji. Nato postopoma zmanjšuje pritisk v manšeti in s stetoskopom posluša, pri kakšnem tlaku začne kri spet teči. Tako odčita sistolični in diastolični krvni pritisk. EKG spremlja srčno aktivnost in se ga meri s pomočjo elektrod, ki se jih pritrdi na različne točke na telesu (na vse štiri okončine in po prsnem košu). Telesno temperaturo zdravnik odčita s termometrom. Nekoč so se večinoma uporabljali živosrebrni

termometri, danes pa so jih praktično povsod nadomestili električni, ki temeljijo na termočlenu. Za meritev hitrosti dihanja ne potrebujemo posebne naprave, ta podatek lahko določimo s štetjem vdihov v eni minuti (za zdravega odraslega posameznika v mirovanju so vrednosti med 12 in 20 vdihov, ocene se nekoliko razlikujejo med različnimi viri). Nasičenost krvi s kisikom zdravnik meri s pulznim oksimetrom, napravo, ki se natakne na pacientov prst ali na ušesno mečico. Meritev temelji na spremembah absorbance za svetlobo dveh različnih valovnih dolžin, saj oksigeniran in deoksigeniran hemoglobin v krvi različno absorbirata svetlobo.

Poleg spremljanja teh petih vitalnih znakov naj bi bila naprava sposobna prepoznati trinajst pogostih bolezenskih stanj ali laboratorijskih parametrov. Gre za anemijo, infekcijo spodnjega urinarnega trakta, diabetes tipa II, atrijsko fibrilacijo, možgansko kap, obstruktivno spalno apneo, tuberkulozo, kronično obstruktivno pljučno bolezen, pljučnico, otitis, levkocitozo, hepatitis A in odsotnost stanj. Za prepoznavanje teh stanj bi naprava imela dostop do vzorcev sline, urina, krvi ali blata, s tem da za odvzem vzorca krvi ne bo potrebna pomoč šolane osebe. Kot dodatek pri točkovanju bo štelo, če bo naprava sposobna prepoznati nekaj od sledečih bolezenskih stanj: oslovski kašelj, hipertenzija, infekcijska mononukleoza, alergije, hiper- in hipotiroidizem, okužbe s hrano, pasavec, melanom, streptokokna angina, povišanje koncentracije holesterola, okužba s HIV ter osteoporoza. Danes zdravnik večino zgoraj naštetih bolezenskih stanj diagnosticira s pomočjo laboratorijskih testov, ki so lahko dragi ali dolgotrajni. »Trikorder« bi pospešil diagnoze, skrajšal čakalne vrste v zdravstvu in tudi omogočil, da bi se posamezniki pregledovali sami.

Naprava bo morala biti sposobna podatke v rednih intervalih prenašati tudi v oblak, seveda pa bodo zdravstveni podatki morali biti ustrezno zaščiteni pred morebitnimi zlorabami.

3 PRIMERI OBSTOJEČIH APLIKACIJ

3.1 Aplikacije za rekreacijo

Na tržišču najdemo množico aplikacij za pametne telefone, ki so povezane s posameznikovo aktivnostjo. Vrsta aplikacij, kot je na primer Nike+ Running App [4], je namenjenih spremljanju športne aktivnosti, denimo teku, kolesarjenju ali pohodništvu. Te aplikacije s pomočjo GPS sprejemnika beležijo posameznikovo lokacijo in potem prikažejo, s kakšno hitrostjo se je športnik premikal na posameznih odsekih ter koliko kalorij je pri tem porabil. Pogosto imajo te aplikacije tudi možnost povezave z merilcem srčnega utripa. Nekatere aplikacije uporabljajo tudi pedometer – števec korakov, ki temelji na vgrajenemu senzorju pospeškov (do neke mere se lahko pretečena razdalja in porabljene kalorije odčitava tudi z uporabo samo tega senzorja). Aplikacije vsebujejo tudi močno socialno komponento, podatke o svoji športni aktivnosti lahko uporabniki delijo s prijatelji preko družabnih omrežij.

3.2 Meritev srčnega utripa

Drug tip aplikacij je namenjen prav spremljanju posameznih zdravstvenih parametrov. Že nekaj časa so na razpolago aplikacije za merjenje srčnega utripa, denimo Instant Heart Rate [5], ki utrip spremljajo s pomočjo videokamere. Uporabnik položi prst pred bliskavico telefona. Bela svetloba bliskavice presvetli kožo, kamera pa nato spremlja majhne spremembe v barvi kože, ki so posledice spreminjanja pretoka krvi zaradi bitja srca. Razvoj te tehnologije poteka v smeri poenostavljanja, načeloma za merjenje utripa zadostuje samo kamera, namesto prsta pa bi lahko utrip merili na ušesu – posameznik bi lahko meritev opravil kar med telefoniranjem [6]. Druga izboljšava bo temeljila na uporabi kombinacije dveh tipov svetlobe – bele, ki jo oddaja bliskavica, in zelene, ki jo oddaja kamera.

Raziskovalci so že razvili tehnologijo, ki samo s pomočjo zajemanja videa lahko istočasno spremlja srčni utrip treh posameznikov, ki se hkrati nahajajo pred kamero [7]. Uporabili so Bland-Altmanovo metodo in korelacijsko analizo, za zajemanje videa pa so uporabili enostavno internetno kamero. Dobljene vrednosti srčnega utripa so se dobro ujemale z vrednostmi, ki jih je izmeril zdravnik.

3.3 Meritve dihalnih funkcij

V zadnjem času se razvijajo tudi aplikacije, ki spremljajo posameznikovo dihanje. Pomembna meritev, ki jo zdravnik opravi za spremljanje delovanja pljuč, je spirogram. Gre za meritev pretoka izdihanega zraka v odvisnosti od časa. Pri medicinskem testu pacient na silo izdihne zrak v merilno napravo (cevko), ki meri trenutni pretok zraka in kumulativni izdihani volumen. Iz časovne odvisnosti pretoka lahko zdravnik sklepa na vrsto bolezni, povezanih s pljuči, kot so astma ali kronična obstruktivna pljučna bolezen. Poleg tega je spirogram koristen tudi pri določanju, ali ima pacient probleme z dihanjem zaradi bolezni pljuč ali zaradi bolezni srca.

Spirometrija se širi tudi v domačo uporabo, saj je pogosto spremljanje stanja zaželeno pri zdravljenju bolnikov s kroničnimi pljučnimi boleznimi. Problem z domačo spirometrijo je v tem, da so naprave relativno drage, uporaba pa zahtevna.

Raziskovalci iz University of Washington so razvili aplikacijo za pametni telefon, SpiroSmart [8], ki spirometrično meritev opravi s pomočjo vgrajenega mikrofona. Pri meritvi uporabnik drži telefon v iztegnjeni roki, globoko vdihne (do polnega volumna pljuč) in na silo izdihne proti zaslonu telefona, dokler ne izdiha vsega zraka v pljučih. Telefonov mikrofon posname zvok ob izdihu in pošlje zvočni posnetek na strežnik, kjer programska oprema iz spreminjanja zvoka izračuna pretok izdihanega zraka. Prve primerjave s kliničnimi testi so pokazale, da je povprečna napaka za tipično meritev pljučne funkcije znotraj 5,1 % v primerjavi s kliničnim spirometrom. Sama aplikacija načeloma niti ni omejena na pametni telefon, raziskovalci poskušajo razviti tudi storitev, ki bi delovala s stacionarnim telefonom v povezavi z avtomatskim odzivnikom. Na ta način metoda ni odvisna od tipa telefona.

Spirometrija s pomočjo mikrofona ima tudi vrsto omejitev. Pri kliničnem testu se pogosto meri tudi pretok vdihanega zraka, kar ta metoda ne omogoča. Druge omejitve vključujejo šume iz okolice in dejstvo, da so za dobro opravljeno meritev pogosto potrebna navodila operaterja med samo meritvijo (»Še pihaj!«). Kot navajajo avtorji raziskave, trenutni telefoni niso sposobni v realnem času obdelati in prikazati vseh podatkov, zato za analizo uporabljajo strežnik v oblaku. Gledano dolgoročno bodo analize in obdelave meritev sposobni tudi procesorji v telefonih.

3.4 Spremljanje gibanja

Pomembno področje, na katerem pametne računalniške metode lahko znatno izboljšajo kvaliteto življenja, je spremljanje gibanja starostnikov. Z zviševanjem deleža starostnikov, ki pri življenjskih opravilih potrebujejo pomoč, namreč naraščа potreba po individualni oskrbi. Ker vseh potreb starostnikov ne bo mogoče zadostiti z usposobljenimi pomočniki, se razvijajo inteligentni računalniški sistemi, ki bodo omogočali denimo zaznavanje padcev in varnostni nadzor [9].
Analiza gibanja starostnikov poteka v treh stopnjah. V prvi stopnji senzorji zaznavajo, kako se oseba giba – kar merimo preko senzorjev ali oznak, ki so pritrjene na telo. Lahko gre za senzorje pospeškov, ki zaznavajo spremembe v gibanju. Druga možnost so radijski oddajniki, s pomočjo katerih se lahko določa pozicijo na nekaj centimetrov. Tretja možnost je uporaba sistema kamer, ki spremljajo, kako se premikajo značke, ki so pritrjene na različne dele telesa – ta metoda lahko določa pozicijo na nekaj milimetrov natančno. V drugi stopnji sistem iz gibalnih vzorcev prepozna, kaj oseba počne: sedi, leži, vstane, gre v kopalnico, hodi, šepa pri hoji ali pade. V primeru nevarnega dogodka (padca) sistem v tretji stopnji pokliče intervencijsko službo.
V študiji [9] so avtorji primerjali uporabo senzorja pospeškov in radijskih senzorjev za prepoznavanje različnih tipov gibanja: prevračanje, omedlevanje, zdrs s stola (kar so nevarni dogodki) in nenevarnih dogodkov, denimo, ko se oseba hitro uleže v posteljo, hitro sede na stol ali išče nekaj pod mizo ali pod posteljo. Raziskava je pokazala, da senzor pospeška 100 % pravilno prepozna nekatere tipe gibanja (padec in iskanje nečesa pod posteljo), medtem ko se veliko slabše odreže pri prepoznavanju omedlevanja ali zdrsa s stola. Po drugi strani radijski senzor skoraj vse tipe gibanja prepozna z gotovostjo, višjo od 95 %, le pri iskanju nečesa pod posteljo je zanesljivost 79,6 % (kar je še vedno zelo dobro).
Čeprav te metode niso bile razvite za uporabo na pametnem telefonu, se jih lahko prilagodi – pametni telefon se namreč lahko uporabi namesto posebnega senzorja, saj je opremljen s senzorjem pospeškov in z brezžičnimi povezavami.

3.5 Pametni telefon kot vmesnik

Na trgu je dostopna vrsta naprav, ki so namenjene merjenju posameznih zdravstvenih parametrov, kot vmesnik pa se uporablja pametni telefon. Smartphone Physical [10] razvija naprave, s katerimi se lahko določa telesna teža, krvni pritisk, srčni utrip, nasičenost krvi s kisikom, EKG, vključuje tudi stetoskop, oftalmoskop in spirometer. Čeprav se v teh primerih uporablja specifične dodatne naprave in ne le vgrajenih senzorjev v telefonu, vse te aplikacije omogočajo beleženje zgodovine zdravstvenih podatkov, kar se lahko s pridom kombinira z metodami umetne inteligence in iz znatnih sprememb napove morebitno poslabšanje zdravstvenega stanja.

3.5 Integrirani senzorji

Trenutno najbližje izpolnjevanju prvega dela razpisa Qualcomm Tricorder XPRIZE, kontinuiranemu spremljanju petih vitalnih znakov posameznika, je verjetno naprava Scanadu Scout™ podjetja Scanadu [11].



Slika 1: Naprava Scanadu Scout™ [11]

Naprava ima obliko diska, ki ga uporabnik drži s palcem in kazalcem ter prisloni k čelu. Vgrajeni senzorji odčitajo vseh pet vitalnih znakov (krvni pritisk, EKG, telesno temperaturo, hitrost dihanja in nasičenost krvi s kisikom), podatke preko Bluetooth protokola naložijo na pametni telefon (Android ali iOS) ter omogočajo spremljanje posameznikove zgodovine in trendov – tako lahko naprava denimo napove začetek vročine. Vzporedno se razvijajo tudi algoritmi, ki bodo znali izmerjene podatke čim bolje interpretirati.

4 POGLED NAPREJ

Polje neinvazivne medicinske diagnostike se v zadnjih letih bliskovito razvija, prav tako kot se razvijajo vse tri panoge,

katerih znanja se pri diagnostiki uporablja: medicina, fizika in metode umetne inteligence ter strojnega učenja.

V medicini se kaže vedno večja potreba po hitrem in zanesljivem spremljanju zdravstvenih podatkov. Posamezniki so opremljeni s širokim naborom informacij o različnih boleznih in zato pogosto brez poznavanja ključnih podatkov sklepajo, da bolehajo za to ali ono boleznijo. Včasih lahko sklepajo na pravilno diagnozo, še pogosteje pa je samodiagnoza napačna in je povod za neprimerno ukrepanje, s katerim si posameznik lahko dela škodo. Razvoj na področju pametne diagnostike bo po eni strani omogočal hitrejšo izmenjavo podatkov med pacientom in zdravnikom, ki bo na ta način lahko zanesljiveje postavil pravilno diagnozo, poleg tega pa bo sistem posameznike, ki sicer ne čutijo bolezenskih znakov, opozoril na možno poslabšanje in jih po potrebi napotil na zdravniški pregled.

Razvijajo se novi fizikalni pristopi za merjenje različnih zdravstvenih parametrov. Senzorji se miniaturizirajo in integrirajo v naprave, kot je denimo pametni telefon. Velika prednost uporabe pametnega telefona kot senzorja je v tem, da uporabniku ni treba kupiti vrste (dragih) diagnostičnih naprav, saj telefon že ima. Zgoraj smo omenili nekaj aplikacij, ki že spremljajo zdravstvene parametre zgolj z uporabo vgrajenih senzorjev, še več pristopov pa je v različnih fazah razvoja in na poti do komercialno uporabnih aplikacij. Razvijajo se tudi pristopi, ki združujejo podatke več senzorjev za spremljanje posameznega zdravstvenega parametra, ti pristopi odpravljajo potrebo po specializirani dodatni napravi. Če nek zdravstveni parameter odčitamo le enkrat, imamo na voljo le eno številčno vrednost. Če pa ta parameter spremljamo v določenih časovnih intervalih (kar nam bo omogočala enostavna naprava, denimo aplikacija na pametnem telefonu), dobimo posameznikovo zdravstveno zgodovino, iz katere lahko z metodami umetne inteligence spremljamo trende in napovedujemo ter hkrati opozarjamo na morebitno poslabšanje zdravja, še preden do njega dejansko pride. Na področju individualne medicinske diagnostike smo priče revoluciji, ki bo močno izboljšala celotni zdravstveni sistem, saj bo koristila tako zdravnikom kot tudi vsakemu posameznemu uporabniku.

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DESIGNING A QUALITY-CONTROL PROCEDURE FOR COMMUTATOR MANUFACTURING

Valentin Koblar[1,3]*, Bogdan Filipič*[2,3]

[1]Kolektor Group d.o.o., Vojkova ulica 10, SI-5280 Idrija, Slovenia
[2]Department of Intelligent Systems, Jožef Stefan Institute, Jamova cesta 39, SI-1000 Ljubljana, Slovenia
[3]Jožef Stefan International Postgraduate School, Jamova cesta 39, SI-1000 Ljubljana, Slovenia
E-mail: valentin.koblar@kolektor.com, bogdan.filipic@ijs.si

ABSTRACT

This paper presents a methodology for designing an automated quality-control procedure in manufacturing graphite commutators for automotive industry. It focuses on assessing the quality of the copper-graphite joints on the commutators, using an advanced approach involving computer vision, machine learning and optimization. Based on the features of the captured images, classification models are built as a basis of the quality-control procedure, and optimized with respect to their accuracy and complexity. The preliminary results indicate that the proposed approach successfully identifies the features important for quality assessment, but needs further improvements to be applicable in industrial production.

1 INTRODUCTION

Quality-control requirements in automotive industry are very strict. Typically, the allowed proportion of defective supplied products is 1 ppm (part per million). To ensure the required quality of the supplied products, their quality has to be verified during and at the end of the manufacturing process. In addition, to meet the quality standards, every production procedure in the manufacturing process has to be controlled. In parallel with the improvement of the production processes, the quality control-systems have to be upgraded as well.

This paper deals with designing an automated procedure for inspecting the quality of commutators during their manufacturing at the Kolektor production plant. A commutator is an integral part of the commutator motor, mounted on the shaft of the rotor. Its function is to periodically reverse the direction of electric current in the rotor's winding and thus maintain commutation of the motor. During the motor operation, the commutator can be exposed to various stresses: mechanical, electrical, and, in the case of corrosive media, also chemical. To ensure reliable operation of the commutator over its entire lifetime, the commutator has to pass several quality tests. Currently, the quality of the manufactured commutators at the plant is checked only at the end of the production process. To reveal potential irregularities in the production process and minimize the waste of the raw material, faults on the semiproducts need to be detected as early as possible. To accomplish this goal, quality control after each operation in the manufacturing process is needed.

The plant produces commutators of different types for various applications, including graphite commutators for fuel pumps in the vehicle fuel systems. To prevent excessive wear and corrosion of commutators in the fuel pump application, these commutators are made of graphite and cooper. One of the phases in graphite commutator manufacturing is soldering of metalized graphite, representing the brush track, to the copper base. Soldering of metalized graphite is one of the most critical phases of commutator production, since the reliability of the end user application directly depends on the strength of the copper-graphite joint. In commutator production at the plant, there is currently no automated quality-control procedure of the soldering phase. All the manufactured graphite commutators are inspected manually, which is time consuming. Moreover, human errors are present, and the results of manual inspection may be subjective.

To overcome the drawbacks of manual product inspection, we aim to design an automated quality-control procedure for graphite commutator manufacturing. Currently, we focus on the soldering phase with the goal of synthesizing an advanced, information technology based procedure which is to employ computer vision for capturing images of the copper-graphite joints, digital image processing for extracting features from the images, and machine learning based classification for determining the quality of the joints, utilizing the extracted features. The design of the quality-control procedure is at its initial stage of producing a suitable classification model to predict the quality of the copper-graphite joints. To that end we apply machine learning from examples of the joint images. A challenge here is to produce a model accurate enough to ensure the required product quality, and sufficiently compact to allow for efficient on-line operation. In this paper we present off-line experiments involving machine learning and multiobjective optimization aimed at generating and tuning the quality prediction models.

The paper further describes data preparation for preliminary experiments in designing the quality-control procedure, presents learning and optimization of the classification models that represent the basis of the quality-control procedure, reports on the preliminary results, and concludes with a summary of work and directions for further improvements.

2 DATA PREPARATION

The initial stage of designing automated quality control is data preparation for machine learning. It consists of capturing the images of the joints resulting from copper-graphite soldering, extracting features from the images and assigning quality classes to the joints. An example of the copper-graphite joint can be seen in Figure 1. To capture as informative images as possible, several layouts of the camera and lightning were tested. In total, 394 images were captured.

Next, the images were then processed using a computer vision algorithm, designed in the LabView graphical programming environment [4]. The computer vision algorithm allows for the extraction of preselected image features to be later used as the attributes of the learning examples. In fact, these were values describing physical properties of the soldered joints, such as the size and the number of unsoldered areas, the size and the number of defected graphite areas, orientation of the cooper-graphite joint, the size of the solder spots on cooper, etc. There were 16 attributes describing each joint and they were all numerical.

Finally, the quality control experts were involved to assign a quality class to each joint. There were five quality classes possible (see Table 1 for their meaning and distribution).



Figure 1: The copper-graphite joint on a commutator

Table 1: Characteristics of the commutator soldering learning domain

Class	Number of examples	Frequency [%]
Well soldered	241	61.2
Excess of solder	49	12.4
Deficit of solder	36	9.1
Metalization defect	36	9.1
Disoriented	32	8.1
Total	394	100.0

The data preparation stage resulted in a set of learning examples described by attribute vectors, each containing 16 numerical attribute values and a discrete class value.

3 LEARNING AND OPTIMIZATION OF CLASSIFICATION MODELS

The next stage in designing automated quality control is induction of a classification model from the provided learning examples. This model is then aimed at classifying previously unseen instances from the copper-graphite soldering domain into appropriate classes. Machine learning of such a model can be viewed as search for a function that maps the attributes of the domain to the target classes. Generally, the machine learning algorithms do not provide optimal results without being properly tuned. For building models of high classification accuracy and, at the same time, reasonable size, it is not only necessary to choose an appropriate machine learning algorithm but also requires time-consuming setting of the learning algorithm parameters.

For building the classification model for the copper-graphite soldering domain, we used the Weka data mining environment [9], more specifically, its implementation of the C4.5 algorithm [6] for building decision trees, called J48. Decision trees are the most widespread classification models since they are easy to use and understand. However, the J48 learning algorithm enables us to set more than ten parameters that influence the resulting decision tree. In our study we selected five key parameters (see Table 2) and optimized them to balance between the accuracy and the complexity of the resulting classification models.

The classification accuracy of the models was assessed using 10-fold cross-validation, and their size was measured by the number of nodes in the decision tree. As Table 2 suggests, there are many possible combinations of the learning algorithm parameter values. Manual tuning of parameters and finding high-quality settings can be very time-consuming. It also requires expert knowledge of the used algorithms and properties of the learning domain.

An alternative approach to the manual parameter tuning is employing suitable optimization methods. The problem of tuning the machine learning algorithm parameters can be defined as an optimization problem. The objectives functions are the classification accuracy of the induced decision trees and their size. To solve this optimization problem, we integrated the Weka data mining environment with suitable optimization algorithms. A schematic representation of the machine learning algorithm parameter optimization is shown in Figure 2. Three optimization algorithms were tested in this scheme: grid search, random search and DEMO (Differential Evolution for Multiobjective Optimization) [7].

The grid search algorithm uses predefined discrete values of the parameter values. The algorithm systematically searches and evaluates decision models, built by using the grid values of machine learning algorithm parameters. Grid search is a computationally demanding process: by increasing the number of parameters and reducing the discretization step, the number of possible combinations increases exponentially. This method has proven to be more effective and efficient than manual search, as it provides more accurate decision models in shorter time [2].

The random search algorithm randomly selects discrete parameter values of the machine learning algorithm. It then evaluates decision models built by randomly generated parameter values and identifies the set of nondominated solutions to the multiobjective optimization problem. In general,

Table 2: Parameters of the J48 machine learning algorithm used classification model tuning

Parameter	Possible values	Default value
M – Minimum number of instances in a leaf	1, 2, ...	2
U – Use of unpruned trees	yes/no	no
C – Confidence factor used in postpruning	[0.01; 0.5]	0.25
S – Subtree raising operation in postpruning	yes/no	yes
B – Use of binary splits	yes/no	no

random search rather quickly converges to good solutions, but the found solutions are usually not optimal [8].

DEMO is a differential evolution algorithm [5] adapted for multiobjective optimization. The advantages of differential evolution are its simplicity and efficiency. Differential evolution starts with a population of random solutions from which progressively better solutions are obtained over generations. However, the major limitation of differential evolution originates from the requirement for numerical vector representation of solutions in the decision space that prevents the algorithm from being applicable to combinatorial optimization problems. A detailed description of the DEMO algorithm is available in [7]. In our experiment, the parameter values of the DEMO itself were set as follows: population size 20, number of generations 25, probability of crossover CR 0.6, differential evolution selection scheme DE/rand/1/bin and environmental selection procedure SPEA2 [1, 3].

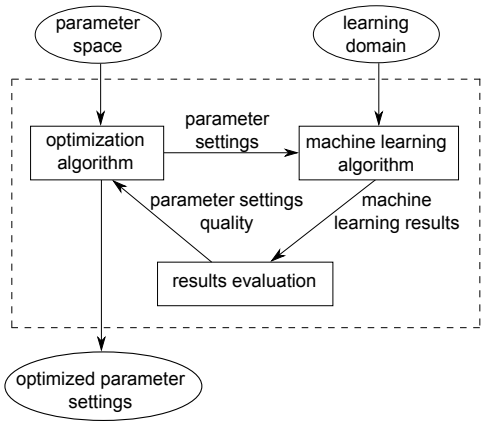


Figure 2: Schematic representation of machine learning algorithm parameter optimization

4 PRELIMINARY RESULTS

Preliminarily, we built decision trees for the copper-graphite soldering domain using the J48 algorithm default parameter settings. The default parameter values are shown in Table 2. We then compared the decision tree built using the default parameter values with trees built using the parameter values optimized by grid search, random search and the DEMO optimization algorithm. The result of building decision trees optimized with respect to two objectives, i.e., the classification accuracy and the size, is not a single decision tree, but a set of nondominated trees for each optimization algorithm. The decision tree built with the default parameter values and the nondominated solutions built using the optimized parameter values are shown in Figure 3. This figure presents the results of a single run of the optimization algorithms.

The comparison between the decision tree built using the default parameter values and the trees built with the optimized parameter values shows that the default decision tree tends to be larger and less accurate than the optimized trees. Because the grid search step size is determined by the number of evaluated solutions, in multiple runs the algorithm always finds the same nondominated solutions. In our experiments the stopping criterion was set to 500 evaluated solutions (built decision trees), defined by the grid discretization steps. Since random search and DEMO are stochastic algorithms, they find different parameter values in multiple runs. In the objective space this is reflected in different nondominated solutions.

The classification accuracy of the decision tree built using the default parameter values is 79.2 %. The highest classification accuracy of the decision tree found by the grid search algorithm was 80.5 %, but compared to the default decision tree, this tree is smaller. Decision tree with the highest classification accuracy was found by the random search algorithm. Its classification accuracy is 80.7 % and size 31 nodes. The decision tree with the highest classification accuracy found by DEMO was the same as the decision tree found by grid search. All three algorithms found several different parameter settings that results in the same nondominated solution in the objective space.

To understand the nondominated decision trees found by the optimization algorithms, we analyzed a number of them. The smallest nondominated decision tree that classifies the copper-graphite joints into all five quality classes, found by DEMO, is shown in Figure 4. Its classification accuracy is 77.2 % and the size 11 nodes. It is to be noted that this decision tree uses only 3 out of 16 attributes. The most informative attribute, *Max. size of graphite area*, describes the maximal size of the commutator area where the graphite metalization is not present. The second attribute, *Max. size of unsoldered area*, describes the maximal size of unsoldered area near the commutator cooper pad. If this area is too large, either there is a deficit of solder or the metalization of graphite is defected. Finally, the third attribute, *Size of unsoldered area in total*, describes the cumulative unsoldered area around the commutator pad. If this cumulative area is too large, there is

high possibility of the solder deficit. Knowing the background of the soldering process, we can claim that in practice the connection between the attribute *Max. size of graphite area* and the class *Excess of solder* is not so obvious. The decision tree shown in Figure 4 correctly classifies all instances of the class *Excess of solder*. Based on this fact, we can argue, that the described methodology in comparison to the usage of only machine vision application for classifications is advantageous.

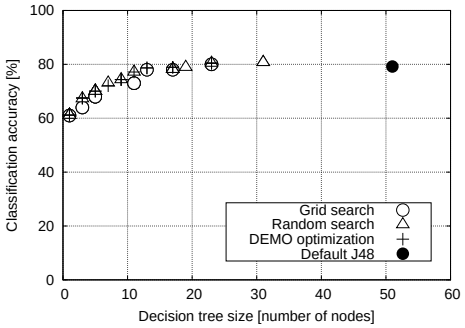


Figure 3: Results of decision tree building using default parameter values and optimized parameter values of the J48 machine learning algorithm

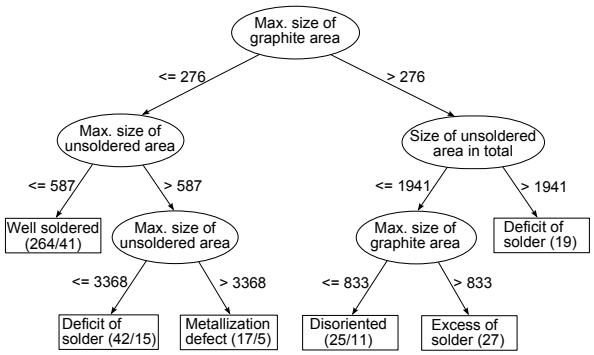


Figure 4: The smallest nondominated decision tree with all classification classes included, found by DEMO

5 CONCLUSION

We presented a preliminary study in the design of a quality-control procedure for graphite commutator manufacturing based on computer vision, machine learning and optimizations algorithms. The results of the initial experiments on real-world data show that, using the described methodology, we can enhance the performance of the classification models to serve as the basis of the quality-control procedure. Specifically, we used the J48 learning algorithm available in the Weka data mining environment, but the methodology could also be deployed using other machine learning algorithms.

From the perspective of practical implementation of the classification model, its high classification accuracy is essential. The highest classification accuracy achieved in the presented work is 80.7 %. Knowing the background of this domain, we can argue that this is still insufficient for practical application. To improve the classification performance, additional and more informative attributes from the captured images should be extracted. Moreover, tuning of the machine vision algorithm used for attribute extraction needs to be performed. Another direction for future work is to add additional objectives to the optimization problem. For example, from the practical point of view, minimizing the false-positive classification measure as an objective, would increase the reliability of the classification model.

ACKNOWLEDGMENT

This work has been partially funded by the ARTEMIS Joint Undertaking and the Slovenian Ministry of Economic Development and Technology as part of the COPCAMS project (http://copcams.eu) under Grant Agreement number 332913, and by the Slovenian Research Agency under research program P2-0209.

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IDENTIFIKACIJA OSEB NA PODLAGI OBLIKE TELESA

Tomaž Kompara, Jernej Zupančič, Matjaž Gams
Inštitut Jožef Stefan – Odsek za inteligentne sisteme
e-mail: { tomaz.kompara, jernej.zupancic, matjaz.gams }@ijs.si

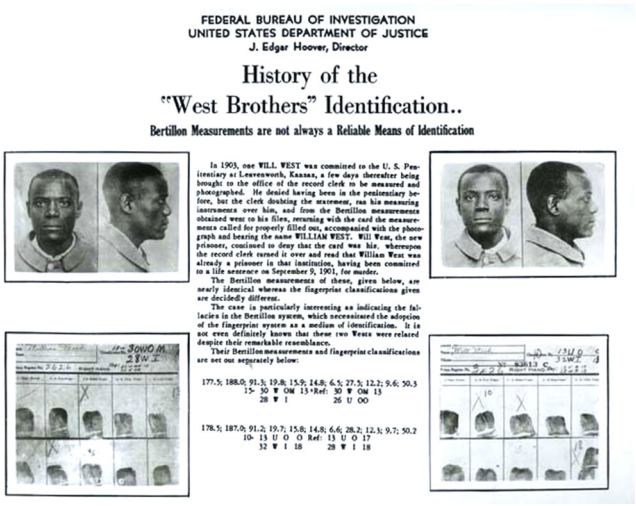
POVZETEK

Identifikacija oseb je v modernem svetu uporabljena na vsakem koraku. Največkrat so za identifikacijo uporabljena različna gesla, prstni odtisi, slike in podobno, ki pa so navadno časovno potratni in za uporabnika moteči. Prav zaradi tega se v zadnjem času razvijajo novi sistemi za identifikacijo, ki so za uporabnika neopazni in zato nemoteči. Eden takih sistemov je identifikacija na podlagi oblike telesa. Oblika telesa je lahko izmerjena brez kontakta z osebo (kamere, globinski senzorji, …), vendar je tako merjenje nenatančno. V tem prispevku smo pokazali, da lahko z uporabo več telesnih mer zmanjšamo vpliv napake na točnost identifikacije.

1 UVOD

Biometrija je zelo široko in še vedno razvijajoče se področje. Prvi razširjen biometrični sistem za identifikacijo ljudi je Bertillonov, izumljen leta 1879 [1]. Bertillonov sistem temelji na podatkih fizičnih mer telesa osebe, uporabljal pa se je predvsem za iskanje prej poznanih zločincev. Po letu 1903, ko so skoraj po nedolžnem obsodili Willa Westa na podlagi Bertillonovega sistema (Slika 1)[2], so mere telesa počasi zamenjali za bolj zanesljive prstne odtise. Sedaj, več kot 100 let po tem, je prstni odtis daleč najbolj uporabljeno biometrično identifikacijsko orodje. Kljub temu se identifikacijski sistemi, ki temeljijo na podlagi oblike telesa, še vedno razvijajo, saj imajo vrsto drugih prednosti.

Najpomembnejša lastnost vseh identifikacijskih sistemov je točnost pravilne identifikacije, vendar to ni edina lastnost, ki vpliva na izbiro identifikacijskega sistema. Raziskovalci iščejo biometrične podatke, ki jih je težko ponarediti in se skozi življenje ne spreminjajo. Oblike telesa drugega človeka ni težko ponarediti, vendar se le ta skozi življenje zelo spreminja (obleke, ki jih nosimo, drža, debelost, rast, ...). Drugi kriteriji, ki vplivajo na razširjenost uporabe so: enostavnost uporabe, čas identifikacije, prijaznost do uporabnika in cena. Sistem za razpoznavanje na podlagi oblike telesa je za uporabnika neopazen in zato enostaven za uporabo, hiter in nemoteč. Zaradi razvoja kamer in globinskih senzorjev pa so taki senzorji tudi cenovno ugodni. Zaradi vseh omenjenih prednosti je razvoj identifikacijskih senzorjev, ki delujejo na podlagi oblike telesa, smiseln. Ti senzorji so bolj primerni za aplikacije, kjer točnost pravilne identifikacije ni na prvem mestu [3 - 5].


FEDERAL BUREAU OF INVESTIGATION
UNITED STATES DEPARTMENT OF JUSTICE
J. Edgar Hoover, Director

History of the
"West Brothers" Identification..

Bertillon Measurements are not always a Reliable Means of Identification

Slika 1: Velika podobnost med Willom in Williamom Westom.

V tem članku želimo pokazati kolikšno točnost identifikacije je mogoče doseči z uporabo oblike telesa. Najprej bomo opisali način izvedbe eksperimenta in nato predstavili, kako na točnost identifikacije vpliva velikost napake, izbira mer in število oseb, ter na koncu prikazali vse rezultate skupaj.

2 OPIS EKSPERIMENTOV

Z eksperimentom želimo pokazati, kako na točnost identifikacije vpliva napaka, izbira mer in število oseb. Pri tem smo uporabili realne antropometrične podatke, katerim smo dodali napako ter nato merili točnost identifikacije.

Pri izvedbi eksperimenta smo uporabili antropometrične podatke ANSUR [6]. Ti podatki so bili izmerjeni na osebju, zaposlenem v vojski med letoma 1987 in 1988, in so prosto dostopni na spletu [7]. Podatki obsegajo 1774 moških in 2208 žensk, starih med 17 in 51 let. Na vsakem človeku je bilo izmerjenih 132 standardnih mer, 60 jih je bilo izračunanih s seštevanjem oziroma odštevanjem standardnih mer ter dodatnih 48 mer obraza in glave.

Za določanje identitete smo uporabili metodo najbližjega soseda in evklidsko razdaljo. V vseh primerih smo za učenje modela uporabili izmerjene antropometrične podatke, nato pa smo identificirali podatke z dodano uniformno napako. Uniformna napaka predstavlja naključno spremembo oblike telesa, ki je lahko posledica nošnje drugačnih debelin oz. kroja oblačil, nihanja telesne teže, oblike pričeske, itd. Z

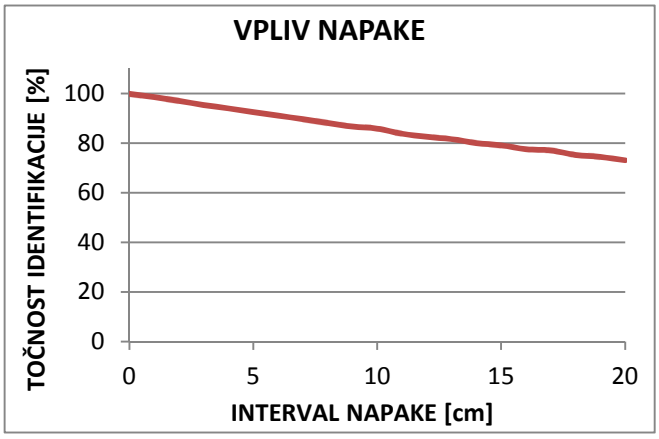
algoritmom najbližjega soseda iščemo, ali je podatek z dodano napako razpoznan kot pravilna oseba ali ne.

3 VELIKOST NAPAKE

Največjo težavo pri identifikaciji na podlagi oblike telesa predstavlja napaka meritev. V kolikor bi lahko na milimeter natančno izmerili vsaj nekaj telesnih mer, bi bila točnost identifikacije zelo visoka. Žal pa je tudi z namenskimi orodji in merilniki to težko zagotoviti. Problem je še toliko bolj kompleksen v primeru, ko meritve izvajamo s kamero oz. globinskim senzorjem v naravnem okolju. Napaka meritev je ena izmed glavnih vzrokov za nizko točnost identifikacije.

Za prikaz vpliva napake na točnost identifikacije, bomo uporabili le eno mero in dve naključno izbrani osebi. Za mero smo izbrali *višino* osebe, kateri smo dodali naključen šum znotraj spreminjajočega se intervala. Za vsak interval napake smo 100.000 krat naključno izbrali dva človeka, dodali naključno napako z uniformno porazdelitvijo ter izračunali povprečno točnost identifikacije.

Slika 2 prikazuje točnost identifikacije v odvisnosti od intervala napake. Najprej lahko opazimo, da v primeru, ko meritvi ne dodamo šuma in uporabimo na milimeter natančne podatke, dosežemo zavidljivo 99,8% točnost identifikacije dveh oseb. Razlog za to je precej majhna možnost, da v celotni populaciji najdemo dve do milimetra enako visoki osebi. Z večanjem intervala napake se manjša tudi točnost identifikacije.



Slika 2: Točnost identifikacije v odvisnosti od velikosti intervala napake.

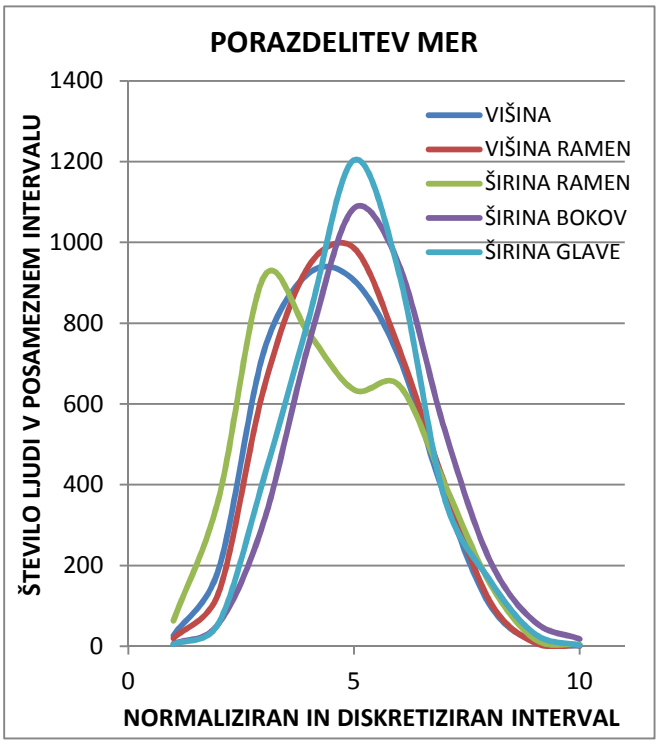
Za višjo točnost identifikacije potrebujemo čim bolj natančne meritve. Večja kot je napaka, večkrat osebo napačno razpoznamo. Druga ugotovitev je, da le z eno mero ne moremo zadovoljivo identificirati osebe. Posledično uporabimo več mer, kot je opisano v nadaljevanju.

4 IZBIRA MER

Ker je točnost identifikacije na podlagi ene same mere nizka, za izboljšanje identifikacije uporabimo več mer. Izbira mer je navadno pogojena z izbiro merilne naprave. V našem primeru smo izbrali 5 mer, ki jih je mogoče določiti s pomočjo kamere. Izbrane mere so:

- višina,
- višina ramen,
- širina ramen,
- širina bokov,
- širina glave.

Kako dobro je mogoče identificirati človeka na podlagi ene mere, je odvisno od širine intervala, v katerem se mere nahajajo in od porazdelitvene funkcije znotraj intervala. Širši kot je interval, več je možnih meritev, boljša je identifikacija in obratno. Prav tako na točnost identifikacije vpliva porazdelitev ljudi znotraj intervala. Najvišjo točnost dosežemo z uniformno porazdelitvijo. Bolj kot je porazdelitev skoncentrirana v eni točki, nižja je točnost. Enakomernost porazdelitve smo izračunali s pomočjo entropije. Večja kot je entropija, bolj enakomerno so ljudje porazdeljeni po intervalu in obratno. Na Slika 3 vidimo, da so porazdelitve približno enake, rahlo izstopa le širina glave. Podobne rezultate dobimo tudi z računanjem entropije (*Tabela 1*).



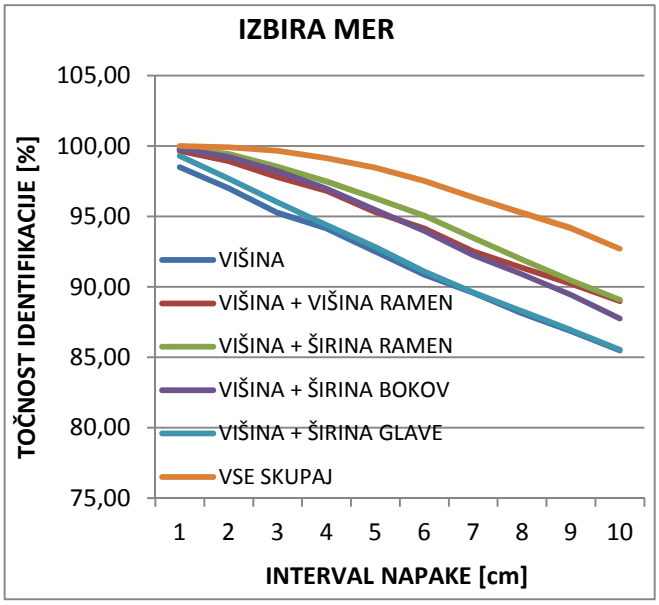
Slika 3: Porazdelitev mer po celotnem intervalu.

V zadnjem stolpcu v *tabeli 1* je zapisana točnost identifikacije dveh poljubnih oseb in pri napaki 1cm. Opazimo lahko, da sta meri širine bokov in višine ramen kljub podobni razporeditvi (entropiji sta podobno veliki) dosegli zelo različne rezultate in sicer zaradi širine intervala. Druga zanimivost sta meri višina ramen in širina ramen, ki kljub zelo različnim intervalom dajeta podobne rezultate, saj je širina ramen veliko bolj enakomerno razporejena kot višina ramen. Najboljši rezultat dosežemo z mero višine, ki ima dobro razporeditev in širok interval.

Mera	Interval [mm]	Entropija	Točnost identifikacije [%]
Višina	614	2,61	98,56
Višina ramen	565	2,57	97,92
Širina ramen	224	2,77	96,23
Širina bokov	150	2,59	92,74
Širina glave	47	2,49	78,82

Tabela 1: Lastnosti posameznih mer.

Naslednje vprašanje, ki se pojavi, je katere mere dajejo skupaj najboljše rezultate. V ta namen smo izmerili, kako se točnost identifikacije izboljša, če meri višina dodamo še eno mero. Rezultati so prikazani na Slika 4. Vidimo lahko, da se točnost izboljša v vseh primerih. Za primerjavo smo izračunali točnost z uporabo vseh petih mer. Opazimo, da se točnost še dodatno izboljša. Poleg tega pri uporabi več mer z večanjem napake točnost identifikacije počasneje pada.

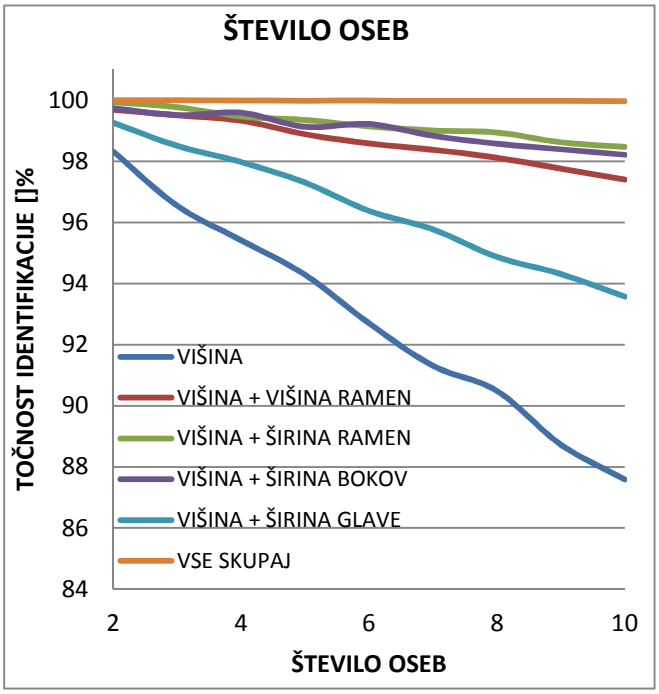


Slika 4: Vpliv združevanja mer na točnost identifikacije.

5 ŠTEVILO OSEB

Do sedaj smo se osredotočili na ločevanje le med dvema osebama, v nadaljevanju pa si bomo ogledali, kako na točnost identifikacije vpliva razlikovanje med več osebami. V tem primeru smo uporabili napako 1cm in enak nabor mer kot v prejšnjem primeru:

- višina,
- višina in višina ramen,
- višina in širina ramen,
- višina in širina bokov,
- višina in širina glave,
- vseh pet mer skupaj.



Slika 5: Vpliv števila oseb na točnost identifikacije.

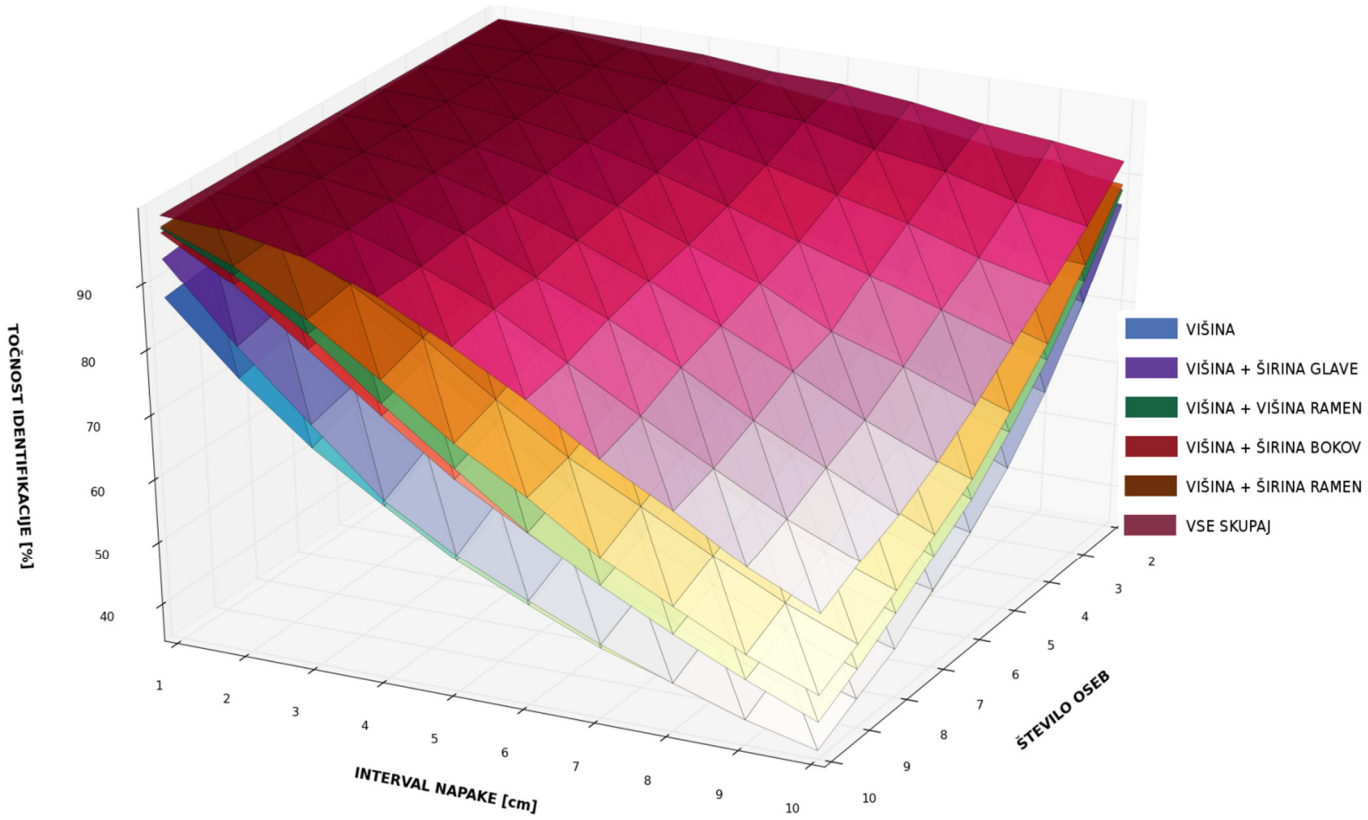
Rezultati so prikazani na Slika 5. Opazimo, da točnost identifikacije s številom oseb počasneje pada pri uporabi več mer. Najslabša kombinacija mer je zopet višina in širina glave, ki pa je še vedno mnogo boljša od uporabe ene same mere. Posebej izrazito izboljšanje je opaziti pri uporabi vseh mer.

6 SKUPAJ

Odvisnost vseh opisanih vplivov je prikazana na Slika 6, kar omogoča dodatno analizo na celotnem področju. Pri uporabi več mer skupaj lahko opazimo izboljšanje v celotnem območju ne glede na velikost napake oz. število identificiranih oseb. S tem smo še enkrat pokazali, da uporaba več mer pozitivno vpliva na zmanjšanje vpliva napake in večanje točnosti identifikacije.

Druga ugotovitev je, da ob večanju napake točnost identifikacije hitreje pada ob večanju števila identificiranih oseb. Torej moramo poleg uporabe več mer zagotoviti tudi dovolj dobre meritve.

Za izbranih 5 mer je pri 10 osebah in napaki 2cm točnost identifikacije 99.3%. Pri 2 osebah je ta napaka lahko 2 krat večja in je točnost identifikacije še vedno visokih 99.2%. Sicer je to v primerjavi z ostalimi identifikacijskimi sistemi (prstni odtis) še vedno nizek rezultat, vendar je na tem področju še vedno veliko prostora za izboljšave.



Slika 6: Vpliv napake, števila oseb in izbire mer na točnost identifikacije.

7 ZAKLJUČEK IN NADALJNJE DELO

V tem delu smo predstavili glavne vplive na točnost identifikacije pri identificiranju na podlagi oblike telesa. Pokazali smo, da lahko s takim sistemom dosegamo visoke točnosti identifikacije v primeru, ko imamo na voljo dovolj dobrih meritev.

V nadaljnjem delu bomo pregledali obstoječe sisteme za brezkontaktni zajem oblike telesa ter uporabili te podatke za identificiranje. Pri tem bomo uporabili dodatne mere, ki jih v tem delu nismo obravnavali, s čimer želimo še izboljšati točnost identifikacije.

Pri izvajanju eksperimentov smo uporabili uniformno napako za simuliranje sprememb oblike telesa (drugačna debelina oz. kroj oblačil, nihanja telesne teže, oblike pričeske, itd.), vendar je ta napaka v realnem svetu nekoliko drugačna. S prilagojenimi algoritmi bomo poskušali še izboljšati točnost identifikacije z upoštevanjem narave te napake.

Glavni cilj raziskav je razviti sistem za identifikacijo na podlagi oblike telesa, ki bo imel zadovoljivo točnost identifikacije in bo za uporabnike nemoteč.

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ANDROID DESIGN PRINCIPLES AND THEIR USE IN APPLICATION E-DOORMAN

Sanja Kovač[1], Vedrana Vidulin[2]
[1]Faculty of Computer and Information Science - University of Ljubljana
[2] Department of Intelligent Systems - Jožef Stefan Institute
e-mail: sanja.kovac@gmail.com, vedrana.vidulin@ijs.si

ABSTRACT

This paper presents basic principles for designing visually attractive and complex, but user-friendly applications in Android programming language. The principles are demonstrated on the e-doorman application, the goal of which is to provide services similar to those of a human doorman.

1 INTRODUCTION

Android operating system continually evolves. Each new version brings improvements to existing functionalities and some new concepts [1]. One of the important goals of these enhancements is to introduce new means for building beautiful, aesthetically pleasing applications that are extremely rich yet easy to understand and simple to use. In this paper, the basic guidelines for building such applications will be presented. It will also be discussed how these principles were applied in the application e-doorman[1].

2 USER INTERFACE DESIGN

Applications should be visually stunning to draw user's attention at a first glance. This can be achieved with creative design through the appropriate choices of color palette, typography, diverse layout elements and icons.

The color palette should be used to emphasize important elements of Android user interface. For example, in e-doorman application we use simple color palette, where the dominant colors are white, grey, black, with blue as the standard accent color. Different shades of colors are used to provide good contrast between components.

Because typography affects the overall appearance and understanding of presented information, it should be crisp and meaningful. In other words, font, color and size of text should be chosen for the targeted group of users. For this purpose, Android programming language offers several type families (the latest type family, Roboto, was introduced in the Ice Cream Sandwich), color styles and type sizes. If the predefined options do not suffice, they can always be customized and tailored to the needs of the application. Writing style, the second aspect of typography, should be simple, brief and should address user directly and in a friendly matter. Text should include only the necessary information and more important information should be presented first.

Attractive look of the application, as well as increased level of usability, can be achieved with the use of appropriate layout elements and icons. Android offers a variety of elements, such as tabs, lists, spinners, seek bars, check boxes, switches, date and time pickers, etc. to choose from. Elements have to be chosen in a way to present the information in the most simple and effective way and not to clutter the screen.

Icons take up very little space and have intuitive meaning, which makes them ideal to use as a representation of an action, status or a button. In e-doorman application, they are also used to represent the types of events. This enables the user to quickly scan through the list of events and to locate the events of specific type without reading the accompanying description. Appearance of an icon is different in different contexts. When used as a launcher icon, it should have distinct silhouette and should be three-dimensional. In other cases, it should be pictographic, simple and flat. For easier understanding of their meaning, it is recommended to use android-specific icons[2].

3 APPLICATION STRUCTURE AND NAVIGATION

Besides attractive design, the application should offer an understandable structure and effortless navigation through the screens.

3.1 Structure

Structure of the application depends on its content and purpose, but it always has to be intuitive. Structure defines types of layouts or views that will be used in the application. Typical application uses a top-level view and one or several of the detail/edit views**.** To avoid deep and complex navigation hierarchy, category views can be used. Figure 1 presents different views that may compose application structure [2]. The appropriate choice of the top level view is very important, because it is an entry point for the application and is the first screen that the user sees. It should

[1] Description of the application, together with images of the screens can be found on the website [3].

[2] Android-specific icons can be downloaded from website [4].

be visually interesting and should contain the most important functions and content. For example, in e-doorman the function for unlocking the door and the list of the user-specific messages were put at the top level view since they are used on a daily basis. The top level view should also provide a simple and effective navigation to the other parts of the application.

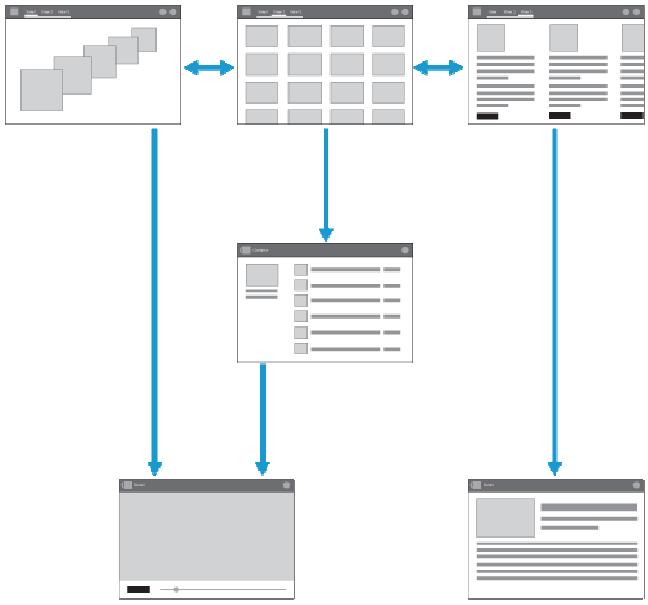


Figure 1: Example of an application structure.

3.2 Navigation

Navigation is a vital part of the user experience and has to be implemented in a consistent way. To facilitate the navigation, Android 3.0 introduced action bars and with them a new mechanisms for navigating through the application.

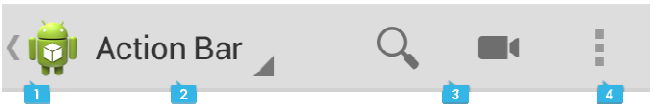


Figure 2: Action bar with the four sections: 1-application icon, 2-view control, 3-action buttons, 4-action overflow.

As shown in the Figure 2, action bar consists of application icon, view control, action buttons and action overflow [2].

Application icon has the role of establishing application's identity by showing its logo. If the screen is not the top-level view screen, a left-point caret that serves as an Up button can be put next to the icon. In comparison to the Back button, which can be hardware or software[3] implemented, Up button can only be software implemented and is used to navigate between the application screens that are on different levels of hierarchy. In comparison, Back button is used to navigate through history of screens, which the user has opened, in reverse chronologically order. Back button can also be used to dismiss floating windows and contextual action bars and hide onscreen keyboard. Sometimes Up and Back buttons behave in the same way. This occurs if previously viewed screen is also the hierarchical parent of the currently viewed screen. The additional difference between these two buttons is, that Back button can lead us to Home screen or to some other application unlike Up button, which insures us we stay inside the same application. Figure 3 shows an example on navigation with Up and Back buttons [2].

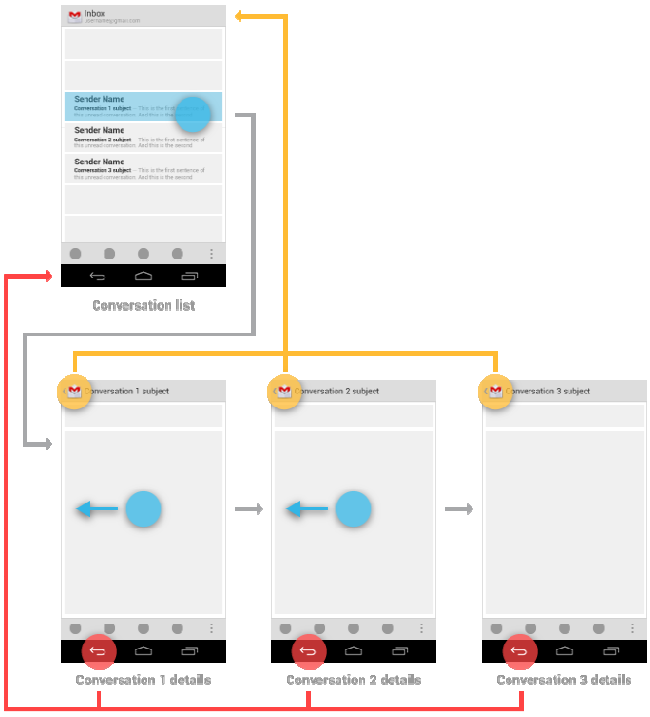


Figure 3: Behavior of the Up and Back buttons

The view control part of the action bar can be used to switch between different application views. Switching can be implemented through drop-down menus or tab controls (fixed or scrollable). The tab control is a better choice when there are a small number of views between which the user will frequent switch. In case there are a larger number of views or we have limited amount of space on the screen, it is recommended to use the drop-down menu.

Action buttons show the most important actions in the application and are used to access other parts of the application. If there is not enough space in the action bar, action buttons are moved to the overflow part of the action bar. Overflow section buttons can be accessed through the hardware menu key or through the overflow icon when such key does not exist. For each action button it can be specified when it will be shown: always, never[4], or when enough space is available[5]. When deciding which of these three options to

[3] Android 4.0 introduced *Navigation bar* positioned at the bottom of the screen, which implements the functions of hardware keys *Back*, *Home* and *Recent*.

[4] Action button will always be in the overflow menu.

[5] When there is not enough room, action button is moved to the overflow.

use, FIT scheme (F-how frequent will this action be used, I-how important this action is, T- where is it typically placed) can be used as guidance.

As an example, for the top-level navigation e-doorman application uses fixed tabs in combination with swipes for the content area. For the navigation through the lower-level screens action buttons are used.

Other common means of navigation are Navigation drawers, which are slide-out menus, and swipe gestures. Both can be used for navigation through top-level or lower-level screens.

4 USABILITY

4.1 The simplicity principle

An application should enable the user to start using it without previous training by acting in a predictable way. This means that components of the application that look the same in other applications, should also act the same. Principle that is even more important is that there should be a simple way of using the essential functionalities, but also the more complex way for more knowledgeable users.

For example, if we consider the settings screen of the application, the beginner should always feel in control and never overwhelmed with too many choices. In contrast, advanced users should have option to modify detailed settings and to customize application according to their needs. For example, e-doorman application uses a wizard that guides the user through basic settings after the first installation. After that, the user may start to use the application without further tuning its settings. For the advanced users the application offers a screen with detailed settings to further fine tune the application.

The second example of the simplicity principle in e-doorman is reflected at the main application screen. When none of the users with administrator role is at home, simple version of the main screen is shown (Figure 4 – right screen). Simple version offers only a small subset of the functionalities and is more appropriate for children and elderly. When at least one administrator is at home, complex version with all functions is shown (Figure 4 – left screen).



Figure 4: Main screen of the e-doorman application. Left-classic main screen, right- simple main screen

The third example is the "Event history" screen that lists events such as alarms, warnings, visitors, entrances and exits, etc. The beginner will use this screen to overview the complete list of events, or will filter the list using one of the tree quick filters. The advanced user may prefer to use detailed filters (event, person and time filter), searching for an event that happened in a specific time interval or was triggered by a certain person.

4.2 Feedback and instructions

Weather the users have previous experience with Android applications or are just beginners, they should always feel competent when working with the application. In each moment, they should know where in the application they are and what is happening. For this purpose, it is important that they receive feedback information from the application and the instructions on how to use application's functions.

Feedback can be given to the users through dialogs, changing components' colors, toasts, progress bars, etc. Dialogs are used throughout the e-doorman as a notification about the success of an action and for issuing warnings. Dialogs may also be used for the confirmation of user's decision or for suggesting an action. One of the basic Android design principles is that application should always decide for the user, but let him have a final say in the matter. This is achieved by issuing a suggestion through the confirmation dialog or by directly executing the action and issuing a dialog with an option to undo the action. Confirmation dialogs are also used to confirm user's decisions that cannot be undone and have major consequences as it is in the case of deleting a user or resetting the system settings in the e-doorman application.

Another way of letting know that the action was successful is through changing components' colors. For example, when a button is pressed, it can change color, which signifies that the action was performed. In e-doorman, we used this approach to inform the user in which mode the

system is. When the button changes a background color to black and a border color to blue, this signifies that the mode represented by the button is currently active. Similarly, different colors are used to show the current state of event filters. The event filters are divided into groups. For each group there is a button that indicates how many events are selected in the group and enables the user to select all or none of the events. When all events are chosen, the button is colored in blue having the label "ALL". When some of the events in the group are selected, the button is colored in grey and has the label "SOME". Finally, when none of the events is chosen, the button is colored in black and has the label "NONE".

In addition, instructions that explain the meaning of application's settings should accompany well-designed application. Instruction can be accessible in different ways and in different places, but should always be written in a simple and clear manner, without going into too many technical details. In e-doorman, different forms of instructions are offered. Hints in *EditText* fields are used for instructions on how to enter the data in a correct form and for providing the feedback when the entered data is incorrect. All settings have on site instructions that explain their meaning and how to set them. Sometimes only brief instructions are given. Then, an additional button is provided that allows the user to view the more detailed explanation. There is also a separate help page with instructions for the whole application.

5 PERSONALIZATION

One of the most obvious and simple ways for the user to personalize the application is to change the appearance of the application. There are many options how to achieve that goal: through the change of color, background, sound effects, etc. E-doorman has a setting that enables the user to choose the color of the text and the background of the application. Other ways of personalization in e-doorman are user profile pictures and recording custom greeting messages that are played on user's arrival and departure. The user may also choose the language of the application. Currently, there are two languages available: Slovenian and English.

6 FLEXIBILITY

Since Android operating system can be found on different mobile phones and tablets, it is crucial that the application is built in a way that is compatible with a wide range of devices. Android design language allows us to build applications that are very flexible and can adapt do different screen sizes, densities, languages, orientations, etc.

The code for the application is the same, the only thing that changes is the resources that are used. These resources are defined in folder *res*: folder *res/drawable* contains all graphical materials; layouts are saved in folder *res/layout*; menus are defined in folder *res/menu*; and strings for different languages are in folder *res/values*. When we want to define the resources for a specific language, the resources are put in the folder *res/values-xx*, where xx is a two-letter language code. For the pictures and icons to be shown properly, they have to be scaled (scaling ratio 3:4:6:8) and saved to the appropriate folders (*res/drawable-xx*, where xx is the specific qualifier ldpi/mdpi/hdpi/xhdpi). Similarly, the layouts may be defined for different devices. Android supports many configuration qualifiers that allows us to control which resources will be used for which device. For example, the resources may be defined for devices with specific screen density (ldpi, mdpi, hdpi, xhdpi,...), screen size (small, normal, large, xlarge), orientation (land, port), minimum screen width, etc. More about naming conventions can be found in [5]. Application always uses the most specific resources that are defined for the device on which it runs. If there are no resources defined for this specific device, general resources from *res/drawable res/menu*, *res/values*, etc. are used. E-doorman application supports 7'' and 10'' tablets with medium, high and extra high-density in portrait orientation. It comes in two languages: Slovenian and English. Language of the application can be set in the application and can be different from the language that is set on the device.

7 CONCLUSION

As we can see, Android design language is very powerful and allows us to create extremely flexible application. It offers a lot of predefined resources that can be used while developing the application. If these resources do not suffice, there is always a possibility to customize the resources and to tailor them to meet the designer's needs. If all these aspects are considered when designing the application, the result is visually attractive, complex, powerful and simple to use application.

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IMPLEMENTACIJA VIRTUALNEGA ASISTENTA V SISTEM E-VRATAR

Simon Kozina, Rok Piltaver, Damjan Kužnar, Matjaž Gams
Odsek za inteligentne sisteme
Institut »Jožef Stefan«
Jamova cesta 39, 1000 Ljubljana, Slovenija
Tel: +386 1 477 3195; fax: +386 1 477 3131
e-mail: {simon.kozina, rok.piltaver, damjan.kuznar, matjaz.gams}@ijs.si

POVZETEK

Inteligentni sistem e-vratar je mobilna aplikacija, ki običajno tablico spremeni v sistem za nadzor vstopa v stanovanje ali hišo. Ljudem, ki niso vešči uporabe sodobnih tehnologij, so takšni sistemi običajno prezahtevni za uporabo. V ta namen smo e-vratarja razširili z virtualnim asistentom, ki je sposoben komunikacije v naravnem jeziku. Zasnovan je okrog obstoječega sistema Asistent in prilagojen za delovanje na tabličnem računalniku z uporabo lokalne podatkovne baze ter razširitvijo za izvaja akcije v fizičnem svetu (npr. odklepanje vrat).

1 UVOD

Inteligentni sistem e-vratar [1] pretvori navadno tablico v celoviti sistem za nadzor vstopa v stanovanje ali hišo. Uporabniki, ki niso vešči uporabne najnovejših informacijskih rešitev, imajo pogosto težave s prilagajanjem in uporabo takšnih sodobnih sistemov. Da bi bilo upravljanje z nadzornim sistemom lažje in uporabnikom bolj prijazno, smo sistem e-vratar obogatili z možnostjo komuniciranja v naravnem jeziku – tj. implementirali smo virtualnega asistenta (VA) [2]. Ta je sposoben prepoznati veliko množico vprašanj in ukazov v naravnem, človeku razumljivem, jeziku in na njih tudi odgovoriti. VA smo dodatno razširili tako, da lahko pri generiranju odgovorov poizveduje po lokalni podatkovni bazi na tablici in zna izvajati ukaze (na primer: odklene vrata).

V nadaljevanju je predstavljeno delovanje sistema, tipi podatkov, ki jih morajo hraniti tablica in strežnik VA. Podana je tudi diskusija o različnih mogočih načinih implementacije in smiselnosti ter prednostih izbrane.

2 DELOVANJE SISTEMA

Implementacija sistema sestoji iz več različnih komponent, ki skupaj sestavljajo virtualnega asistenta v sistem e-vratar. Sledi pregled vrst vprašanj na katere odgovarja VA in bile v fazi zasnove sistema uporabljene kot uporabniške zahteve.

2.1 Tipi vprašanja za virtualnega asistenta

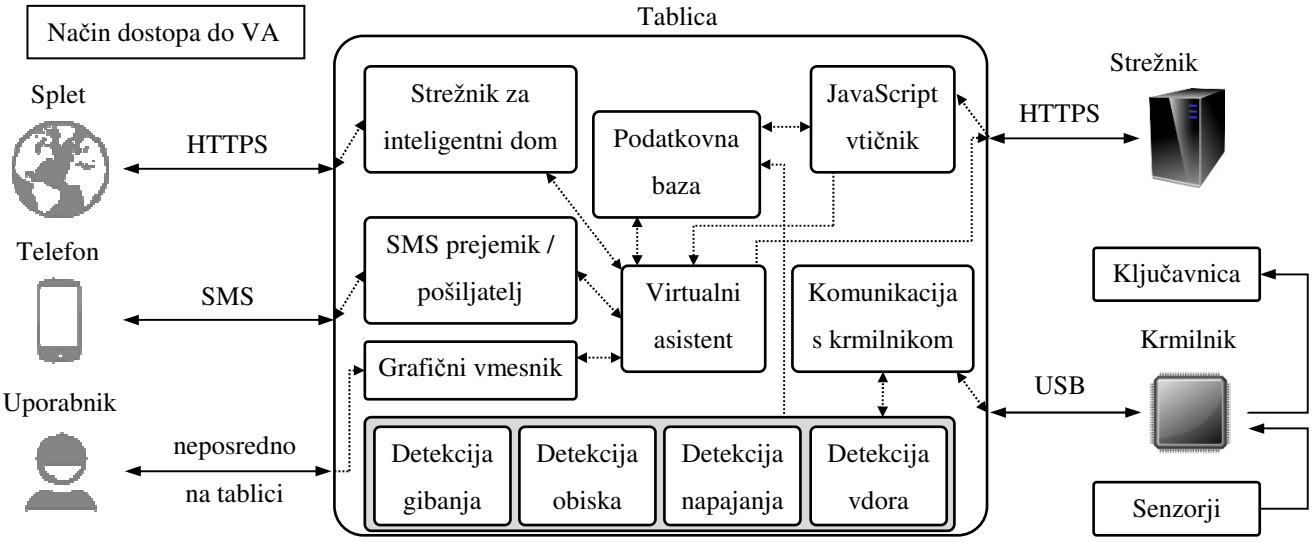
Virtualni asistent mora odgovarjati na naslednje štiri vrste vprašanj:

- čvek z uporabnikom – uporabnik lahko obravnava VA kot sogovornika in ga sprašuje o splošnih stvareh, na primer: »Kaj delaš?« in »Kako si?«
- vprašanja povezana z naročniki sistema e-vratar – VA odgovarja na poizvedbe o osnovnih informacijah povezanih s podjetji Elgoline [3], Kovinoplastika Lož [4] in INTECH-LES [5], na primer: »Kaj proizvaja Elgoline?«.
- vprašanja o stanju sistema – uporabnik lahko poizveduje o vstopih/izstopih ter prisotnosti oseb ali specifične osebe, o ostalih dogodkih in alarmih, na primer: »Ali je Janez doma?«
- vprašanja o stanju vrat in ukazih povezanih z vrati – VA odgovori ali so vrata odprta/zaprta, odklenjena/ zaklenjena in v kakšnem načinu delovanja so. Uporabni lahko poda tudi ukaz za odklepanje vrat ali spremembo načina delovanja, na primer: »Odkleni vrata!«

Naštete tipe vprašanj lahko razvrstimo v 2 različni skupini vprašanj. Prva skupina vprašanj so *statična vprašanja*, med katera spadajo čvek in vprašanja povezana s podatki o podjetjih. Ta skupina vprašanj je enaka za vse sisteme e-vratar, ki lahko delujejo na poljubni lokaciji. Vprašanja vrste čvek pa so uporabna tudi v drugih implementacijah virtualnega asistenta. Druga skupina vprašanj so *dinamična vprašanja*. Sem spadajo vprašanja povezana s stanjem sistema in s stanjem vrat. Za odgovor na ta vprašanja je poleg statičnega dela odgovora potrebna tudi poizvedba po lokalni podatkovni bazi specifične instance e-vratarja ali izvršitev ukaza na krmilniku oz. vratih. Na podlagi rezultata poizvedbe ali izvajanja akcije se formira končni odgovor, ki se ga posreduje uporabniku. Opisana raznovrstnost vprašanj je bila vodilo pri snovanju VA v sistem e-vratarja, ki je opisan v nadaljevanju.

2.2 Shema sistema

Shema sistema je prikazana na Sliki 1. Levo so našteti načini, preko katerih je mogoče uporabljati virtualnega asistenta:



Slika 1: Shema sistema

- Splet – uporabnik lahko dostopa do spletnega strežnika sistema e-vratar, ki posreduje vprašanje VA.
- Telefon – z uporabo namenske aplikacije na pametnem telefonu z operacijskim sistemom Andorid, ki preko SMS komunicira z VA.
- Tablica – z uporabo grafičnega uporabniškega vmesnika na tablici.

V okviru aplikacije e-vratar na tablici deluje večje število programskih modulov. Na Sliki 1 so prikazani samo tisti, ki so pomembni za delovanje VA:

- Strežnik za inteligentni dom – deluje kot vmesnik med VA in uporabnikom na spletu.
- Modul za sprejem in pošiljanje SMS – deluje kot vmesnik med VA in aplikacijo za Android telefon.
- Grafični uporabniški vmesnik – skrbi za neposredno komunikacijo med sistemom e-vratar in uporabnikom.
- Virtualni asistent – prejme vprašanje iz kateregakoli vira in ga posreduje v obdelavo strežniku VA ter skrbi za posredovanje odgovora uporabniku.
- JavaScript vtičnik [6] – interpretira odgovore posredovane iz strežnika za VA in jih pošlje naprej modulu VA.
- Podatkovna baza – hrani podatke o vsem, kar se dogaja s sistemom e-vratar.
- Komunikacija s krmilnikom – skrbi za prenos senzorskih podatkov iz krmilnika in ukazov za ključavnico na krmilnik.
- Detekcije gibanja/obiska/napajanja/vdora – se izvajajo na podlagi podatkov, ki jih priskrbi Arduino krmilnik. V primeru detekcije se le-ta zapiše v podatkovno bazo.

Na sliki 1 sta na desni strani prikazani še dve enoti pomembni za delovanje VA. Prva je strežnik na katerem teče program virtualnega asistenta. Ta skrbi za pravilno transformacijo vprašanja v odgovor. Strežnik se nahaja ločeno od tablice (tablica je pri uporabniku, uporabnikov je lahko poljubno mnogo). Druga enota je krmilnik, ki je preko USB povezan s tablico. Krmilnik upravlja delovanje ključavnice in sprejema vhode iz različnih senzorjev (pospeškomer, PIR senzor, RFID, prstni odtis, odprtost in odklenjenost vrat) ter vse informacije pošilja na tablico.

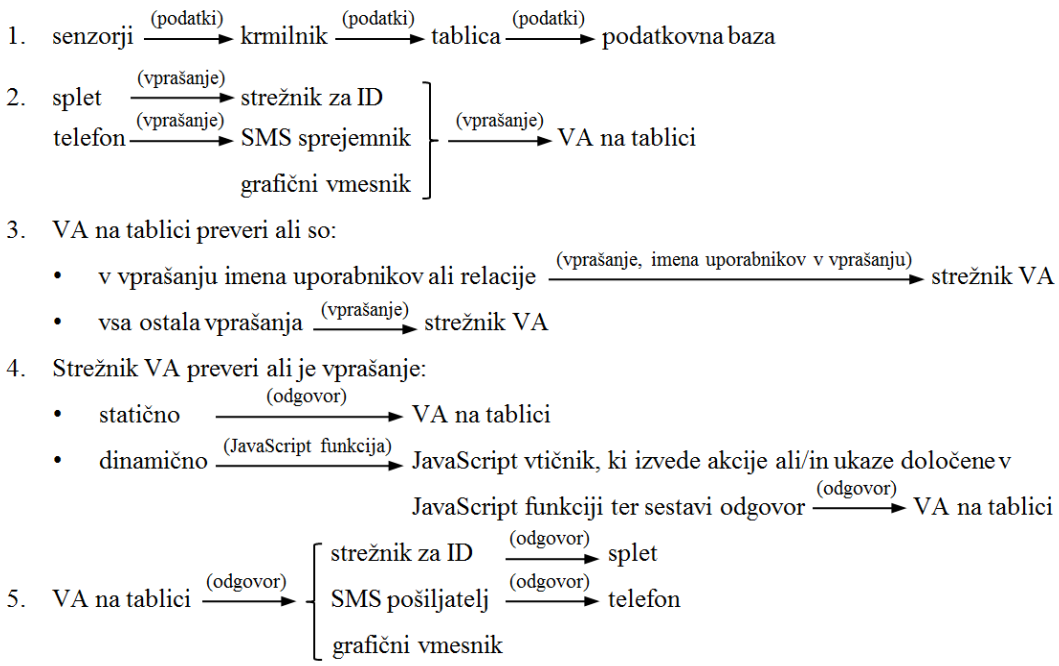
2.3 Postopek delovanja sistema

Postopek delovanja sistema je prikazan na Sliki 2. Postopek pod točko 1. je neodvisen od delovanja virtualnega asistenta in je ključnega pomena za zagotavljanje pravilnega odgovarjanja na dinamična vprašanja, saj so pri tem potrebni podatki, ki so shranjeni v bazo.

Kot je bilo izpostavljeno že zgoraj, tablica prejme vprašanje iz različnih virov in ga posreduje modulu VA (Slika 2, točka 2). Preden ga ta posreduje naprej, preveri, ali se v vprašanju pojavijo imena uporabnikov (npr. Janez) ali kakšne sopomenke za relacije med uporabniki (npr. žena, mož, otroci). Če najde ujemanje, pošlje strežniku tudi imena uporabnikov, ki jih je prepoznal v vprašanju, sicer pa samo vprašanje (Slika 2, točka 3). Strežnik za VA nato preveri ali je vprašanje statično ali dinamično: izlušči ključne besede in jih primerja z zapisi v bazi vprašanj in odgovorov ter vrne odgovor (Slika 2, točka 4). Odgovor je, tako kot vprašanja, lahko dveh tipov. Prvi tip so odgovori na statična vprašanja, ki so zapisani v bazi in se ne spreminjajo. Takšni odgovori se lahko takoj posredujejo VA na tablici. Drugi tip so odgovori na dinamična vprašanja; tak odgovor je podan kot JavaScript funkcija, ki vsebuje pravila za sestavljanje odgovora in ukaze za poizvedbo po podatkovni bazi ali/in ukaze za spreminjanje stanj vrat. Primer preproste JavaScript funkcije:

```
stanje = window.myHandler.checkDoorOpen();
if(!stanje){x = 'Vrata so odprta. '}else{x =
' Vrata so zaprta.'
```

Vsi odgovori v obliki funkcije se posredujejo JavaScript vtičniku implementiranem v e-vratarju. Ta funkcije izvede, sestavi odgovor in ga posreduje modulu



Slika 2: Postopek delovanja sistema

VA (Slika 2, točka 4). Funkcija zapisana v primeru zgoraj, preveri ali so vrata odprta in glede na rezultat poizvedbe poda odgovor: »Vrata so odprta.« ali »Vrata so zaprta.«. Modul VA na tablici nato samo še posreduje odgovor ustreznemu pošiljatelju (Slika 2, točka 5).

3 OPIS PODATKOVNIH BAZ

Virtualni asistent za delovanje uporablja dve ločeni podatkovni bazi. Prva se nahaja na tablici, saj hramba osebnih podatkov, ki se nahajajo na tablici, ni zaželena na strežniku VA zaradi zasebnosti. Druga podatkovna baza se nahaja na strežniku VA. Tako so vsi odgovori poenoteni med različnimi tablicami, lažje je tudi vnašanje novih odgovorov in popravljanje obstoječih. Obe podatkovni bazi sta podrobneje opisani v nadaljevanju.

3.1 Podatkovna baza na tablici

Podatkovna baza na tablici je sestavljena iz velikega števila tabel, ki vsebujejo nabor podatkov od samih podatkov o uporabnikih do nastavitev grafičnega vmesnika. V nadaljevanju so predstavljene samo 3 tabele, ki so relevantne za pravilno delovanje VA:

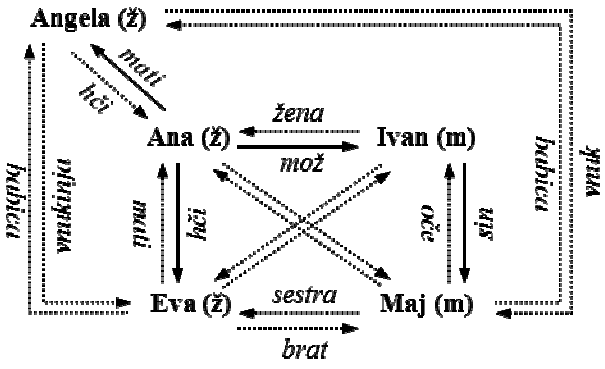
- tabela dogodki – v njej so podatki o vstopih/izstopih oseb, o alarmih in tipih alarmov ter dogodkih, ki spremenijo delovanje e-vratarja.
- tabela vrata – tukaj so podatki o odprtosti/zaprtosti vrat in o tem ali so vrata odklenjena
- tabela uporabniki – vsak uporabnik je unikatno določen s svojim imenom, poleg imena so v tabeli shranjeni še kazalci na tabelo relacij in podatki o RFID kartici in prstnih odtisih posamezne osebe ter stanje prisotnosti uporabnika.
- tabela relacije – vsebuje vse možne relacije, ki se pojavijo v običajni družini, njihove sopomenke, obratne relacije in spola na katera se relacija nanaša. Primer takšne relacije:

```
žena, draga/ljuba, mož, ž, m
```

V zgornjem primeru je opisana relacija žena, s sopomenkama draga in ljuba. Obratna relacija je mož, relacija žena pa se nanaša na žensko in moškega – v tem vrstnem redu.

Ker bi bilo vpisovanje vseh relacij za uporabnika preveč zamudno, je sistem zasnovan tako, da ta zahteva le vnos potrebnih relacij, preostale pa generira avtomatsko in doda k opisu uporabnika v tabelo uporabniki.

Primer avtomatskega generiranja relacij je predstavljen na Sliki 3. Relacije označene s polno črto so uporabniki vnesli ročno, relacije označene s črtkano črto, pa so generirane avtomatsko.



Slika 1: Avtomatsko izpolnjevanje relacij

3.2 Podatkovna baza na strežniku virtualnega asistenta

Na strežniku je podatkovna baza sestavljena iz tabele, ki hrani ključne besede za prepoznavanje vprašanja in odgovore. V tabeli se nahajajo 4 pomembna polja:

- tip odgovora – določa ali je odgovor statičen ali dinamičen
- ključne besede – namenjene za lažjo preslikavo vprašanja v odgovor
- utež – v primeru prekrivanja ključnih besed pri več različnih odgovorih se uporabi tistega z večjo utežjo. Tako se npr. zagotovi, da imajo dinamični odgovori vedno prednost pred statičnimi.
- odgovor – je lahko podan kot končni odgovor v obliki besedila ali pa kot JavaScript funkcija za dinamična vprašanja.

4 DISKUSIJA O ODLOČITVI ZA IZBRANO IMPLEMENTACIJO

V postopku izbire načina implementacije VA v sistem e-vratar smo obravnavali 5 možnih rešitev. Odgovori statičnega tipa ne predstavljajo problema in so pri vsaki rešitvi shranjeni na strežniku VA. Vsaka rešitev je osredotočena na odgovarjanje na dinamična vprašanja in je predstavljena v nadaljevanju. Izpostavljene so tudi slabosti in prednosti določenih implementacij.

Inteligenca na tablici – Odgovori dinamičnega tipa so shranjeni kot imena funkcij, ki se izvedejo na tablici. Rešitev ni primerna, ker je bistven del odgovora vezan na obstoječo programsko opremo na tablici in je zato težko popravljati ali dodajati nove dinamične odgovore.

Prenos trenutnega stanja tablice na strežnik VA – Skupaj s vprašanjem se na strežnik pošlje tudi vsebina podatkovne baza tablice in trenutno stanje sistema. Strežnik nato sam sestavi odgovor. Kljub temu, se morajo na tablico poslati ukazi za izvajanje akcij in vrniti rezultati izvajanja na strežnik. Rešitev ni primerna, ker vsebuje nepotreben prenos podatkov in zmanjšuje zasebnost uporabnikov zaradi pošiljanja vsebine baze na strežnik VA.

Inteligenca na strežniku VA – Strežnik po prejetem vprašanju pošlje tablici seznam akcij in poizvedb. Rezultati izvajanja na tablici se vrnejo na strežnik, ki sestavi odgovor in ga nato pošlje na tablico. Slabost te rešitve je, da sta potrebna dva prenosa podatkov iz tablice na strežnik in nazaj. Prednost je, da so vsi odgovori in logika shranjeni na strežniku in je zato urejanje in dodajanje novih odgovorov neodvisno od tablice.

Distribuirana inteligenca (JSON objekti) – Kot odgovor strežnik tablici pošlje JSON objekt v katerem je definiran seznam akcij in poizvedb ter način formatiranja odgovorov. Prednost tega pristopa je, da so vsi odgovori na strežniku, torej jih je enostavno popravljati, in da gre za en sam prenos od tablice do strežnika in nazaj. Manjša slabost je, da mora biti logika za oblikovanje odgovora na tablici, kjer je malo več omejitev za implementacijo kot na strežniku. Večja težava je, da imamo pri takšni implementaciji na voljo le vnaprej določene funkcije (preko programskega vmesnika), ki bodo dejansko implementirane na tablici in jih ni mogoče enostavno dodajati (potreben popravek izvorne kode aplikacije za tablico, prevajanje, nalaganje na splet, posodabljanje aplikacije na vseh tablicah). S pravilno in dovolj široko zasnovanim programskim vmesnikom se te težavi lahko izognemo. Druga manjša težava je sestavljanje JSON objektov, še posebej, če je v odgovoru več poizvedb, saj tako narašča kompleksnost in število različnih odgovorov.

Distribuirana inteligenca (JavaScript funkcije) – Kot odgovor strežnik pošlje JavaScript funkcijo, ki izvede potrebne akcije in poizvedbe z uporabo programskega vmesnika, ki ga nudi sistem e-vratar na tablici, in oblikuje odgovor. Rešitev je podobna tisti z JSON objekti, vendar pa je še bolj splošna, saj je za oblikovanje odgovorov na voljo »Turingov stroj« (JavaScript), vendar je za delovanje potrebno vgraditi JavaScript vtičnik v aplikacijo na tablici. Ta interpretira funkcijo, se poveže s programskim vmesnikom, ki nato poskrbi za izvajanjem poizvedb in akcij, ter sestavi odgovor. Podobno kot pri JSON odgovorih, je potrebno zagotoviti da v JavaScript funkcijah ni napak.

5 ZAKLJUČEK

Predstavili smo implementacijo virtualnega asistenta v sistem e-vratar. Implementacija je zasnovana upoštevajoč različne tipe vprašanj (statična in dinamična) in skrbi za ohranjanje zasebnosti uporabnikov. V ta namen se generiranje odgovorov izvaja na distribuiran način s pomočjo JavaScript funkcij, saj se osnovni odgovori nahajajo na centralnem strežniku, nato pa se po potrebi (v primeru dinamičnih odgovorov) izvedejo akcije še na tablici, da se tako sestavi končni odgovor.

Uporabnikom je s to implementacijo omogočeno upravljajo s sistemom e-vratar tudi z uporabo naravnega jezika, kar je za uporabnike, nevešče uporabe sodobnih informacijskih tehnologij, velika prednost. Hkrati je zaradi distribuirane arhitekture zagotovljena varnost in zasebnost uporabnikovih podatkov ter možnost centraliziranega urejanja baze odgovorov.

Reference

[1] M. Pušnik, R. Piltaver, V. Vidulin, M. Gams. Inteligentni sistem e-vratar. *V Zborniku 16. mednarodne multikonference Informacijska družba*. 2013.

[2] D. Kužnar, A. Tavčar, M. Gams. Virtualni asistent. *V Zborniku 16. mednarodne multikonference Informacijska družba*. 2013.

[3] Elgoline, http://www.elgoline.si/.

[4] Kovinoplastika Lož, http://www.kovinoplastika.si/.

[5] Intech-les. http://www.intechles.si/.

[6] Rhino JavaScript Engine, www.mozilla.org/rhino.

VIRTUALNI ASISTENT

Damjan Kužnar, Aleš Tavčar, Matjaž Gams
Odsek za inteligentne sisteme
Institut »Jožef Stefan«
Jamova cesta 39, 1000 Ljubljana, Slovenija
e-mail: damjan.kuznar@ijs.si, ales.tavcar@ijs.si, matjaz.gams@ijs.si

POVZETEK

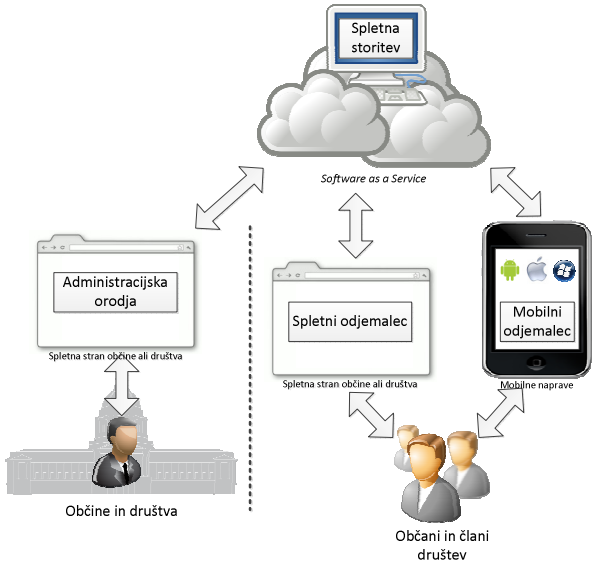
Opisan je del novosti v sistemuAsistent, ki omogoča enostavno kreiranje, skrbništvo in uporabo virtualnih asistentov kot dopolnilno storitev na spletnih straneh ter kot samostojno aplikacijo na mobilnih platformah.
Implementacija temelji na principu Software as a Service, kar bistveno olajša namestitev in vzdrževanje sistema ter posledično znižuje stroške za naročnike.

1 UVOD

Spletne strani večjih podjetij, raznih institucij, ministrstev ter občinskih uprav so pogosto zelo obsežne in z zelo kompleksno navigacijsko strukturo, ki obiskovalcem otežuje iskanje informacij, ki jih potrebujejo. Ta problem poskušajo odpraviti virtualni asistenti, ki obiskovalcem pomagajo pri iskanju informacij, z njimi pa je mogoče interaktirati v naravnem jeziku s čimer se uspešno zakrije vsa kompleksna struktura v ozadju. Takšen način je obiskovalcem, še posebej tehnično manj veščim, veliko bolj domač, saj lahko iščejo informacije v obliki specifično zastavljenih vprašanj, na katere virtualni asistent poskuša odgovoriti.
V tem prispevku opisujemo virtualnega asistenta, ki je bil razvit v sklopu projekta Asistent [1] in v času pisanja tega prispevka že deluje pri petih naročnikih. Pri razvoju so bile upoštevane moderne smernice razvoja in distribucije programske opreme. Tako je bila razvita spletna storitev, ki deluje v oblaku, kar naročnikom virtualnega asistenta močno olajša uporabo, spletni odjemalec, ki komunicira z obiskovalci spletne strani, in aplikacije za pametne mobilne telefone, ki močno olajšajo uporabo storitve z mobilnih napravah.

2 ARHITEKTURA SISTEMA

Storitev, ki podpira kreiranje, upravljanje in uporabo virtualnih asistentov, je razvita po principu Software as a Service (SaaS) [2], kar prinaša vrsto pozitivnih učinkov za naročnike, npr. odpade potreba po nakupu in vzdrževanju strojne opreme, ker programska oprema teče v oblaku, ter odpade potreba po nameščanju in vzdrževanju programske opreme.



Slika 1: *Modularna zasnova sistema.*

Sistem sestoji iz naslednjih komponent:

- Spletna storitev v oblaku, ki po principu SaaS omogoča naročnikom in uporabnikom enostavno uporabo.
- Spletni odjemalec, ki ponuja obiskovalcem spletnih strani grafični vmesnik za komunikacijo z virtualnim asistentom.
- Mobilni odjemalci v obliki mobilnih aplikacij za platforme Android, iOS, BlackBerry in Windows Phone 8, ki omogočajo komunikacijo z virtualnim asistentom, prilagojeno za mobilne telefone.
- Administracijska orodja za upravljanje z virtualnimi asistenti, ki omogočajo naročnikom, da svojega asistenta prilagodijo za svoje potrebe. Orodja so dostopna preko brskalnika in zaščitena z geslom.

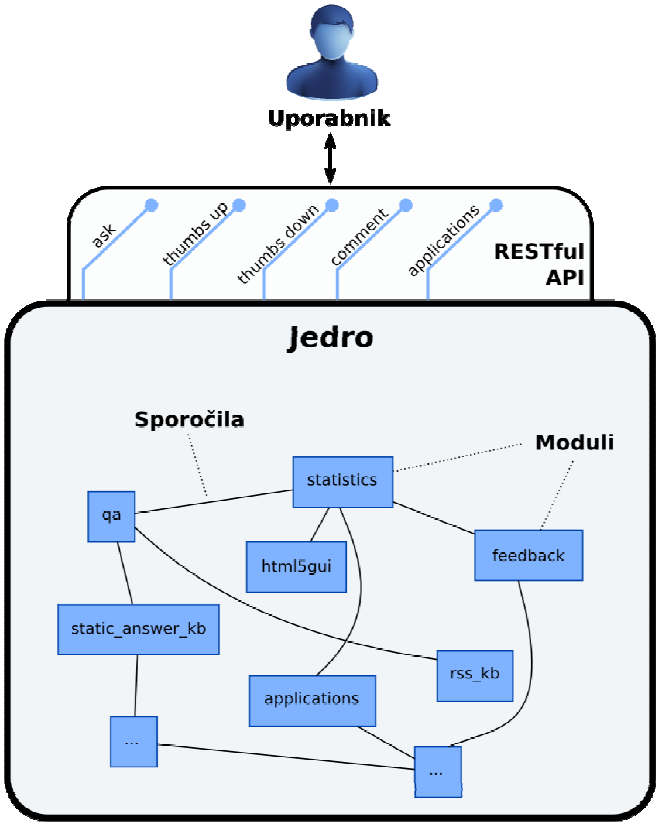
3 SPLETNA STORITEV

Bistvena lastnost sistema je njegova modularnost, ki temelji na principih večagentnih sistemov [3]. To se odraža tako, da so vse funkcije sistema implementirane kot samostojni moduli (oz. agenti) med katerimi obstajajo mehanizmi za komunikacijo, za katero skrbi jedro sistema, ki igra podobno vlogo kot platforma v večagentnih sistemih. Slika 2 prikazuje komponente sistema, ki bodo opisane v nadaljevanju.

3.1 Jedro

Jedro sistema implementira naslednje funkcije sistema, ki omogoča modulom, da razširijo osnovno funkcionalnost sistema:

- Upravljanje modulov, kar zajema prepoznavanje, nameščanje, posodabljanje, poganjanje in ustavljanje modulov. Sistem za virtualne asistente ima na voljo kopico modulov, ki pa jih je možno po želji ustaviti in tako na primer pohitriti delovanje.
- Nudi funkcije za registracijo in proženje dogodkov ter registracijo za prejemanje proženih dogodkov. Ob proženju dogodka lahko moduli pošiljajo tudi sporočilo, ki je poljubne oblike, kar omogoča komunikacijo med moduli.
- Omogoča modulom, da definirajo funkcije RESTful API-ja [4]. To pomeni, da lahko vsak modulov definira funkcijo, katero lahko kličejo uporabniki oz. klienti (npr. spletni asistent ali mobilna aplikacija), ki jih uporabljajo uporabniki.
- Omogoča dostop do relacijske podatkovne baze, kjer lahko moduli shranjujejo podatke, potrebne za svoje delovanje.
- Omogoča dostop do datotečnega sistema za module, ki morajo imeti možnost pisanja in branja datotek.



Slika 2: *Modularna zasnova sistema.*

3.2 Moduli

Moduli so neodvisni deli funkcionalnosti, ki razširjajo osnovni nabor zmožnosti sistema. Sama modularnost omogoča, da sistem opravlja poljubne naloge, vendar ta prispevek opisuje module sistema za virtualnega asistenta. Med najpomembnejšimi moduli so:

- `qa`: modul, ki prejema vprašanja od uporabnika, jih posreduje modulom za odgovarjanje in izbira najbolj primeren odgovor na podlagi definiranega postopka.
- `html5gui`: modul, ki implementira grafični vmesnik virtualnega asistenta oz. vmesnik, s katerim uporabniki interaktirajo na spletnih straneh.
- `*_kb` (npr. static_answer_kb): moduli za odgovarjanje, ki pridobivajo odgovore na različne načine. Npr. rss_kb pridobiva odgovore iz RSS virov.
- `applications`: modul za urejanje aplikacij (vsak modul lahko definira svojo aplikacij), ki jih nudi virtualni asistent poleg osnovne funkcionalnosti odgovarjanja na vprašanja.

Obstoječ sistem vsebuje še kopico drugih modulov, ki zagotavljajo odgovore na vprašanja, omogočajo lažje skrbništvo nad sistemom, beležijo pogovore med uporabniki in sistemom, itd.

3.3 Sporočila

Sporočila med moduli se prenašajo ob nastopu dogodkov (npr. ob podanem vprašanju uporabnika) znotraj sistema. Dogodke lahko definira jedro ali modul, ki hkrati definira tudi strukturo sporočila, ki se bo ob proženja dogodka poslalo vsem modulom, ki so se registrirali na prejemanje sporočil ob nastopu določenega dogodka. Moduli, ki prejmejo sporočilo, lahko rezultate svojega procesiranja nato posredujejo nazaj modulu, ki je dogodek sprožil, ter tako gradimo kompleksne postopke procesiranja.

3.4 RESTful API

Za sistem je bistveno, da je sposoben komunicirati z zunanjim svetom, kar je doseženo z API-jem v obliki spletne storitve, ki se podreja specifikaciji REST [5]. Vsa komunikacija med uporabniki in sistemom gre preko tega vmesnika, za kar ponavadi skrbijo namenski klienti, kot sta npr. HTML5 klient za spletne strani in aplikacije za mobilne platforme.

Najpomembnejše funkcije, ki jih nudi API za virtualnega asistenta so:

- `/ask` (HTTP GET metoda)
  - Vhodni parametri:
    - `question`: vprašanje, na katerega želimo asistentov odgovor.
    - `context` (opcijsko): kontekst, znotraj katerega se sprašuje (npr. o vlogah in obrazcih občinske uprave). Razpoložljive kontekste se dobi preko funkcije `/applications`.
  - Odgovor:

        - `answer`: odgovor virtualnega asistenta v HTML formatu.
        - `id`: zaporedna številka odgovora, ki kasneje služi za ocenjevanje in komentiranje odgovora.
        - `url` (opcijsko): spletna stran, ki je povezana z odgovorom. V primeru uporabe spletnega klienta, se stran samodejno odpre v ozadju, v primeru mobilnih aplikacij ima uporabnik možnost odpreti povezavo v integriranem brskalniku.
- `/vote/id/up` (HTTP POST metoda)
    - Vhodni parametri:
        - `id` del poti zamenjamo z vrednostjo, ki smo jo dobili kot del odgovora pri klicu funkcije `/ask` in ki predstavlja številko odgovora. Primer: klic povezave `/vote/42/up` posreduje pozitivno oceno za odgovor z zaporedno številko 42.
    - Funkcija ne vrača odgovora
- `/vote/id/down` (HTTP POST metoda)
    - Enako kot `/vote/id/up`, le da v tem primeru oddajamo negativno oceno. V primeru več oddanih ocen za isti odgovor, se upošteva zadnja oddana ocena.
- `/comment/id` (HTTP POST metoda)
    - Vhodni parametri:
        - `id`: številka odgovora, na katerega se nanaša komentar.
        - `comment`: komentar na odgovor.
        - `name_and_surname` : ime in priimek komentatorja.
        - `email` (opcijsko): Elektronski naslov komentatorja.
    - Funkcija ne vrača odgovora

Vse funkcije vračajo odgovore v JSON notaciji [6], razen če klient ob klicu definira vhodni parameter `callback`, v katerem primeru storitev vrne odgovor v JSONP notaciji [7].

5 SPLETNI ODJEMALEC

Spletni odjemalec se uporablja za integracijo virtualnega asistenta na spletno stran naročnika. Mogoče je, da se odjemalec prikaže samodejno ob obisku spletne strani ali pa preko klika na povezavo, ki dinamično zažene asistenta.

Spletni odjemalec po zagonu lebdi nad vsebino spletne strani in ga je mogoče poljubno premikati, kar omogoča, da uporabnik tudi naprej brska po spletni strani v ozadju. Ob vpisu vprašanja v vnosno polje spletni odjemalec od spletne storitve pridobi odgovor in ga prikaže v polju pod vnosnim poljem, hkrati pa v ozadju odpre z odgovorom povezano spletno stran, če ja ta bila navedena s strani skrbnika virtualnega asistenta. Takšen način delovanja omogoča, da se v spletne odjemalcu prikaže povzetek odgovora, obiskovalec pa je povabljen, da pridobi bolj podrobne informacije iz spletne strani, če ga te zanimajo.



Slika 3: *Primer virtualnega asistenta na občini Pivka.*

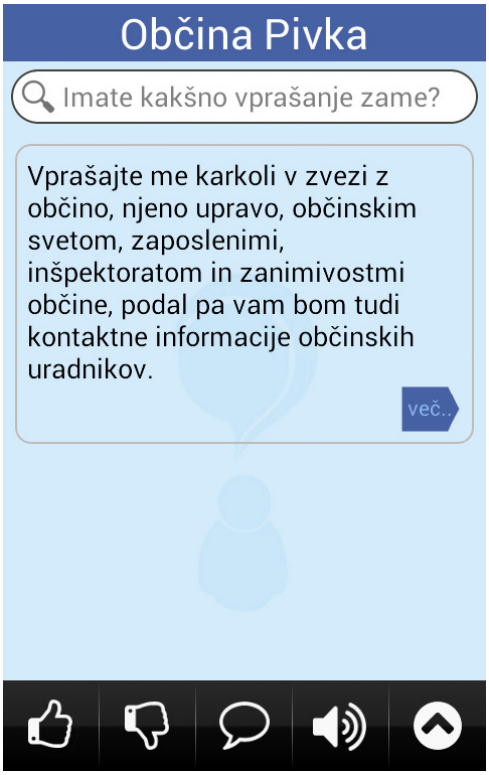
Poleg običajnega delovanja omogoča naš sistem tudi uporabo aplikacij, ki so dosegljive preko menija. Aplikacije so razširitve oziroma dopolnitve osnovne funkcionalnosti, saj omogočajo uporabo posebnih storitev, npr. rezervacija vstopnic s pomočjo asistenta, ali da osredotočimo iskanje odgovorov na neko specifično področje, npr. vloge in obrazci občine. Pomembno je izpostaviti, da ima lahko vsak naročnik svoj nabor aplikacij, ki jih želi nuditi svojim obiskovalcem.

6 MOBILNE APLIKACIJE

Komunikacija z virtualnim asistentom je možna tudi preko mobilnih naprav, in sicer s posebej prilagojenim vmesnikom za majhne zaslone, saj je uporaba spletnega vmesnika na mobilnih napravah nerodna, še posebej za tehnično nevešče uporabnike. Uporaba mobilnih aplikacij je pomembna iz več razlogov. V prvi vrsti je to podpora mobilnosti, saj lahko uporabnik iz kjerkoli povpraša asistenta določeno vprašanje. Npr. Kje v občini lahko najdem lekarno? Asistent hitro najde pravilen odgovor in uporabniku ponudi seznam lekarn v neki občini, s pripadajočim delovnim časom.

Razvili smo mobilne aplikacije za štiri trenutno najpopularnejše mobilne platforme: Android, iOS, BlackBerry 10, Windows Phone 8. Vse mobilne aplikacije

so si po funkcionalnostih enakovredne, podoben je tudi grafični vmesnik. Na sliki 4 je prikazana zaslonska slika mobilne aplikacije za Android sisteme. Na zgornji strani zaslona je vnosno polje, kjer uporabnik vpiše vprašanje. Pod vnosnim poljem je prostor za odgovor asistenta, spodaj pa orodna vrstica, kjer najdemo vse funkcionalnosti sistema.



Slika 4: *Osnovna zaslonska slika mobilne aplikacije Asistent* .

Funkcionalnosti mobilne aplikacije so identične tistim, ki jih najdemo pri spletnem vmesniku. Uporabnik v iskalno polje vpiše vprašanje, na kateri želi odgovor, aplikacija pošlje poizvedbo na strežnik, kateri vrne najustreznejši odgovor. V spodnji orodni vrstici se nahajajo preostale funkcije asistenta. Omogočeno je glasovanje o določenem odgovoru (pozitivna in negativna ocena), uporabnik lahko poda komentar na nek odgovor, aplikacija omogoča sintetizacijo govora in s tem branje odgovora, ter omogoča izbiranje ene izmed aplikacij, ki jih ponuja asistent.

Zaradi enotne mobilne aplikacije in manjših zaslonov na mobilnih napravah smo določene funkcionalnosti spremenili in jih prilagodili za mobilne naprave. Spletna stran, ki vsebuje podrobnejše informacije in se na spletnem odjemalcu prikaže v ozadju, je tukaj dosegljiva preko gumba »več..«. Prav tako ni mogoče objaviti ločeno mobilno aplikacijo za vsakega asistenta posebej in zato lahko znotraj aplikacije uporabnik izbere iz seznama asistentov željeno instanco. Seznam asistentov se najprej prikaže ob prvem zagonu aplikacije, kasneje pa je dosegljiv preko nastavitev aplikacije. Mobilna aplikacija je prilagojena tudi za starejše in slabovidne, saj poleg sintetizacije govora omogoča povečanje velikost pisave celotnega grafičnega vmesnika.

Z razvojem mobilnih aplikacij smo želeli asistenta še bolj približati uporabnikom in omogočiti njegovo vsakodnevno rabo.

7 ZAKLJUČEK

V pričujočem prispevku smo predstavili spletno storitev Asistent, ki predstavlja ogrodje za kreiranje in vzdrževanje virtualnih asistentov.

Storitev deluje na najnaprednejših tehnologijah in ena bistvenih lastnostih je modularnost zasnove, ki omogoča hitro dodajanje novih funkcionalnosti. Zato je ta storitev primerna za široko paleto naročnikov od občin, društev, do javnih in zasebnih podjetij, ki imajo svoje specifične zahteve.

Zahvala

Delo je financiralo Ministrstvo za izobraževanje, znanost in šport preko javnega razpisa za sofinanciranje projektov razvoja e-storitev in mobilnih aplikacij za javne in zasebne neprofitne organizacije 2012-2013 (JR ESMA JZNO 2012-2013).

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E-TURIST: INTELIGENTNI ELEKTRONSKI TURISTIČNI VODNIK

Mitja Luštrek, Boštjan Kaluža, Božidara Cvetković, Hristijan Gjoreski
Institut Jožef Stefan, Odsek za inteligentne sisteme
Jamova cesta 39, 1000 Ljubljana, Slovenija
Telefon: +386 1 4773380; telefaks: +386 1 4773131
E-pošta: {mitja.lustrek, bostjan.kaluza, boza.cvetkovic, hristijan.gjoreski}@ijs.si

POVZETEK

Turist, ki se ne želi udeležiti organiziranega izleta, bi si pa rad v omejenem času kar najbolje ogledal nek kraj, potrebuje dober program ogleda in primerne opise znamenitosti na programu. Sestaviti tak program z uporabo obstoječih publikacij in spletnih strani ni vedno lahko. Sistem e-Turist za turista pripravi program ogleda, prilagojen njegovim željam, in ga s pomočjo mobilne aplikacije na ogledu vodi. Ponudi mu pisne in govorne opise znamenitosti, turist pa lahko znamenitosti tudi oceni. Za pripravo programa ogleda sistem uporablja priporočilni sistem, ki izkorišča ocene turistov, in metode za iskanje najkrajše poti z najzanimivejšimi znamenitostmi. Del sistema so tudi administrativne strani, ki turističnim delavcem omogočajo vnos podatkov o znamenitostih ter pregled obiska in ocen obiskovalcev.

1 UVOD

Turizem je z napovedano 4-odstotno rastjo ena najhitreje rastočih gospodarskih panog na svetu, po podatkih Svetovne turistične organizacije pa je svet leta 2012 zabeležil že milijardo mednarodnih turističnih prihodov [9]. Slovenija se turistično že več kot desetletje razvija pretežno hitreje od svetovnega povprečja in tudi v letu 2012 je zabeležila 6-odstotno povečanje števila mednarodnih prihodov [7]. Kljub temu pa v boju za turiste ne gre popuščati in sodobne tehnologije so lahko v njem pomembno orožje. Spričo silovitega razmaha pametnih telefonov v zadnjih letih se zdijo posebej primerne mobilne aplikacije. To potrjuje podatek, da si trenutno približno polovica potnikov lasti pametne telefone, polovica teh pa telefone uporablja tudi za potrebe potovanja; pričakovati je, da se bosta ta dva deleža v prihodnjih letih še povečala [4].

Turist, ki si želi v omejenem času kar najbolje ogledati nek kraj, potrebuje dober program ogleda in primerne opise znamenitosti na programu. Organizirane skupine turistov si navadno ogledajo le najpomembnejše, širše zanimive in vnaprej določene turistične znamenitosti, pri čemer jih vodi usposobljen vodič. Za posamične turiste in majhne skupine pa so privlačne tudi znamenitosti, ki so manj znane, a morda zanimive prav zanje. Ti usposobljenega vodiča nimajo na voljo ali pa ga niti ne želijo, zato informacije o znamenitostih iščejo sami, pa tudi program ogleda si sestavijo sami. To običajno ni lahka naloga, saj so turistične informacije razdrobljene po raznih publikacijah in spletnih straneh, pri sestavljanju programa pa je treba poleg privlačnosti znamenitosti upoštevati tudi njihovo zemljepisno razporeditev, odpiralne čase in še kaj.

Sistem e-Turist sestavljajo mobilne aplikacije in spletna aplikacija [2], ki si prizadevajo posamičnim turistom in majhnim skupinam ponuditi izkušnjo, kakršno bi omogočil usposobljen vodič, ki bi ogled pripravil prav zanje. Turist v aplikacijo vnese svoja zanimanja (zabava, aktivni turizem, gastronomija, kulturna in naravna dediščina), čas ogleda, ali si med ogledom želi kosilo ter po želji tudi svoj profil (starost, spol, gibalne omejitve ...). Na podlagi tega aplikacija pripravi program ogleda, prilagojen turistovim zahtevam. V ta namen uporablja priporočilni sistem in metode za iskanje najkrajše poti z najzanimivejšimi znamenitostmi. Poleg tega aplikacija turista s pomočjo GPSa vodi in mu pri vsaki znamenitosti postreže s pisnim in govornim opisom. Vsako znamenitosti obiskovalec lahko tudi oceni, kar priporočilni sistem upošteva pri pripravi programov ogleda v prihodnje. Del sistema e-Turist so tudi administrativne strani, ki turističnim delavcem omogočajo vnos opisov znamenitosti in njihovih metapodatkov ter pregled obiska znamenitosti in ocen obiskovalcev.

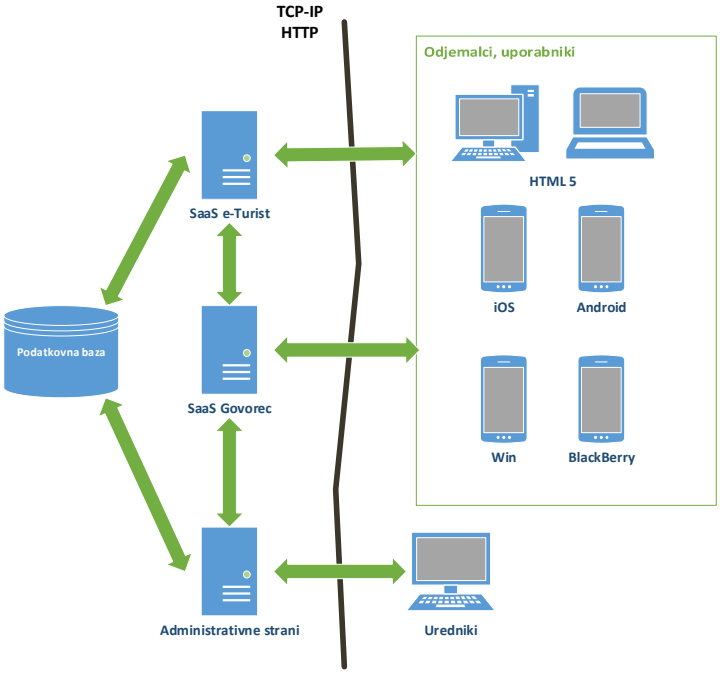
2 ARHITEKTURA SISTEMA

Sistem e-Turist je zasnovan kot spletna storitev (software as a service, SaaS), do katere uporabniki dostopajo prek odjemalcev na mobilnih platformah in spletnih brskalnikov. Njegove komponente in povezave med njimi so prikazane na sliki 1. Za komunikacijo se uporabljajo protokoli TCP/IP in HTTP ter JSON. Odjemalci so podrobneje opisani v razdelku 3, administrativne strani pa v razdelku 4.

SaaS e-Turist v dveh korakih sestavi program ogleda. V prvem koraku priporočilni sistem za vsako znamenitost izračuna primernost za danega turista. V ta namen uporablja kombinacijo priporočanja na podlagi znanja in skupinskega filtriranja (collaborative filtering). Priporočanje na podlagi znanja primernost znamenitosti izračuna iz strokovnega mnenja o njeni pomembnosti in tega, katere znamenitosti so primerne za katere turiste na podlagi starosti, izobrazbe, narodnosti in finančnih sredstev turistov, ki jih ti lahko vnesejo v svoj profil. Če je profil na voljo, je prednost tega načina priporočanja, da deluje takoj – ne potrebuje nobenih

predhodnih ocen znamenitosti ali turista. Skupinsko filtriranje pa primernost izračuna iz ocen, ki so jih znamenitosti dali drugi turisti, ki so v preteklosti izkazali podoben okus kot turist, za katerega se primernost računa.

V drugem koraku se znamenitosti na podlagi primernosti, ki jih izračuna priporočilni sistem, in njihovih zemljepisnih položajev uvrstijo na program ogleda. Za sestavitev optimalnega programa bi bilo treba rešiti sklopljena problema nahrbtnika (uvrščanje na program) in trgovskega potnika (določanje poti med znamenitostmi). Ker sta oba problema NP-polna, znamenitosti na program uvrščamo požrešno, pri čemer imajo prednost znamenitosti z večjo primernostjo, ki pa se zmanjša, če je za njihov ogled treba veliko časa ali če so daleč od drugih znamenitosti. Ko je dolžina programa blizu časa, ki je na voljo (pri čemer trajanje poti med znamenitostmi le ocenimo), po dodajanju vsake znamenitosti pokličemo algoritem za približno reševanje problema trgovskega potnika [8], ki predlaga pot med znamenitostmi (tako da poznamo točno trajanje ogleda).



Slika 1: Povezanost komponent sistema e-Turist

SaaS Govorec pisne opise znamenitosti pretvori v govorne in jih shrani. Tako SaaS e-Turist odjemalcem pošlje le povezave do zvočnih datotek, ki jih streže SaaS Govorec. Za pretvorbo v govor se za slovenščino uporablja sintetizator Govorec [1], ki je nastal v sodelovanju med podjetjem Amebis in Institutom "Jožef Stefan", za druge jezike pa Microsoft Speech Platform [5] (trenutno e-Turist podpira angleščino, nemščino in italijanščino).

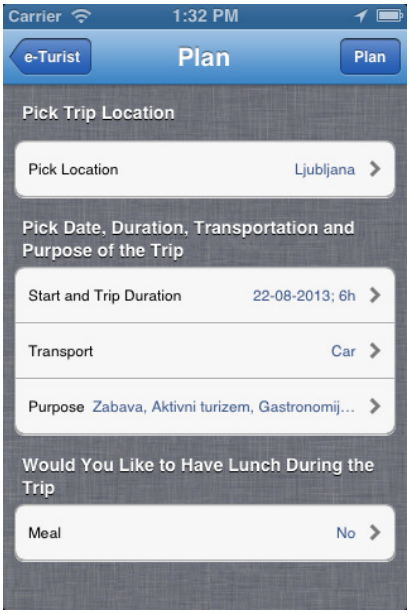
Podatkovna baza hrani vse podatke o znamenitostih in uporabnikih, pa tudi nekaj dodatnih podatkov, potrebnih za pravilno delovanje sistema – denimo razdalje med znamenitostmi, ki so sicer pridobljene z Google maps API [3], a se zaradi omejitve števila klicev tega programskega vmesnika hranijo v bazi.

3 APLIKACIJE ZA TURISTE

Mobilne aplikacije so na voljo za štiri platforme: Android, iOS, Windows Phone in BlackBerry, poleg tega pa je na voljo tudi spletna aplikacija. Mobilne aplikacije so namenjene tako načrtovanju ogleda, kot tudi vodenju po njem. Spletna aplikacija je namenjena predvsem načrtovanju ogleda, ogled pa se nato lahko shrani in odpre v mobilni aplikaciji. Aplikacije omogočajo osnovno načrtovanje ogledov vsakomur, polno zmogljivost pa le prijavljenim uporabnikom, saj so zanjo potrebni uporabniški profil in pretekle ocene znamenitosti.

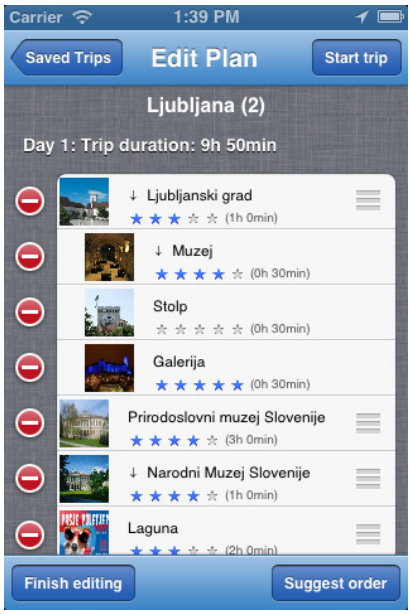
3.1 Mobilne aplikacije

Načrtovanje ogleda (slika 2, prikazuje aplikacijo za iOS) se začne z izbiro kraja, kamor se turist kani podati na izlet. Če je že na cilju, zna aplikacija sama izbrati pravi kraj. Nato turist določi začetek in trajanje ogleda ter prevozno sredstvo – zaradi omejitev Google Directions API za Slovenijo sta na voljo samo avto in pešačenje. Izbira namena ogleda bo vplivala na znamenitosti, ki bodo uvrščene na program ogledov – če je turist razpoložen za aktivni turizem, mu bo aplikacija predlagala npr. adrenalinski park, če bi rad spoznavali kulturno dediščino, pa muzej. Na koncu je mogoče še določite, ali naj aplikacija predlaga restavracijo za kosilo ali drug obrok, nakar aplikacija turistove želje pošlje strežniku, ki pripravi program ogleda.

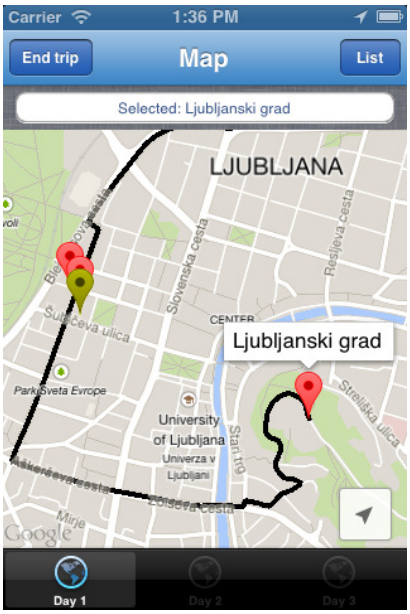


Slika 2: Zaslon za načrtovanje ogleda

Program ogleda (slika 3) je razdeljen po dnevih in je sestavljen iz znamenitosti in podznamenitosti (npr. grad in muzej v gradu). Za vsako znamenitost so prikazani vrsta, predvideni čas ogleda, ocena in kratek opis. Program turist lahko ureja – preuredi vrsti red znamenitosti, izbriše tiste, ki ga ne zanimajo, in doda nove. Za spremenjeni program lahko sistem predlaga najboljši vrstni red znamenitosti. Program je tudi mogoče shraniti za kasneje.



Slika 3: Zaslon za urejanje programa ogleda



Slika 4: Zaslon z zemljevidom ogleda

Zemljevid ogleda (slika 4) prikazuje pot ogleda za vsak dan. Z različnimi barvami so prikazane znamenitosti na programu, znamenitosti ob poti, turistična infrastruktura (npr. informacijske točke) in ogledane znamenitosti. Aplikacija opozori na znamenitost, ko se jim turist približa (tudi če teče v ozadju), in ponudi njihov opis. Opis je lahko sestavljen iz podopisov in opremljen s slikami, na voljo pa so tudi praktične informacije o znamenitosti (odpiralni časi, dostopnost za osebe z gibalnimi omejitvami, parkirišča, izposoja opreme …). Poleg pisnega opisa aplikacija uporabniku postreže tudi z govornim. Turist lahko znamenitost oceni z oceno od ena do pet, odda komentar in prebere komentarje drugih uporabnikov. Te ocene nato uporablja priporočilni sistem.

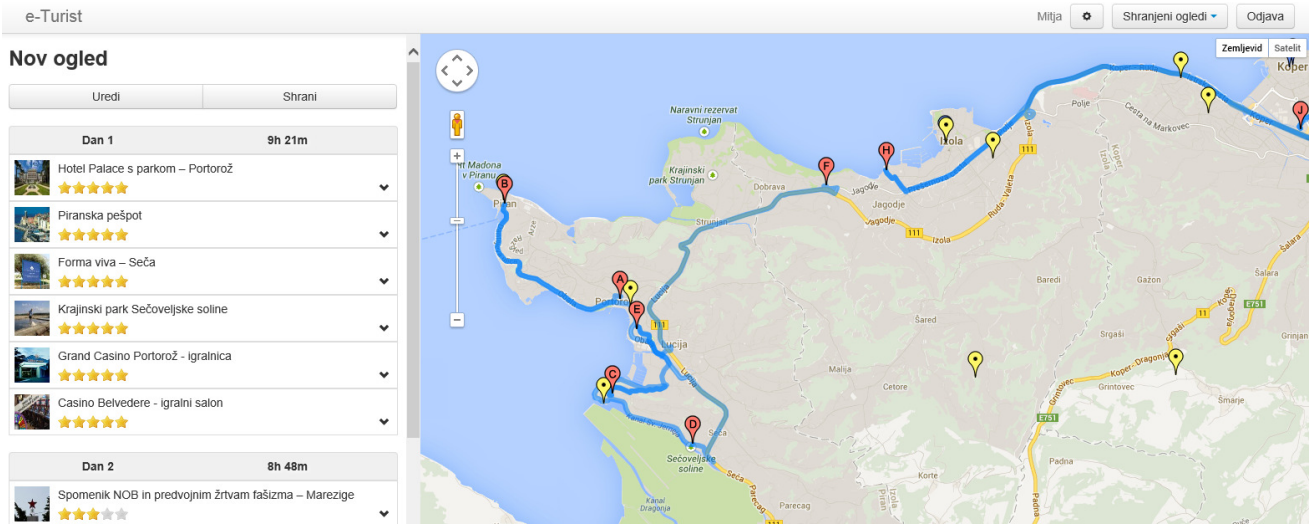
Druge možnosti, ki jih aplikacija ponuja, so urejanje profila in nastavitev ter nalaganje shranjenih ogledov.

3.2 Spletna aplikacija

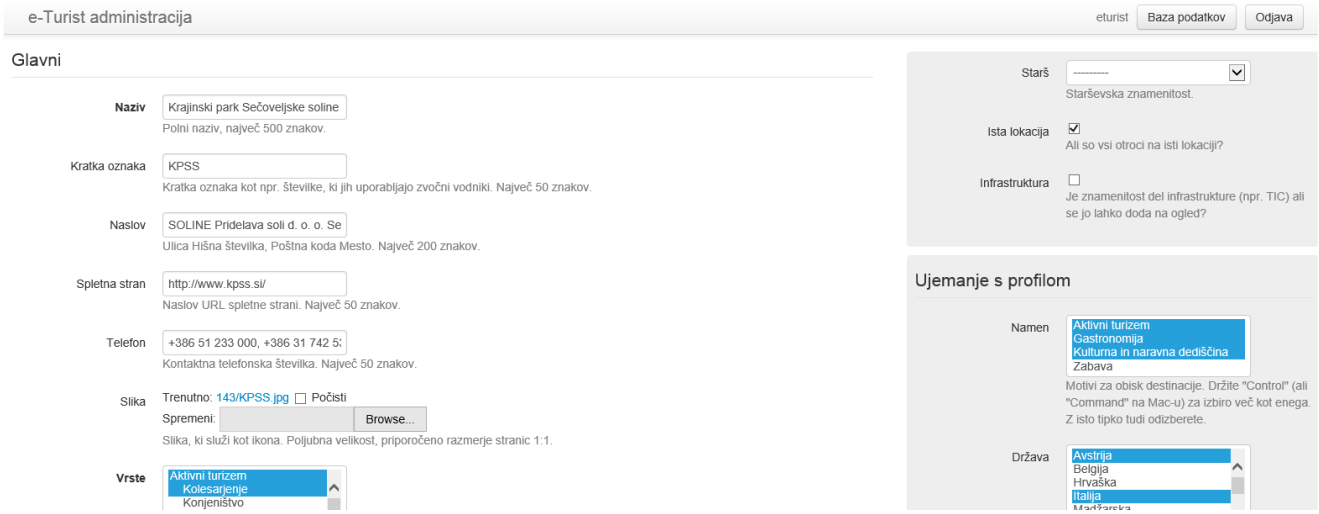
Spletna aplikacija opravlja iste naloge kot mobilne, le da ne omogoča vodenja s pomočjo GPSa. Ker je namenjena predvsem uporabi na računalnikih, sta prikaz programa ogleda in zemljevida združena, kot kaže slika 5.

4 ADMINISTRATIVNE STRANI

Administrativne strani v prvi vrsti omogočajo urejanje lokacij in znamenitosti. Za lokacije se določita geografski položaj in okvirna velikost (polmer). Za znamenitosti pa se vnesejo opis s slikami in bogati metapodatki. Prva skupina metapodatkov so glavni podatki, med katere sodijo naziv,



Slika 5: Prikaz ogleda v spletni aplikaciji



Slika 6: Administrativna stran za urejanje znamenitosti

naslov, vrsta, strokovna ocena, geografski položaj, odpiralni čas idr. Druga skupina so dodatni podatki, med katere sodijo čas ogleda, dostopnost za osebe z gibalnimi omejitvami, raznovrstna dodatna ponudba idr. Tretja skupina so podatki o starših in otrocih, ki sestavljajo hierarhijo podznamenitosti, ter podatek o tem, ali znamenitost v resnici ni znamenitost, temveč del turistične infrastrukture. Četrta skupina določa, za kakšne profile turistov je znamenitost primerna. Stran za urejanje znamenitosti je prikazana na sliki 6.

Administrativne strani omogočajo tudi pregled obiska znamenitosti in ocen obiskovalcev, kar so za turistične delavce dragoceni podatki. Skrbnikom pa poleg tega omogočajo urejanje raznih šifrantov, npr. vrst znamenitosti in možnih izobrazb turistov.

5 ZAKLJUČEK

Sistem e-Turist turistom omogoča izdelavo programa ogleda in vodenje po ogledu na način, ki je precej bolj enostaven od tradicionalnih (knjižni turistični vodniki) in malo manj tradicionalnih (mobilne turistične aplikacije) alternativ. Obstajajo sicer tudi e-Turistu močno podobne aplikacije, a jih je zelo malo, njihova inteligentnost pa vprašljiva [6].

Ker se je razvoj (prve različice) sistema pravkar končal, se s prvimi turisti šele sooča, tako da še ni jasno, ali dejansko zadovoljuje njihove potrebe. Domnevamo lahko, da bodo za resnično uporabnost potrebne prilagoditve priporočilnega sistema in metod za iskanje najkrajše poti z najzanimivejšimi znamenitostmi. Te metode so načeloma sicer zrele, vendar je njihova uporaba v turizmu še dokaj raziskovalna.

Poleg izboljšav, ki jih bo narekovala praktična uporaba, za prihodnje razmišljamo o dveh smereh razvoja. Prva smer je vključevanje obstoječih virov turističnih informacij v sistem e-Turist (npr. baze gostinskih lokalov). Druga smer pa je vključevanje načrtovanja programa ogleda iz e-Turista v druge spletne strani, ki ponujajo turistične informacije, če bomo pri njihovih lastnikih uspeli zbuditi zanimanje (npr. strani mest in regij ter namenske turistične spletne strani).

Zahvale

Projekt e-Turist sta delno financirala Evropska unija in Ministrstvo za znanost, izobraževanje, kulturo in šport v okviru javnega razpisa za sofinanciranje projektov razvoja e-storitev in mobilnih aplikacij za javne in zasebne neprofitne organizacije 2012–2013. Projektnim partnerjem Turistica in Občina Litija se zahvaljujemo za prispevana znanje o turizmu in turistične vsebine, Andreju Tratniku, Vitu Janku in Maji Somrak pa za večino implementacije sistema.

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GENETIC ALGORITHM BASED FEATURE SELECTION FOR BIO-MOLECULAR EVENT EXTRACTION

Amit Majumder[1], *Asif Ekbal*[2], *Sriparna Saha*[2], *Md. Hasanuzzaman*[3]
Academy of Technology, Hooghly, India[1]
Department of Computer Science and Engineering, Indian Institute of Technology Patna, India[2]
University of Caen Basse-Normandie, France [3]
e-mail: jobamit48@yahoo.co.in, {asif,sriparna}@iitp.ac.in,hasanuzzaman.im@gmail.com

ABSTRACT

In this paper we propose a genetic algorithm (GA) based feature selection approach for event trigger extraction from biomedical texts. A system is developed for extracting complex events from biomedical texts specially in the context of BioNLP-2009 shared task. Conditional Random Field (CRF) has been used as a base classifier that makes use of a wide array of features which helps in identifying event triggers from biomedical texts. The features which have been considered are statistical and linguistic features that represent various morphological, syntactic and contextual information of the candidate bio-molecular trigger terms. The proposed method is evaluated with the BioNLP-2009 shared task framework. We have applied 3-fold cross validation method and it shows the overall average recall, precision and F-measure values of 62.25%, 74.75% and 67.93%, respectively.

Keywords: Genetic algorithm (GA), feature selection, event extraction, biomedical domain

I. INTRODUCTION

In recent years several competitions have been organized based on carefully curated resources for solving different problems of text mining, for example MUC [1], and ACE [2] events. Like all these, bio-text mining (bio-TM) is one of the important event organized for solving different problems of bio text mining. Some other bio-text mining evaluation challenges include the TREC Genomics track, JNLPBA [3], and BioCreative[4]. The first two shared tasks are associated with the problems of biomedical information retrieval (bio-IR) and bio-Named Entity Recognition (bio-NER), respectively. The last two evaluation campaigns considered the problems of biomedical information extraction (bio-IE).

Relations among biomedical entities (i.e. proteins and genes) are relevant for understanding biomedical problems and must be identified automatically from a large number of published literature. Most research in the field of Biomedical Natural Language Processing (BioNLP) devoted on extracting binary relations, including protein-protein interactions (PPIs) such as LLL and BioCreative challenges. But it is not sufficient to extract binary relations for capturing biomedical phenomena in detail, and it is necessary to extract more detailed and complex relations. Two new corpora, BioInfer and GENIA, have been proposed which contain some detailed and complex events. The BioNLP-09 Shared task was organized to discuss about bio-IE, but it was further extended to consider finer-grained IE. The difference is due to the application domain as being supported by the IE methods. For example, BioCreative is developed to support curation of PPI databases such as MINT [5] which is one of the primary objective of bioinformatics research for a long time. Simple and complex events both are available in BioNLP-09 shared task. Simple events are made of binary relations between proteins and their textual triggers. Whereas multiple relations among proteins, events, and their textual triggers are treated as complex events. For example one complex event is Binding which shows relationship among multiple proteins, and regulations which show causality relations between proteins and events. These complex events are difficult to identify but these carry more information than simple events which help to model some biological systems like pathways. Thus one of the primary motivations of BioNLP-09 shared task was to help to develop some detailed and structured databases, e.g. pathway [6] or Gene Ontology Annotation (GOA) [7] databases. These databases are very much helpful for bioinformatics research. Three subtasks are included in the BioNLP-09 shared task [8]: finding core events (Task 1), finding the secondary arguments (such as location and sites) (Task 2), and recognizing speculation and negation (Task 3). In total, nine potential events were determined for extraction. Among these nine events, five events were simple such as gene expression, transcription, protein catabolism, phosphorylation, and localization. The other four events, termed as binding, regulation, positive regulation, and negative regulation were relatively complex. A single primary theme protein is included in a simple event, and multiple primary theme and cause arguments are included in a complex event. Proteins and events mainly constitute these themes and causes. In this paper we have solved the problem which is a part of Task 1.

The performance of any classification technique primarily depends on the features of training and test datasets. Feature selection, also termed as variable selection, feature reduction, attribute selection or variable subset selection, is a commonly used technique in machine learning. From machine learning point of view, feature selection is treated as an optimization problem that involves choosing an appropriate feature subset.

In the present paper, we propose a genetic algorithm (GA) [9] based feature selection technique for event extraction. GAs are some search and optimization techniques guided by the process of natural evolution and genetics. In this paper GA is utilized for identifying relevant sets of features for the task of event term extraction. The task of event extraction is posed as a classification problem where the problem is to identify trigger terms that denote the event expressions in texts. We use Conditional Random Field (CRF) [10] as a base classifier that makes use of a rich set of features exploiting local contexts, morphological, syntactic and semantic information. Thereafter we select the most relevant set of features for event extraction that optimizes the objective function, F-measure. The parameters of the proposed algorithm are determined using the development data. As gold annotations are not available for test data set, we have evaluated our approach using 3-fold cross validation on training data. Evaluation results on 3-fold cross validation show the overall average recall, precision and F-measure values of 62.25%, 74.75% and 67.93%, respectively. The rest of the paper is organized as follows. Section 2 presents our proposed approach on event extraction. Section 3 describes different features used for event extraction. In Section 4 we report the data sets and the detailed experimental results. Finally Section 5 concludes with future work road-map.

II. Proposed Approach for Event word Extraction

Our approach for event extraction is based on genetic algorithm (GA) [9]. We have developed a GA based feature selection technique for identifying relevant features for the task of event extraction. We optimize the classification quality measure, F-measure which is a combination of both recall and precision. As a base classifier we use Conditional Random Field [10]. The classifier is trained with a diverse set of features. Thereafter we determine the most relevant set of features using our proposed approach. The data set that we used has the following characteristics : tokenized, stemmed, Part-of-Speech (PoS) tagged and named entity (NE)-tagged, and provided in the CoNLL-X format. McClosky-Charniak parsed outputs[1] which can be converted to the Stanford Typed Dependencies format [11] are used in this paper.

A. Genetic Algorithm

Genetic algorithms (GAs) [9] are some natural evolution based search and optimization tool. In GAs, a chromosome is a string which represents the parameters of the search space. A population is a collection of chromosomes. Initially, the first population is initialized randomly representing different points in the search space. Each chromosome is associated with an objective or fitness function which captures the degree of goodness of that chromosome. A few of the chromosomes are selected on the basis of the principle of survival of the fittest, and each is assigned a number of copies that go into the mating pool. Two biologically inspired operators like crossover and mutation are used in GA. These are applied on an old population to obtain a new generation of chromosomes. Crossover is an operation by which an offspring chromosome is generated from two parent chromosomes by taking over parts of each. In mutation, a new chromosome is produced by changing parts of the parent chromosomes according to a certain probability. The three operators, selection, crossover and mutation, are repeated for a fixed number of generations or till a termination condition is satisfied. These basic steps are also shown in pseudo-code form in Figure 1. The steps of GA based feature selection technique are as follows:

[1]http://www-tsujii.is.s.u-tokyo.ac.jp/GENIA/SharedTask/tools.shtml

Genetic Algorithm

1.set time $t = 0$
2.initialize population P_0=$\{s_1, s_2..\}$ /* $Popsize = |P|$ */
3.repeat
  3a. compute fitness F_{s_i} for each member of the population P_t
  3b. select (P_t)
  3c. crossover (P_t)
  3d. mutate (P_t)
  3e. generate P_{t+1} from the output of steps 3b-3d.
  3f. $t = t + 1$
 untill the termination criterion achieved
5. output the best chromosome and stop

Fig. 1. Basic Steps in a Genetic Algorithm

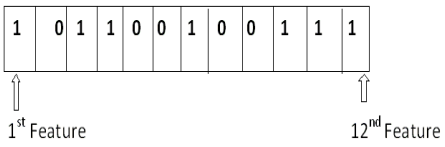


Fig. 2. Chromosome representation for GA based feature selection

B. Chromosome Representation and Population Initialization

Here chromosome length is equal to F if total number of features present in the data set is F. As an example, the encoding of a particular chromosome is represented in Figure 2. Here number of features is 12. The chromosome shows that total 7 features are available for training and testing the classifier. In the current case first, third, fourth, seventh, tenth, eleventh and twelfth features are available for constructing the classifier. Here binary representation is used. Strings are initialized randomly using 0 or 1. Here 0 at the ith position represents that ith feature will not take part in constructing the classifier. Else 1 represents that ith feature will take part in developing the classifier. If population consists of P number of chromosomes then all these P chromosomes will be initialized randomly.

C. Fitness Computation

In order to compute the objective or fitness function, following steps are executed:

1) Suppose there are M number of 1s in the current chromosome. This means we can consider these M number of features for developing the classifier.
2) The CRF based classifier is constructed using these M number of features.
3) The classifier is evaluated on development data and three evaluation metrics are computed on this data: recall, precision and F-measure.

4) For this particular chromosome the fitness or objective function is the F-measure value on the development data. This fitness value is maximized using the search capability of GA.

D. Genetic Operators

For selection operation, roulette wheel selection operator is used to implement the proportional selection strategy. Normal single point crossover [9] is utilized for implementing the crossover operation. Crossover probability is calculated adaptively as in [12]. Mutation operation is applied on each chromosome with a probability μ_m. The mutation probability is also calculated adaptively for each chromosome as done in [12]. In case of mutation, value present at a particular position is flipped.

In GA, the steps of fitness computation, selection, crossover, and mutation are implemented for a maximum number of generations. The final solution of the feature selection problem is the best chromosome seen up to the last generation. We have stored the best chromosome of each generation in a place outside the population. This is also termed as elitism. Thus at the time of termination, this location contains the best feature combination.

III. Features for Event Extraction

In our work, we have defined several features like context word, root word Part-of-Speech(PoS) information, named entity information, semantic feature and some dependency path based features. Semantic feature, dependency path based features and some additional features like word suffixes, prefixes, distance from nearest protein have been added in our work. These features are described below.

1) Semantic feature: this feature is based on global context information.
2) Dependency features: here a dependency parse tree is constructed which captures the dependencies among the words of a sentence.
3) Dependency path from the nearest protein: here we have constructed dependency path using the edge labels of dependency tree.
4) Distance from nearest protein: here we have calculated the distance of the nearest protein from the current token and it is used as a feature.
5) Word prefix and suffix: these are fixed length (say, n) word suffixes and prefixes of the current token. These are determined by collecting the fixed length character strings either from the rightmost (for suffix) or from the leftmost (for prefix) positions of the token.
6) Named Entities in context: this feature is calculated based on he observation that frequencies of NEs are more near to the event triggers.
7) Boolean feature for distance: this feature is set to 1 if distance from nearest protein and the current token is less than 10 and current word is a member of the event-trigger set, otherwise the feature is set to 0. Event-trigger denotes the set of events extracted from the training data.

IV. Datasets and Experimental Results

A. Datasets

The organizers of Bio-NLP Shared task provide human-curated reference material for the training and evaluation. A data set based on the publicly available portion of the GENIA corpus has been provided in a stand-off format for training. In order to evaluate the system, a held-out part of the same corpus is given with the gold event annotation hidden. The organizers want that participating systems should recreate the gold annotation for the evaluation data based on the information provided in the form of training data given to them. The statistics of the training and development data sets have been provided in Table I.

TABLE I. Statistics of the datasets

Dataset	#abstracts	#sentences	#words	#events
Training	800	7,449	176,146	8,597
Development	150	1,450	33,937	1,809

B. Conditional Random Field Framework for Event Detection

Conditional Random Fields (CRFs) [10] are some special forms of undirected graphical models. A special case of CRF represents a conditionally trained probabilistic finite state automata. As CRFs are conditionally trained, a large number of arbitrary, non-independent features can be incorporated in it. But CRF can still support some efficient procedures for non-greedy finite-state inference and training.

In order to apply CRF for solving the event trigger problem we consider the following: an observation sequence is a set of tokens of a sentences or document of text and the state sequence is its corresponding label sequences. In principle, any value between $-\infty, \ldots + \infty$ can be considered by CRFs. But traditionally binary values are considered. A feature function $f_k(s_{t-1}, s_t, o, t)$ can take a value of 0 for most of the cases and is only set to 1, when s_{t-1}, s_t are certain states and the observation has certain properties. In this paper in order to generate CRF based model, we have used the C++ based CRF^{++} package[2], a simple, customizable, and open source implementation of CRF for segmenting or labeling sequential data.

C. Experimental Results

We use CRF for training and testing. The system is tuned on the development data. The chromosome with best features obtained by running the system on development data, is used for performing 3-fold cross validation. The features which have been selected after application of the proposed GA based feature selection technique on the development data are root word, POS of the current token, named entity (NE) class of the current token, distance from the nearest protein, root word of nearest protein, semantic feature, dependency path from nearest protein in that sentence, boolean feature ("true" if dependency label between token and its child is OBJ), length of dependency path, frequency of named-entities in sliding window, prefixes of length upto four, suffixes of length upto three, previous five and next five context words, previous

[2]http://crfpp.sourceforge.net

word's POS tag, previous two word's NE classes, next two word's POS classes, next one word's NE class and Distance.

Please note that due to unavailability of gold-standard annotations in the test data we have not evaluated our system on test data. Here strict matching criterion is followed, i.e. credit is given if and only if the boundaries of the entities exactly match with the gold annotation.

TABLE II. EVALUATION RESULTS OF EVENT DETECTION ON THE DEVELOPMENT SET (WE REPORT IN PERCENTAGES)

Case	recall	precision	F-measure
With GA	65.44	74.17	69.53
Without GA	61.62	67.71	64.52

Evaluation results on the development data are reported in Table II. It yields the recall, precision and F-measure values of 65.44%, 74.17% and 69.53%, respectively. We have determined the parameters of the algorithm based on the performance on the development data. In order to report the final results we have evaluated our system for 3-fold cross validation on training data. Here training dataset is randomly divided into three equal sized subsets. Among these three subsets two are used for training and remaining one is used for testing. This procedure is repeated three times. We have collected results of each iteration and finally reported the average results. Average results of 3-fold cross validation for event detection are reported in Table III that shows the overall recall, precision and F-measure values of 62.25%, 74.75% and 67.93%, respectively. We compare these figures with the evaluation results of the baseline model that incorporates all the available features. The baseline developed with all the features yields the recall, precision and F-measure values of 61.62%, 67.71%, and 64.52%, respectively on the development data (this is also reported in Table II). It shows an increment of more than 5 points by our feature selection model. This baseline when evaluated for 3-fold cross validation yields the recall, precision and F-measure values of 61.33%, 69.53%, and 65.17%, respectively. The detailed results of each fold are reported in Table IV. Results of Tables III and IV show that for 3-fold cross validation the GA based feature selection approach attains an improvement of 2.76% F-measure values over the baseline where we generated the classifier with all the available features.

TABLE III. RESULTS OF EVENT DETECTION FOR 3-FOLD CROSS VALIDATION WITH GA

Fold number	recall	precision	F-measure
1	62.17	74.70	67.86
2	62.66	74.67	68.15
3	61.90	74.86	67.77
Average	62.25	74.75	67.93

TABLE IV. RESULTS OF EVENT DETECTION FOR 3-FOLD CROSS VALIDATION WITHOUT GA

Fold number	recall	precision	F-measure
1	60.34	68.30	64.07
2	62.33	69.78	65.85
3	61.32	70.50	65.59
Average	61.33	69.53	65.17

V. CONCLUSION AND FUTURE WORKS

In this paper we have proposed a genetic algorithm based feature selection technique for identification of the most relevant subset of features. As a base classifier we used CRF. We identify and implement a wide varieties of features like statistical and linguistic information in the forms of morphological, syntactic and contextual information of the candidate bio-molecular trigger words. We perform our experiment on data set of BioNLP-09 shared task. The proposed approach attains the overall average recall, precision and F-measure values of 62.23%, 74.75% and 67.93%, respectively.

Experimental results can be further improved by increasing the size of the population and number of generations. In the present work we only address the issues of event trigger detection. In our future work, we would like to classify events and to identify arguments of these events. We would like to try our experiment with other classification tools. Another interesting work will be observing the effects of multiobjective optimization for feature selection.

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A PREDICTIVE-ANALYTICS SYSTEM-DESIGN

Violeta Mirchevska[1], Igor Korelič[2], Franc Škedelj[2], Matjaž Gams[1]
Department of Intelligent Systems, Jožef Stefan Institute, Jamova cesta 39, Ljubljana, Slovenia[1]
Result d.o.o., Celovška cesta 182, Ljubljana, Slovenia[2]
e-mail: {violeta.mircevska, matjaz.gams}@ijs.si, {igor.korelic, franc.skedelj}@result.si

ABSTRACT

This paper presents a predictive-analytics system-design. In addition to machine learning, the system leverages expert domain-knowledge during model generation from historical data. The system recommends to the user potentially interesting analysis based on typical historical user-system interactions.

1 INTRODUCTION

Predictive analytics, a subfield of the broader area of business intelligence [1], aims at improving business decision-making by leveraging enterprise data and machine learning. "Enterprise data is a priceless strategic asset because it represents the aggregate experience of an organization" [2]. Each customer's purchase, feedback or payment default is an experience from which enterprises learn. This experience may be embedded in predictive models using machine-learning approaches [3]. Machine-learning approaches create predictive models solely from data. Predictive analytics stresses the benefits of alternative scoring using predictive models in business decision-making.

Typical predictive-analytics example is assessing direct-marketing response. Consider a company which used direct marketing as the advertising channel for a few years. It has examples of customers' responses to its advertisements in the form <*customer_features*, *response*>, where *customer_features* is a description of a customer to which an advertisement was sent, while *response* is an indicator of whether the customer purchased a product as a result of the advertisement. Predictive models for estimating response probability based on customer features may be created using machine learning and past examples of customers' responses. Consider the company plans to start a novel direct-marketing campaign. It may use the predictive models for excluding customers with low response probability from its campaign. [4] reports a decrease of direct-marketing costs by 20 % and an increase in its response rate by 3.1 % as a result of excluding low response customers from a company's campaign based on predictive models.

Predictive analytics has a broad application spectrum [2][4]. In marketing, we may apply it to estimate a customer account-renewal probability using which we may improve customer retention campaigns. In security, we may apply it to predict breaches in security using which we may focus at security checks on the most risky transactions. In maintenance, we may apply it to estimate system failure probability using which we may improve maintenance efficiency.

We are developing a predictive-analytics prototype aimed at: (1) leveraging expert domain knowledge in the predictive-model generation-process, and (2) leveraging historical user-system interaction for recommending to users

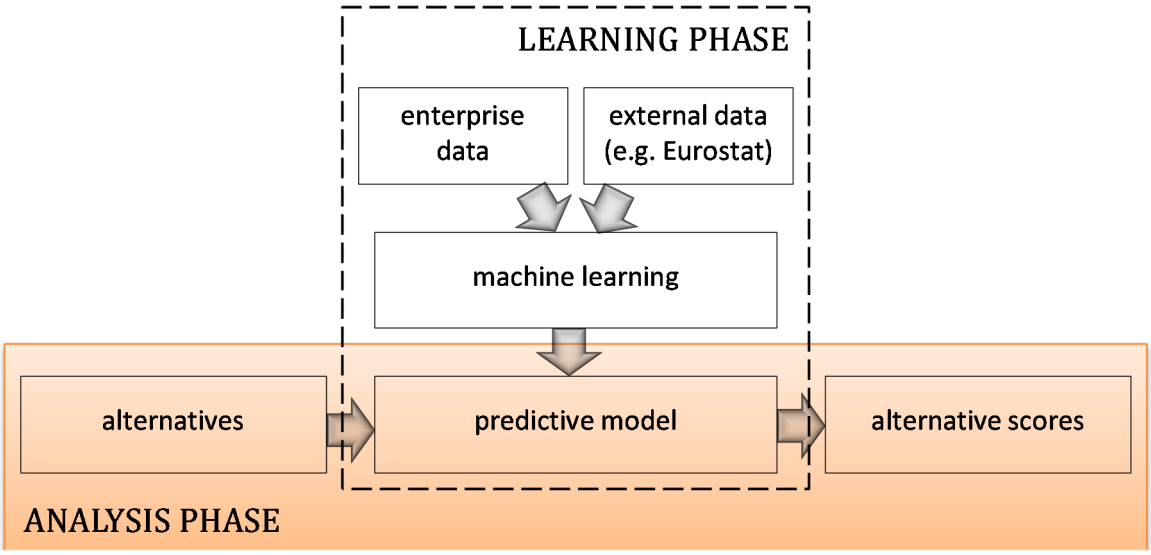


Figure 1 Typical work flow in predictive-analytics systems

the potentially interesting analysis. This paper presents the predictive-analytics system-design. Firstly, we present the typical predictive-analytics application-flow in Section 2. Secondly, we present possibilities for incorporating expert input in the model generation-process in Section 3. Thirdly, we present approaches to generating analysis recommendations from historical user-system interaction in Section 4. Finally, Section 5 concludes the paper, stating future work.

2 TYPICAL PREDICTIVE-ANALYTICS WORK-FLOW

Figure 1 presents the typical work flow of predictive-analytics applications. We separate it in two phases: the learning phase and the analysis phase.

The learning phase considers generation of predictive models using historical data (enterprise and/or external). The predictive models are created using machine learning approaches. Typically, regression models are used to estimate probabilities. Examples of regression algorithms, today widely used, are support-vector-machines regression, neural networks and regression trees [5].

The analysis phase considers alternative scoring using the predictive models created in the learning phase.

3 LEVERAGING EXPERT INPUT IN THE MODEL-GENERATION PROCESS

Machine learning and domain knowledge complement each other. On the one hand, machine learning may extract novel patterns, too subtle for humans to detect. On the other hand, domain knowledge may be related to patterns not captured by historical examples. Therefore, combining machine learning and domain knowledge is expected to provide predictive models with better performance than models created solely using machine learning or domain knowledge [6]. In addition, expert involvement should improve experts' trust in the created models. Figure 2 presents four possibilities for addition of expert input in the learning phase.

Firstly, expert input may be incorporated in the description of the historical examples. Intuitively, more attributes bring more information to the learning process and, by this, should contribute to lower model error. However, the increase in the number of example's attributes increases the hypothesis-space size and by this also the probability of overfitting [3]. Expert's input may be used for creating/selecting the examples' attributes.

Secondly, expert input may be used for machine-learning-algorithm parameter-tuning. Machine-learning-algorithm parameters influence the generality of the created model. One extreme is underfitting (too general predictive models) and another extreme is overfitting (too specific predictive models). The expert input may control the parameter-tuning process.

Thirdly, experts may validate the predictive models. Quantitative measures may aid the pattern verification process [7].

Fourthly, the expert input may be incorporated in the predictive-model patterns. Experts may revise the patterns present in machine-learning models and supplement/modify them based on the domain knowledge [6].

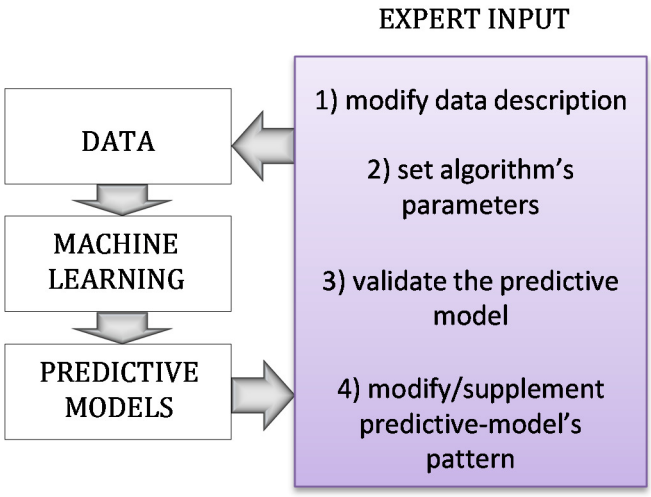


Figure 2 Possibilities for addition of expert input in the predictive-analytics learning phase

4 RECOMMENDATIONS

Although enabling users to review all historical business data and providing a wide spectrum of data analysis-tools, users often have difficulties in obtaining the needed information in business-intelligence systems [8]. This particularly applies for busy business users who, in contrast to technical personnel, do not have deep technical knowledge. Figure 3 presents two possibilities for recommendation generation based on historical user-system interaction at the company level.

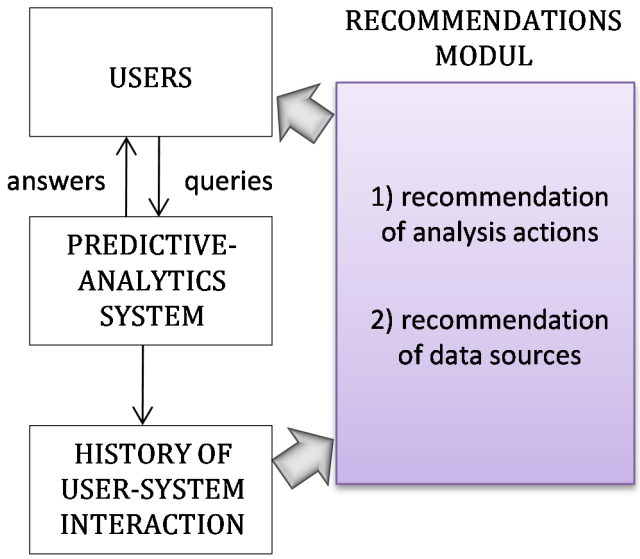


Figure 3 Recommendation generation based on historical user-system interaction

Firstly, historical user-system interaction may be used for recommending the analysis actions. We assume that every analysis requires execution of a sequence of actions. By examining historical user analysis-sequences, we may discover typical action sequences for a concrete business analysis task. The discovered typical action sequences may be used for action recommendations to the user [9].

Secondly, historical user-system interaction may be used for recommending the inclusion of data sources. We assume that every analysis requires an inclusion of a set of enterprise and/or external data. By examining historical user analysis, we may discover typical sets of data used in a concrete business analysis task. The discovered typical data sets may be used for data-inclusion recommendations to the user.

5 CONCLUSIONS AND FUTURE WORK

We presented a predictive-analytics system-design. The system incorporates expert domain-knowledge in the learning phase for the purpose of improving the performance of the predictive model, while it aids the analysis phase by providing recommendations to the user.

Before proceeding to system development, we need to perform an extensive survey of predictive-analytics systems. Such survey would provide an overview of the state-of-the-art practices in these systems and help us to position our prototype in this market.

Acknowledgement

This work was partially financed by the Slovenian Ministry of Education, Science and Sport.

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PRIMERJAVA REŠITEV OB NEGOTOVOSTI V VEČKRITERIJSKI OPTIMIZACIJI

Miha Mlakar, Tea Tušar, Bogdan Filipič

Odsek za inteligentne sisteme, Institut "Jožef Stefan" in
Mednarodna podiplomska šola Jožefa Stefana
Jamova cesta 39, 1000 Ljubljana, Slovenija
e-mail: {miha.mlakar, tea.tusar, bogdan.filipic}@ijs.si

POVZETEK

V prispevku definiramo nove relacije za primerjavo rešitev v večkriterijski optimizaciji v primeru negotovosti, ko so rešitve predstavljene z aproksimiranimi vrednostmi in intervali zaupanja. Z vključitvijo intervalov zaupanja v primerjavo se verjetnost napačnih primerjav zaradi netočnih aproksimacij zmanjša. Primerjava rešitev brez upoštevanja intervalov zaupanja v netočno aproksimiranih rešitvah lahko pri preiskovanju vodi do ohranjanja slabih rešitev na račun novih perspektivnih rešitev. Novo definirane relacije so generalizacija relacij Pareto dominiranosti in jih lahko uporabimo za primerjavo rešitev ob negotovosti ali brez nje. Prikažemo tudi primer uporabe teh relacij v primerjavi dveh rešitev v evolucijskem večkriterijskem optimizacijskem algoritmu z nadomestnimi modeli. Z uporabo novih relacij lahko pogosto ugotovimo, katero rešitev je smiselno obdržati in katero zavreči, ne da bi jih bilo potrebno pred tem eksaktno ovrednotiti.

1. UVOD

Z optimizacijskimi problemi se v različnih oblikah pogosto srečujemo v vsakdanjem življenju. Mnogi optimizacijski problemi zahtevajo sočasno optimizacijo več, mnogokrat nasprotujočih si kriterijev. Takim problemom pravimo večkriterijski optimizacijski problemi. Rešitev takih problemov ni le ena sama točka, ampak množica točk, imenovana Pareto optimalna množica. Ta množica rešitev da odločevalcu vpogled v lastnosti problema, preden izbere eno izmed Pareto optimalnih rešitev.

Eden najučinkovitejših načinov reševanja problemov z več kriteriji je uporaba evolucijskih večkriterijskih optimizacijskih algoritmov [1]. Ti algoritmi so populacijski in se zgledujejo po optimizacijskih procesih, ki potekajo v naravi. Da bi našli kar najboljše rešitve, je potrebno med optimizacijskim procesom ovrednotiti (izračunati) veliko število rešitev. Če so ta ovrednotenja računsko zahtevna, lahko celoten optimizacijski proces traja zelo dolgo.

Da bi hitreje prišli do rezultatov računsko zahtevnega optimizacijskega problema, lahko v optimizacijskem procesu uporabimo nadomestne modele za aproksimiranje kriterijske funkcije problema. Namesto zamudnega eksaktnega vrednotenja rešitve tako lahko isto rešitev aproksimiramo z nadomestnim modelom. Ker je aproksimacija (veliko) hitrejša, lahko s tem pospešimo celoten optimizacijski proces. Vendar pa pri uporabi nadomestnih modelov lahko pride do težav, če so aproksimirane rešitve netočne. Posledica tega je, da so pri primerjavi rešitev lahko dobre eksaktno ovrednotene rešitve zavržene, ker izgledajo slabše kot napačno preveč optimistično aproksimirane rešitve. To lahko upočasni optimizacijski proces oziroma celo prepreči algoritmu, da najde najboljše rešitve. Ker ne poznamo pravih vrednosti aproksimiranih kriterijev, pravimo, da primerjamo rešitve *ob negotovosti*.

Nekateri nadomestni modeli pri aproksimaciji vrednosti enega kriterija vračajo porazdelitev, iz katere se lahko izračunata aproksimirana vrednost in interval zaupanja za to aproksimacijo. Z upoštevanjem intervalov zaupanja smo definirali nove relacije za primerjavo rešitev ob negotovosti, ki upoštevajo intervale zaupanja in zahtevajo eksaktna ovrednotenja samo v primerih, ko ne želimo negotovosti. Ta pristop zmanjšuje napake v primerjavah, ki so posledice netočno aproksimiranih rešitev.

Kot primer uporabe novo definiranih relacij te uporabimo v evolucijskem večkriterijskem optimizacijskem algoritmu, kjer primerjamo rešitvi, ki sta lahko aproksimirani z nadomestnim modelom ali pa eksaktno ovrednoteni.

Struktura prispevka je naslednja. V 2. razdelku pregledamo obstoječe metode, ki so namenjene primerjavi rešitev, predstavljenih z aproksimiranimi vrednostmi in intervali zaupanja. 3. razdelek predstavlja relacije brez negotovosti in 4. razdelek relacije ob negotovosti. V 5. razdelku opišemo primer uporabe relacij ob negotovosti v evolucijskem algoritmu. S 6. razdelkom zaključimo prispevek s povzetkom opravljenega dela in pomena novih relacij.

2. PREGLED LITERATURE

Za reševanje optimizacijskih problemov literatura navaja več nadomestnih modelov, ki se v optimizacijski proces vključujejo na razne načine. V primerjavi z optimizacijo brez nadomestnih modelov je pri optimizaciji z nadomestnimi modeli potrebno manj eksaktnih ovrednotenj kriterijske funkcije, kakovost rezultatov pa ostane primerljiva [5, 12].

Pristopi pri uporabi nadomestnih modelov se razlikujejo

glede na to, katere rešitve se eksaktno ovrednoti in katere aproksimira ter katere in koliko rešitev se uporablja pri gradnji nadomestnih modelov. V našem pregledu literature se omejimo na primere, ki za gradnjo nadomestnih modelov uporabljajo metode, ki poleg aproksimirane vrednosti vrnejo tudi interval zaupanja za aproksimacijo, saj nam ta nudi dodatno informacijo, ki lahko izboljša kakovost rezultatov [4].

V [2] so avtorji uporabili širino intervalov zaupanja za usmerjanje algoritma v iskanje novih rešitev na manj raziskanih področjih, ki bi lahko vsebovala globalni optimum. Zaupanje v napovedi se skupaj z aproksimirano vrednostjo lahko uporabi tudi za izračun kriterija pričakovanega izboljšanja. Pristopi, ki uporabljajo ta način, so predstavljeni v [11]. Primer uporabe tega kriterija za izbiranje rešitev, ki naj bodo eksaktno ovrednotene, in rešitev, ki naj bodo aproksimirane, je opisan v [6].

V primerih, ko je negotovost nemogoče odpraviti z dodatnimi aproksimacijami, so v [7] predstavili primerjavo rešitev ob negotovosti. Avtorji ob primerjavi intervalov zaupanja definirajo možnost, da prvi interval nad drugim dominira z gotovostjo, in možnost, da domininranost ni zanesljiva. Na podlagi teh primerjav avtorji nato predlagajo krepko Pareto domininranost za primere, ko je domininranost možno določiti, in šibko Pareto domininranost za ostale primere, ko to zaradi negotovosti ni mogoče. V takem primeru se za rešitve privzame srednja vrednost in rešitve primerjajo na podlagi teh vrednosti.

V [10] so avtorji predlagali delno urejenost rešitev kot pomoč pri primerjavi rešitev, predstavljenih z intervali zaupanja. Problem takega pristopa je, da ne razlikuje med primerom, kjer zgornji rob prvega intervala dominira nad spodnjim robom drugega intervala, in primerom, kjer se intervala prekrivata. Zelo podoben pristop obravnavanja rešitev, predstavljenih z intervali, imenovan netočne Pareto relacije, je predstavljen tudi v [8].

Mejni okvir, ki je podrobno definiran v 4. razdelku, je bil kot način predstavitve večkriterijskih rešitev z intervali zaupanja že predstavljen v [3]. Vendar pa je primerjava mejnih okvirov tudi v tem primeru poenostavljena na to, da zavržemo rešitve, za katere je malo verjetno, da bi bile dobre, oziroma eksaktno ovrednotimo rešitve, za katere je zelo verjetno, da so dobre.

V našem primeru večkriterijske rešitve z intervali zaupanja prav tako predstavimo z mejnimi okviri, vendar pa pri primerjavi rešitev ne delamo poenostavitev, tako da pokrijemo vse možnosti in tudi pokažemo njihovo možnost uporabe na konkretnem primeru.

3. RELACIJE BREZ NEGOTOVOSTI

Večkriterijski optimizacijski problem je predstavljen kot iskanje minimuma funkcije:

$$f : X \to Z$$
$$f : (x_1, ..., x_n) \mapsto (f_1(x_1, ..., x_n), ..., f_m(x_1, ..., x_n)),$$

kjer n označuje število spremenljivk in m število kriterijev in kjer se vsaka rešitev $x = (x_1, ..., x_n) \in X$ imenuje *odločitveni vektor*, medtem ko se ustrezen element $z = f(x) \in Z$ imenuje *vektor kriterijev*. Ta definicija problema se uporablja za opis relacij, predstavljenih brez negotovosti in z negotovostjo.

Najprej se posvetimo primeru, ko so vse rešitve večkriterijskega optimizacijskega problema eksaktno ovrednotene. To pomeni, da ni negotovosti in so širine intervalov zaupanja enake 0.

Definicija 3.1 (Pareto domininranost) *Vektor kriterijev z* dominira *nad vektorjem kriterijev w, $z \prec w$, če velja $z_j \leq w_j$ za vsak $j \in \{1, ..., m\}$ in $z_k < w_k$ za vsaj en $k \in \{1, ..., m\}$.*

Definicija 3.2 (šibka Pareto domininranost) *Vektor kriterijev z* šibko dominira *nad vektorjem kriterijev w, $z \preceq w$, če velja $z_j \leq w_j$ za vsak $j \in \{1, ..., m\}$.*

Definicija 3.3 (krepka Pareto domininranost) *Vektor kriterijev z* krepko dominira *nad vektorjem kriterijev w, $z \prec\prec w$, če velja $z_j < w_j$ za vsak $j \in \{1, ..., m\}$.*

Če $z = f(x), w = f(y)$ in z (šibko ali krepko) dominira nad w, pravimo, da rešitev x (šibko ali krepko) dominira nad rešitvijo y. Z drugimi besedami, rešitev x je enaka ali boljša od rešitve y. Šibka Pareto domininranost je naravna posplošitev relacije $\leq$ in krepka Pareto domininranost je naravna posplošitev relacije $<$.

Definicija 3.4 (neprimerljivost) *Vektorja kriterijev z in w sta* neprimerljiva, *$z \| w$, če velja $z \not\preceq w$ in $w \not\preceq z$.*

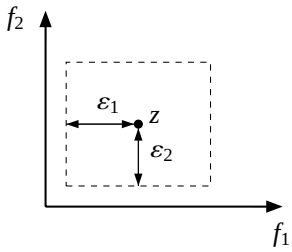
Tudi za ta primer velja, da če sta z in w neprimerljiva, potem sta rešitvi x in y neprimerljivi.

4. RELACIJE OB NEGOTOVOSTI

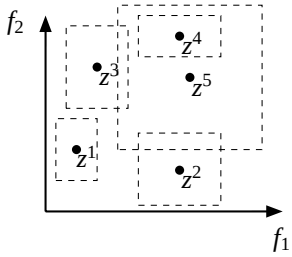
V tem razdelku se posvetimo primerjavi rešitev, predstavljenih z aproksimiranimi vrednostmi in intervali zaupanja za aproksimacijo. Če želimo pri primerjavi upoštevati tudi intervale zaupanja, potem relacije, predstavljene v prejšnjem razdelku, ne zadoščajo, ampak jih je potrebno prilagoditi. Vsaka rešitev x je predstavljena z vektorjem aproksimiranih vrednosti kriterijev, $z = (z_1, z_2, ..., z_m)$, in z vektorjem zaupanja za vsak kriterij, $\varepsilon = (\varepsilon_1, \varepsilon_2, ..., \varepsilon_m)$. Za kriterij z_i je tako interval zaupanja enak $[z_i - \varepsilon_i, z_i + \varepsilon_i]$. Za potrebe primerjave rešitev, predstavljenih na ta način, so relacije med rešitvami ob negotovosti definirane na *mejnih okvirih* (angl. bounding box) vektorja kriterijev. Iz intervalov zaupanja se mejni okvir vektorja kriterijev z izračuna kot (slika 1):

$$\mathrm{BB}(z, \varepsilon) =$$
$$[z_1 - \varepsilon_1, z_1 + \varepsilon_1] \times [z_2 - \varepsilon_2, z_2 - \varepsilon_2] \times ... \times [z_m - \varepsilon_m, z_m - \varepsilon_m].$$

Definicija 4.1 (verjetna Pareto domininranost) *Mejni okvir* $\mathrm{BB}(z, \varepsilon)$ *verjetno dominira nad mejnim okvirom* $\mathrm{BB}(w, \delta)$, $\mathrm{BB}(z, \varepsilon) \prec_u \mathrm{BB}(w, \delta)$, *če za vsak $z' \in \mathrm{BB}(z, \varepsilon)$ in vsak $w' \in \mathrm{BB}(w, \delta)$ velja: $z' \prec w'$.*



Slika 1: Mejni okvir vektorja kriterijev



Slika 2: Aproksimirane rešitve, predstavljene z mejnimi okviri

Če imamo $z = f(x)$ z vektorjem zaupanja ε, $w = f(y)$ z vektorjem zaupanja δ in velja $\mathrm{BB}(z, \varepsilon) \prec_u \mathrm{BB}(w, \delta)$, potem rešitev x verjetno dominira nad rešitvijo y. Z drugimi besedami, x dominira nad y z (velikim) zaupanjem (odvisnim od ε in δ).

Na sliki 2 so predstavljene vrednosti kriterijev $z^1, .., z^5$ in njihovi mejni okviri. Na sliki lahko vidimo, da z^1 verjetno dominira nad rešitvijo z^4 ($z^1 \prec_u z^4$).

Na podoben način so definirane tudi ostale relacije.

Definicija 4.2 (verjetna Pareto nedominiranost) *Mejni okvir* $\mathrm{BB}(z, \varepsilon)$ *je verjetno nedominiran glede na mejni okvir* $\mathrm{BB}(w, \delta)$, $\mathrm{BB}(z, \varepsilon) \not\succ_u \mathrm{BB}(w, \delta)$, *če za vsak* $z' \in \mathrm{BB}(z, \varepsilon)$ *in* $w' \in \mathrm{BB}(w, \delta)$ *velja:* $z' \prec w'$ *or* $z' \| w'$.

Nekaj primerov verjetne Pareto nedominiranosti je vidnih na sliki 2: $z^1 \not\succ_u z^2, z^1 \not\succ_u z^3, z^1 \not\succ_u z^5, z^2 \not\succ_u z^4, z^3 \not\succ_u z^4$.

Če imamo $z = f(x)$ z vektorjem zaupanja ε, $w = f(y)$ z vektorjem zaupanja δ in $\mathrm{BB}(z, \varepsilon) \not\succ_u \mathrm{BB}(w, \delta)$, potem rečemo, da je rešitev x verjetno nedominirana s strani rešitve y. Šele ko se negotovost odstrani, to je ko so vse rešitve eksaktno ovrednotene, lahko izvemo, ali x dominira nad y, ali pa sta rešitvi neprimerljivi.

Definicija 4.3 (verjetna neprimerljivost) *Mejni okvir* $\mathrm{BB}(z, \varepsilon)$ *je verjetno neprimerljiv z mejnim okvirom* $\mathrm{BB}(w, \delta)$, $\mathrm{BB}(z, \varepsilon) \|_u \mathrm{BB}(w, \delta)$, *če za vsak* $z' \in \mathrm{BB}(z, \varepsilon)$ *in* $w' \in \mathrm{BB}(w, \delta)$ *velja:* $z' \| w'$.

Tudi v tem primeru sta dve rešitvi verjetno neprimerljivi, če sta njuna pripadajoča mejna okvira verjetno neprimerljiva. Na sliki 2 je z^2 verjetno neprimerljiva z z^3.

Če rešitvi nista v nobeni od zgoraj definiranih relacij, potem sta v neznani relaciji.

Definicija 4.4 (neznana relacija) *Mejni okvir* $\mathrm{BB}(z, \varepsilon)$ *je v neznani relaciji z mejnim okvirom* $\mathrm{BB}(w, \delta)$, $\mathrm{BB}(z, \varepsilon) \sim_u \mathrm{BB}(w, \delta)$, *če velja* $\mathrm{BB}(z, \varepsilon) \cap \mathrm{BB}(w, \delta) \neq 0$.

Na sliki 2 je z^5 v neznani relaciji z z^2, z^3 in z^4.

Iz verjetne Pareto dominiranosti ali verjetne neprimerljivosti sledi verjetna Pareto nedominiranost:

$$x \prec_u y \Rightarrow x \not\succ_u y$$
$$x \|_u y \Rightarrow x \not\succ_u y.$$

Primeri izpeljane verjetne Pareto nedominiranosti, ki so vidni na sliki 2: $z^1 \not\succ_u z^4, z^2 \not\succ_u z^3, z^3 \not\succ_u z^2$.

Če so vse rešitve eksaktno ovrednotene, so vse širine njihovih intervalov zaupanja enake nič. V takem primeru se relacije, predstavljene v tem razdelku, neposredno pretvorijo v v relacije, predstavljene v 3. razdelku.

Z uporabo relacij ob negotovosti lahko večkriterijski optimizacijski algoritem primerja dve rešitvi in določi, katero obdržati in katero zavreči, brez potrebe, da bi jih moral najprej eksaktno ovrednotiti.

Če pri primerjavi še vedno obstaja negotovost, je potrebno eksaktno ovrednotenje in nato ponovna primerjava rešitev. Ta način primerjanja rešitev zmanjšuje možnost napak pri primerjavi rešitev, ki so posledica netočnih aproksimacij.

5. PRIMERJAVA REŠITEV OB NEGOTOVOSTI

V tem razdelku relacije ob negotovosti uporabimo za primerjavo rešitev v evolucijskem algoritmu za večkriterijsko optimizacijo na osnovi diferencialne evolucije (algoritem DEMO [9]). V tem algoritmu se iz vsake rešitve v populaciji (starš) tvori nova rešitev (kandidat). Algoritem nato primerja starša in kandidata in boljšo rešitev doda v populacijo ter slabšo zavrže. Če sta rešitvi neprimerljivi, se v populacijo dodata obe. Zaradi prisotnosti negotovosti pri primerjavi rešitev je potrebno prilagoditi postopek, ki določa katere rešitve dodati v populacijo, katere zavreči in katere pred primerjavo eksaktno ovrednotiti.

Pri primerjavi kandidata c z vektorjem zaupanja ε in starša p z vektorjem zaupanja δ po vrsti preverimo naslednjih šest možnosti:

1. Če velja $c \|_u p$, obe rešitvi dodamo v populacijo.

   V tem primeru sta rešitvi c in p verjetno neprimerljivi. Torej tudi če bi obe rešitvi eksaktno ovrednotili, bi bili verjetno neprimerljivi in bi obe rešitvi dodali v populacijo. Zato v tem primeru dodatnih eksaktnih ovrednotenj ne izvedemo.

2. Če velja $c \prec_u p$, rešitev c dodamo v populacijo in rešitev p zavržemo.

   V tem primeru je rešitev c verjetno boljša od rešitve p, zato dodatnih eksaktnih ovrednotenj ne izvedemo.

3. Če velja $p \prec_u c$, rešitev p dodamo v populacijo in rešitev c zavržemo.

   Ta možnost je podobna prejšnji, le da je tu rešitev p perspektivnejša.

4. Če velja $c \not\succ_u p$, preverimo ε. Če je $\varepsilon \neq 0$, eksaktno ovrednotimo c in nato rešitvi primerjamo še enkrat. Če

velja $\varepsilon = 0$ (c je že eksaktno ovrednoten), eksaktno ovrednotimo p in nato rešitvi primerjamo še enkrat.

V tem primeru je rešitev c verjetno boljša vsaj po enem kriteriju. Da bi lahko določili, ali rešitev c dominira nad rešitvijo p ali pa sta rešitvi neprimerljivi, je potrebno (vsaj) eno rešitev eksaktno ovrednotiti. Ker ima c več možnosti, da je boljša, najprej preverimo njene intervale zaupanja. Če so širine intervalov različne od nič, kar pomeni, da je rešitev aproksimirana, potem eksaktno ovrednotimo rešitev c in nato ponovno primerjamo rešitvi. Če pa so širine intervalov zaupanja enake nič, kar pomeni, da je rešitev c že eksaktno ovrednotena, potem eksaktno ovrednotimo rešitev p in nato ponovno primerjamo rešitvi.

5. Če velja $p \not\prec_u c$, preverimo δ. Če je $\delta \neq 0$, eksaktno ovrednotimo p in nato ponovno primerjamo rešitvi. Če je $\delta = 0$, eksaktno ovrednotimo c in ponovno primerjamo rešitvi.

   Ta možnost je podobna prejšnji, le da je sedaj rešitev p perspektivnejša.

6. Če velja $c \sim_u p$, preverimo ε. Če je $\varepsilon \neq 0$, eksaktno ovrednotimo c in nato ponovno primerjano rešitvi. Če je $\varepsilon = 0$, eksaktno ovrednotimo p in nato ponovno primerjamo rešitvi.

   V tem primeru je edini način, da izvemo, v kakšni relaciji sta rešitvi, da eksaktno ovrednotimo (vsaj) eno rešitev. Ker za kandidata (potomca) obstaja možnost, da je boljši od starša, najprej preverimo, ali je že eksaktno ovrednoten. Če ni, kandidata eksaktno ovrednotimo. Če je, eksaktno ovrednotimo starša in nato ponovno primerjamo rešitvi.

6. ZAKLJUČEK

V prispevku smo definirali nove relacije za primerjavo rešitev ob negotovosti. V našem primeru je negotovost posledica aproksimacij z nadomestnimi modeli in ne npr. šuma v podatkih. Rešitve so predstavljene z aproksimiranimi vrednostmi in intervali zaupanja. Novo definirane relacije razširjajo že znane relacije Pareto dominiranosti in pri primerjavi upoštevajo tudi intervale zaupanja. Primerjava rešitev s temi relacijami zmanjšuje možnosti napačnih primerjav in preprečuje, da bi netočne aproksimacije poslabšale optimizacijske rezultate. Nove relacije smo uporabili v evolucijskem večkriterijskem optimizacijskem algoritmu za primerjavo rešitev. Poleg tega, da je mogoče z novimi relacijami rešitve primerjati ne glede na morebitne netočnosti v aprokcimacijah, je prednost novih relacij tudi možnost določitve dominiranosti rešitev, ne da bi jih bilo potrebno najprej eksaktno ovrednotiti.

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IDENTIFIKACIJA OSEB OB VSTOPU SKOZI VRATA Z UPORABO POSPEŠKOMERA IN STROJNEGA UČENJA

Rok Piltaver[1], Tadej Vodopivec[2], Matjaž Gams[1]
Institut "Jožef Stefan" – Odsek za inteligentne sisteme[1]
Fakulteta za računalništvo in informatiko – Univerza v Ljubljani[2]
e-mail: {rok.piltaver, matjaz.gams}@ijs.si, tadej@vodopivec.net

POVZETEK

V prispevku sta opisana sistem in postopek za identifikacijo omejenega števila oseb ob vstopu skozi vrata na podlagi izmerjenih pospeškov vratnega krila z uporabo metod strojnega učenja. Postopek je preizkušen na več kot 1000 vstopih 12 različnih oseb in dosega klasifikacijsko točnost do 82 %. V prispevku je podana tudi analiza vpliva razlik v načinu vstopa med različnimi osebami na klasifikacijsko točnost identifikacije, ki kaže, da je za raznolike in majhne skupine oseb mogoče doseči skoraj 100 % točnost, medtem ko je pričakovana točnost za zelo homogene in velike skupine bistveno nižja.

1 UVOD

Identifikacija je postopek, v katerem oseba dokaže svojo identiteto, ki se običajno uporablja za pridobitev določene pravice, do katere je oseba upravičena. V upravnih postopkih, kjer identifikacijo opravlja druga oseba, se običajno uporabljajo različne vrste izkaznic (osebna ali članska izkaznica, potni list ipd.). Pogosteje pa identifikacijo opravljajo naprave, ki po uspešni identifikaciji omogočijo vstop v prostor ali dostop do različnih podatkov in storitev. V ta namen se uporablja gesla, biometrične senzorje (prstni odtis, branje šarenice, prepoznavanje obraza, ali glasu) ali identifikacijske elemente in primerne čitalce (RFID, NFC, Bluetooth, magnetne kartice, ključ) [1]. Slabost vseh naštetih metod je, da mora oseba ob identifikaciji izvesti določeno akcijo (npr. vtipkati geslo) in s sabo nositi identifikacijski element.

Namen tega dela je razviti metodo za identifikacijo oseb ob vstopu skozi vrata glede na sam način vstopa, kar odpravi potrebo po dodatnih akcijah in prenašanju identifikacijskega elementa. Na račun udobnosti pa se metoda odpoveduje visoki zanesljivosti identifikacije (tolerira se nekaj odstotkov napačno identificiranih oseb) in sprejema omejitev na manjše število različnih oseb, ki jih je mogoče identificirati (optiomalno do 5, maksimalno do 10 ali 15).

Znano je, da ima vsaka oseba svoje značilnosti, po katerih jo je mogoče prepoznati: fizični izgled, glas, prstni odtis, način hoje idr. Znanih je precej metod za identifikacijo ljudi na podlagi vzorca hoje [2], identifikacija pa se v komercialnih produktih uporablja tudi v povezavi s senzorji kot je Kinect [3].

Poleg tega je znano tudi, da je mogoče iz izmerjenih pospeškov vratnega krila med odpiranjem ugotoviti morebitne okvare vrat [4] ter da je na podlagi pospeškov posameznih delov človeškega telesa mogoče prepoznati aktivnost, ki jo trenutno izvaja oseba [5]. Našteta dejstva so bila motivacija za razvoj metode za identifikacijo, ki je opisana v tem prispevku.

2 FIZIKALNE ZAKONITOSTI PRI ODPIRANJU VRAT

Pri prehodu skozi vrata lahko opazujemo naslednje faze, ki predstavljajo fizikalno podlago za razvoj sistema za identifikacijo ob vstopu. Pred vstopom vrata mirujejo, zato odstopanja od statičnih vrednosti pospeškov povzroča le šum samih senzorjev ali oddaljeni vpliv (npr. tovornjak). Ko oseba prične z vstopom, najprej pospeši vratno krilo v smeri odpiranja vrat, kar opazimo kot povečevanje kota odprtosti, kotne hitrosti in kotnega pospeška vratnega krila. Za tem se pospešek prične zmanjševati, dokler ne postane negativen (pojemek), ki traja dokler se vratno krilo ne ustavi pri maksimalnem kotu odprtosti. V tem stanju lahko vrata ostanejo dlje časa ali le za trenutek. Za tem oseba vratno krilo pospeši v smeri zapiranja, tako da kotna hitrost postane negativna, kot odprtosti pa se začne zmanjševati. Preden se kot odprtosti ponovno vrne na 0 (zaprta vrata), oseba običajno upočasni zapiranje vrat. Če ga ne upočasni dovolj (vrata se zaloputnejo), po popolnem zaprtju opazimo še nihanje vrat, ki hitro pojema in izzveni v roku do 1 s. Po tem vrata zopet mirujejo, kot so pred odpiranjem.

Za opazovanje opisanih fizikalnih pojavov se lahko uporabijo različni senzorji: npr. pospeškomer, giroskop, magnetomer ali merilnik kota odprtosti vratnega krila. Zaradi dostopnosti, preteklih izkušenj z uporabo in obilice sorodnega dela je bil za senzor izbran triosni pospeškomer. Ta je na vrata nameščen tako, da v eni osi meri gravitacijski a_g, v drugi radialni a_r ter v tretji tangencialni pospešek a_t. Gravitacijski pospešek a_g je - ob predpostavki, da je pospeškomer poravnan z osjo gravitacije - odvisen le od geografske lege vratnega krila. Radialni pospešek a_r je odvisen od kotne hitrosti ω, kot to opisuje enačba (1), tangencialni a_t pa od kotnega pospeška vratnega krila α, kot to opisuje enačba (2). Oba sta odvisna tudi od oddaljenosti pospeškomera od osi rotacije vratnega krila R, ki mora biti zaradi boljšega razmerja signal-šum čim večja.

$$a_r = \omega^2 R \qquad (1)$$

$$a_g = R\alpha \quad (2)$$

3 METODA

Postopek identifikacije, ki je v nadaljevanju tega razdelka opisan bolj podrobno, se prične z zajemom podatkov iz pospeškomera. Ti se zbirajo od trenutka, ko se vrata pričnejo odpirati, do 1 s po popolnem zaprtju vrat. Za tem se iz radialnega pospeška a_r izračunata še kotna hitrost ω in kot odprtosti vrat φ ter se prehod skozi vrata razdeli na posamezne podfaze. V naslednjem koraku se glede na določene podfaze izluščijo značilke, ki se jih uporabi za gradnjo klasifikacijskega modela za identifikacijo ali za samo identifikacijo z uporabo že zgrajenega modela.

3.1 Računanje kotne hitrosti in kota odprtosti

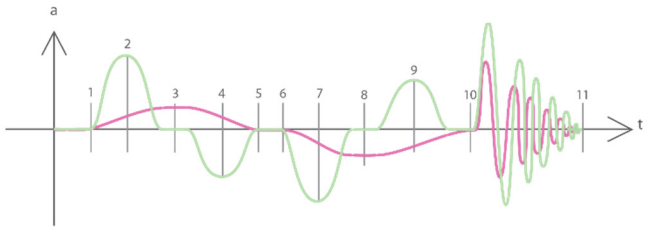
Za uspešno strojno učenje, katerega rezultat je klasifikacijski model za identifikacijo oseb ob vstopu skozi vrata na podlagi izmerjenih pospeškov, je potrebno iz surovih senzorskih podatkov pridobiti relevantne značilke. Te so povezane s spreminjanjem kotnega pospeška α, kotne hitrosti ω in kota odprtosti vrat φ med prehodom. S pospeškomerrom je mogoče neposredno izmeriti le kotni pospešek α; kotno hitrost ω in kot odprtosti φ pa se aproksimira po enačbah (3) in (4), v katerih T pomeni čas med zajemom zaporednih vzorcev radialnega pospeška.

$$R\omega(t) = \sum_{k=0}^{t} a_r\,(k)T \quad (3)$$

$$R\varphi(t) = \sum_{k=0}^{t} \omega\,(k)T \quad (4)$$

Dejanske vrednosti kotnega pospeška, kotne hitrosti in kota odprtosti niso potrebne, zato lahko zanemarimo konstanti R in T, saj so za identifikacijo pomembne le razlike v vrednostih med posameznimi osebami in ne konkretne vrednosti opisanih parametrov.

3.2 Določitev podfaz prehoda skozi vrata



Slika 1: *Kotna hitrost (roza) in kotni pospešek (zelena) ob prehodu skozi vrata ter delitev na podfaze (siva)*

Za potrebe izračuna značilk se podatki o prehodu v naslednjem koraku postopka razdelijo na naslednje podfaze, ki so prikazane na sliki 1 in opisane v nadaljevanju:

- naraščanje pospeška ob odpiranju: od začetka odpiranja vrat do maksimalnega kotnega pospeška med odpiranjem (kot odprtosti narašča) – 1-2;
- zmanjševanje pospeška ob odpiranju: od maksimalnega kotnega pospeška med odpiranjem do spremembe predznaka kotnega pospeška med odpiranjem – 2-3;
- naraščanje pojemka ob odpiranju: od spremembe predznaka kotnega pospeška do maksimalnega pojemka med odpiranjem – 3-4;
- zmanjševanje pojemka ob odpiranju: od maksimalnega pojemka med odpiranjem do spremembe predznaka kotnega pospeška – 4-5;
- mirovanje vrat: čas med odpiranjem in zapiranjem, ko je kotni pospešek enak 0 (lahko traja samo trenutek ali nekaj sekund) – 5-6,
- naraščanje pospeška ob zapiranju: od začetka zapiranja (kot odprtosti prične padati) do maksimalnega pospeška med zapiranjem – 6-7;
- zmanjševanje pospeška ob zapiranju: od maksimalnega pospeška med zapiranjem do spremembe predznaka kotnega pospeška – 7-8,
- naraščanje pojemka ob zapiranju: od spremembe predznaka kotnega pospeška do maksimalnega pojemka med zapiranjem – 8-9,
- padanje pojemka ob zapiranju: od maksimalnega pojemka med zapiranjem do popolne zaprtosti vrat (kot odprtosti je enak 0) – 9-10,
- nihanje vratnega krila: od trenutka popolne zaprtosti vrat do konca nihanja vratnega krila zaradi sunka ob zapiranju – 10-11.

3.3 Izračun značilk prehoda skozi vrata

V naslednjem koraku se za vsako podfazo, za vsak parameter (kotni pospešek, kotna hitrost in kot odprtosti vrat) izračunajo naslednje statistične značilnosti:

- ekstremna vrednost parametra v podfazi (različna od 0),
- strmina linearne interpolacije parametra v podfazi,
- standardni odklon parametra v podfazi,
- ploščina pod krivuljo parametra v podfazi (integral).

Za vsako podfazo se izračuna tudi trajanje. Tako se skupaj izračuna 10 (podfaz) × (3 (parametri) × 4 (značilnosti) + 1 (trajanje)) = 130 značilk, ki se jih uporabi v naslednjem koraku.

3.4 Učenje modela in identifikacija

Ko je zbranih vsaj 15-20 vektorjev značilk o prehodu skozi vrata vsake izmed oseb, ki jo želimo identificirati, se z izbrano metodo za gradnjo klasifikatorja zgradi klasifikacijski model. Potem se vektorji značilk, pridobljeni ob vsakem naslednjem prehodu skozi vrata, uporabijo v povezavi z zgrajenim modelom za napovedovanje identitete osebe, ki je šla skozi vrata, tj. za identifikacijo.

4 REZULTATI

V tem razdelku so opisani rezultati evaluacije opisane metode za identifikacijo. Najprej je opisan postopek zajema učnih in testnih podatkov, sledijo rezultati identifikacije celotne množice razpoložljivih podatkov. V razdelku 4.3 so opisane razlike med posameznimi osebami, v razdelku 4.4 pa je podana analiza vpliva razlik med osebami na pričakovano klasifikacijsko točnost opisane metode za identifikacijo.

4.1 Zajem učnih in testnih podatkov

Učni podatki so bili zajeti na pisarniških vratih, na katere je bil s pomočjo stojala pritrjen tablični računalnik Samsung Galaxy Tab 10.1, ki je med zajemom podatkov shranjeval

odčitke vgrajenega pospeškomera v SQLite podatkovno bazo, ki je bila po zaključku snemanja prenesena na osebni računalnik. Zajetih je bilo 1005 prehodov skozi vrata dvanajstih različnih oseb starih od 21 do 87 let. Največ prehodov je bilo posnetih za osebo številka 10 (208), najmanj pa za osebo številka 8 (38), v povprečju je bilo zajetih po 83 prehodov na osebo. Osebe, ki so izvajale prehode, v času snemanja niso vedele, da se zbirajo podatki o načinu prehoda skozi vrata - da ne bi vplivale na način vstopa jim je bila dana naslednja naloga: »V pisarni je seznam serijskih številk, ki ga je potrebno prepisati na list papirja, ki se nahaja na hodniku, ne daleč od pisarne. Preberite in si zapomnite čim večji del posamezne serijske številke, ki ga nato napišite na list (na hodniku). Postopek ponovite za čim več serijskih številk.«

Med samim snemanjem je oseba, ki je nadzorovala snemanje, s pomočjo aplikacije na mobilnem telefonu, ki je bil preko Bluetooth-a povezan s tabličnim računalnikom, označila začetke in konce posameznih prehodov skozi vrata ter zabeležila ime osebe, ki je izvedla prehod.

4.2 Identifikacija vseh 12 oseb

Za gradnjo klasifikatorjev za identifikacijo oseb ob vstopu skozi vrata so bile uporabljene naslednje metode strojnega učenja: metodo k najbližjih sosedov [6], odločitveno drevo C4.5 [7], umetno nevronsko mrežo [8], metodo podpornih vektorjev [9], naivni Bayesov klasifikator [10], CN2 odločitvena pravila [11] in naključni gozd [12].

Uporabljene so bile implementacije algoritmov v programskem paketu Orange [13], parametri učnih algoritmov so bile privzete vrednosti razen naslednjih izjem: število sosedov za kNN 5, minimalno število primerov v listu za odločitveno drevo 8, število skritih nevronov 30.

Rezultati identifikacije z uporabo naštetih algoritmov, pridobljeni z metodo 5-kratnega prečnega preverjanja, so prikazani v tabeli 1. Najvišjo klasifikacijsko točnost 82,09 % je dosegel algoritem umetna nevronska mreža.

Metoda	CA	AUC	Brier
k najbližjih sosedov	75,32	96,53	0,358
Odločitveno drevo C4.5	63,18	91,06	0,550
Umetna nevronska mreža	**82,09**	**98,90**	**0,264**
Metoda podpornih vektorjev	66,47	97,32	0,484
Naivni Bayesov klasifikator	78,24	97,96	0,413
Odločitvena pravila CN2	59,20	90,74	0,554
Naključni gozd	69,35	96,17	0,407
Večinski razred	20,80	50,00	0,8931

Tabela 1: *mere uspešnosti identifikacije z različnimi algoritmi: klasifikacijska točnost (Ca), površina pod ROC krivuljo (AUC) in Brier score.*

V tabeli 2 je prikazana matrika zamenjav najboljšega modela za identifikacijo 12 oseb ob prehodu skozi vrata. Model 5 osebe identificira pravilno z verjetnostjo večjo od 85 % medtem, ko razmeroma pogosto zamenja osebo številka 11 za sebo številka 12 ali osebo številka 9, osebo številka 9 za osebo številka 7, osebo številka 5 za osebo številka 6 in osebo številka 4 za osebo številka 7.

4.3 Analiza razlik med osebami

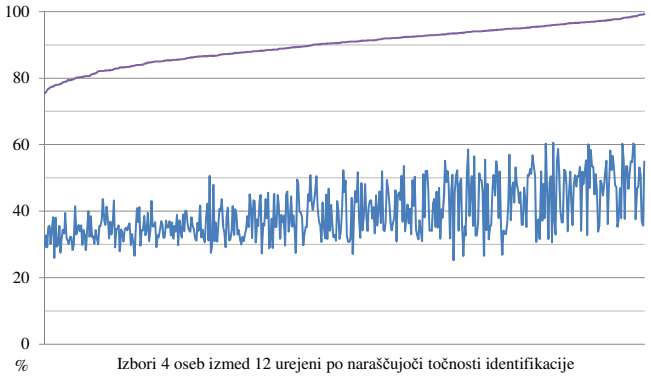
Da bi ugotovili, kako se načini prehoda posamezne osebe skozi vrata razlikujejo od načinov prehoda ostalih oseb, smo zgradili še dodatnih 12 binarnih klasifikatorjev, katerih naloga je bila ločiti eno izmed oseb od preostalih enajstih. Rezultati so predstavljeni v tabeli 3, iz katere sledijo podobni zaključki kot iz tabele 2. Določene osebe je lahko identificirati z veliko točnostjo, ker imajo značilen način prehoda skozi vrata, ki se dovolj razlikuje od načinov prehoda ostalih oseb. Nekaj oseb pa prehaja skozi vrata na način, ki je podoben vsaj eni drugi osebi, zato model take osebe težko loči, posledično pa je klasifikacijska točnost za te osebe občutno nižja.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	**96**	0	1	0	0	1	0	0	0	1	0	0
2	0	**96**	0	0	0	2	2	0	0	0	0	0
3	0	0	**87**	4	0	2	0	0	0	0	0	6
4	0	0	0	66	4	2	**15**	2	2	4	0	4
5	1	0	1	0	73	**8**	**9**	2	2	1	0	3
6	2	1	1	1	8	77	3	4	1	0	1	2
7	0	2	1	2	5	1	73	2	6	3,	0	3
8	5	0	0	0	3	3	3	**85**	0	3	0	0
9	0	0	3	1	4	1	**7**	1	70	0	6	6
10	0	0	0	0	1	1	1	0	0	**98**	1	0
11	0	0	0	0	6	0	2	2	**13**	0	59	**18**
12	0	0	3	1	2	3	5	1	5	1	4	76

Tabela 2: *matrika zamenjav pri identifikaciji (verjetnost %)*

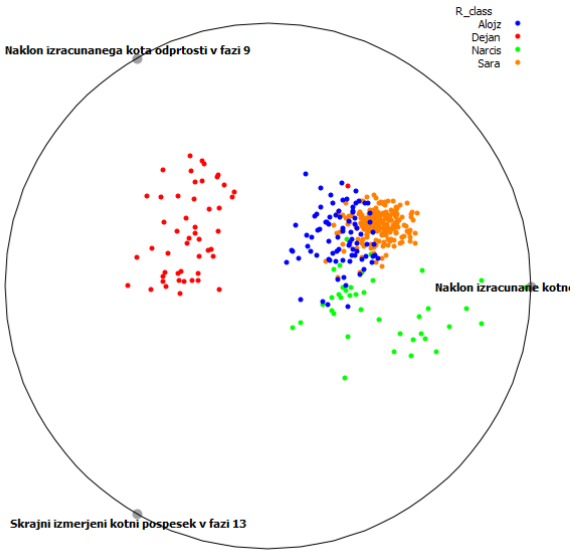
4.4 Analiza vpliva razlik med osebami na točnost klasifikacije

Da bi ocenili maksimalno in minimalno pričakovano točnost identifikacije skupine ljudi z omejeno velikostjo, smo iz celotne množice zbranih podatkov izločili vsako možno podmnožico s po štirimi osebami. Za vsako podmnožico smo z metodo 5-kratnega prečnega preverjanja izračunali pričakovano klasifikacijsko točnost identifikacije z naštetimi algoritmi. Graf, ki prikazuje klasifikacijsko točnost metode podpornih vektorjev, je prikazan na sliki 2 iz katere je razvidno, da je najmanjša klasifikacijska točnost skupine 4 oseb 75,4 % najboljša pa 99,2 %.

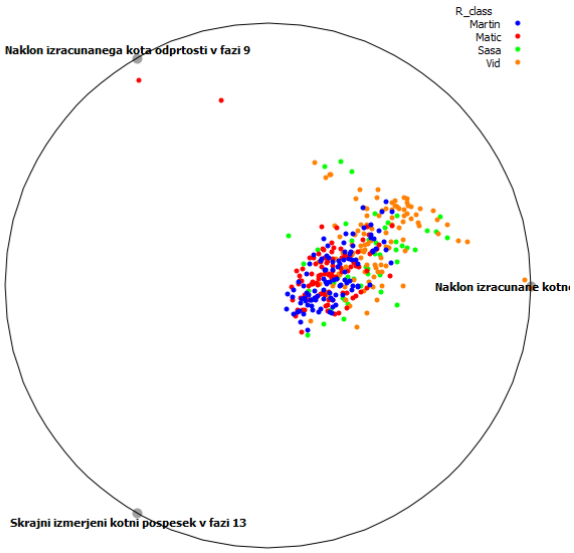


Slika 1: *Klasifikacijska točnost za različne podmnožice štirih oseb za večinski razred (modra) in SVM (rdeča)*

Graf podatkov za skupino 4 oseb, med katerimi model ločuje z največjo verjetnostjo, je prikazan na sliki 3, graf za skupino štirih oseb, med katerimi model loči najslabše, pa na sliki 4.



Slika 2: *Najčistejša vizualizacija podatkov za skupino štirih oseb, med katerimi model ločuje z največjo verjetnostjo*



Slika 3: *Vizualizacija podatkov za skupino štirih oseb, med katerimi model loči z najmanjšo verjetnostjo*

5 ZAKLJUČEK

V prispevku sta predstavljena sistem in metoda za identifikacijo oseb ob vstopu skozi vrata z uporabo pospeškomera in strojnega učenja. Prednost metode je, da od uporabnika razen samega vstopa ne zahteva dodatnih akcij ali prenašanja identifikacijskega elementa. V zameno za udobnost identifikacije pa postopek ne zagotavlja visoke zanesljivosti identifikacije in deluje s točnostjo primerno za uporabo v praksi samo na omejenem številu oseb (do 10).

Postopek deluje tako, da zbrane podatke o pospešku vratnega krila med prehodom razdeli v več podfaz in v vsaki izmed njih izračuna statistične lastnosti naslednjih parametrov: kot odprtosti, kotna hitrost in kotni pospešek. Le-te se uporabijo kot značilke za gradnjo klasifikatorja, ki se uporablja za identifikacijo osebeob vstopu skozi vrata.

Metoda je bila preizkušena na 1005 prehodih skozi vrata, ki jih je izvedlo 12 različnih oseb. Metoda jih identificira s klasifikacijsko točnostjo 82,09 %. Izmed 12 oseb jih ima vsaj 5 značilen način vstopa, ki se močno razlikuje od vseh ostalih, in jih je mogoče identificirati z klasifikacijsko točnostjo nad 85 %. Izmed 12 oseb je mogoče zbrati 273 različnih podmnožic s po 4 osebami, za katere identifikacija deluje z več kot 90% točnostjo. Najbolj homogeno podmnožico štirih oseb pa je mogoče identificirati s točnostjo 99,2 %.

V nadaljnjem delu načrtujemo uporabo Kalmanovega filtra za odstranjevanje šuma v izmerjenih podatkih in izračun kotne hitrosti ter kota odprtosti, povečanje robustnosti algoritma za delitev na podfaze ter natančno analizo pomembnosti posameznih značilk z namenom zmanjšanja števila le-teh. Metode bomo preizkusili tudi na podatkih zajetih v realnih pogojih tekom več mesecev ter skušali uporabiti še dodatne senzorje, npr. merilec kota odprtosti vratnega krila.

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INTELIGENTNI SISTEM E-VRATAR

Marko Pušnik[1], Rok Piltaver[2], Vedrana Vidulin[2], Matjaž Gams[2]
[1]Fakulteta za računalništvo in informatiko, Univerza v Ljubljani
[2]Odsek za inteligentne sisteme, Institut "Jožef Stefan"
e-mail: marko.pusnik2@gmail.com, {rok.piltaver, vedrana.vidulin, matjaz.gams}@ijs.si

POVZETEK

V prispevku je predstavljen sistem e-vratar, ki posnema vedenje človeškega vratarja. Njegov namen je zagotavljanje varnosti v bivalnih ali poslovnih prostorih, poenostavljeno prehajanje skozi vrata in nudenje inteligentnih storitev vratarja. Uporablja algoritme strojnega učenja in se je zaradi tega sposoben prilagajati različnim situacijam ter se je iz njih sposoben učiti. Posebnost sistema ni le v inteligentnem sklepanju, ampak tudi v sposobnosti interakcije na človeku prijazen način. Na podlagi povezave s sistemom Asistent, uporabnikom omogoča, da z njim komunicirajo v naravnem jeziku. To poveča udobje, poenostavi upravljanje z e-vratarjem in izboljša uporabniško izkušnjo. Sistem e-vratar je razdeljen na dva dela: programski del, ki ga sestavljajo aplikaciji na tabličnem računalniku in mobilnem telefonu ter programa na krmilniku in strežniku. Strojni del pa sestavlja elektro-mehanska ključavnica, krmilnik, senzorji, tablični računalnik, več mobilnih telefonov in strežnik.

1 UVOD

Sistem e-vratar sodi v področje sistemov za zagotavljanje varnosti. Končni cilj razvoja e-vratarja je sistem, ki bo omogočal osnovo za celostno vodenje pametne hiše. Ne le iz vidika varnosti, ampak tudi iz vidika povečanega udobja ter racionalnejše porabe energije za npr. ogrevanje, hlajenje in razsvetljavo.

Na tržišču je že nekaj podobnih sistemov. Sistema kot sta Key2Share in Lockitron dajeta poudarek predvsem na fizičnem varovanju vrat ter onemogočanju nepooblaščenih vstopov skozi vrata. Ponujata funkcije, kot so odklepanje na daljavo preko telefona, pošiljanje ključev med uporabniki, upravljanje s pravicami uporabnikov. Sistem Locktrion pa omogoča še zaznavanje trkanja ter razpoznavanje govora.

Sistem Doorboot nudi video ter avdio nadzor. Dostop do kamere lahko preko spletnega strežnika omogočimo komurkoli. Omogoča tudi pošiljanje opozoril ob zvonjenju in povezavo s sistemom Lockitron.

Kwikset Kevo in Goji sta sistema, ki trenutno nudita njširši nabor funkcij, poleg že naštetih omogočata še vstop s pomočjo bluetooth ključa ter vsebujeta senzor dotika kljuke.

Sistem Drop Cam razpoznava gibanje iz kamere in na podlagi tega sprožiti alarm. Naprednejši sistem za detekcijo gibanja pa je Canary, ki se je sposoben sam učiti, kdaj naj ob zaznanem gibanju sproži ali ne sproži alarm. Poleg tega zbira in posreduje tudi podatke iz dodatnih senzorjev.

Seveda na tržišču obstaja še več podobnih sistemov; izpostavljeni so bili le najbolj uspešni in najbolj podobni sistemu e-vratar. Sistem e-vratar v okviru celovitega sistema nudi večino funkcij sorodnih sistemov in njihovo nadgradnjo na podlagi inteligentne programske opreme in širokega nabora senzorjev.

V nadaljevanju prispevka so opisane funkcije e-vratarja (razdelek 2), ki so za uporabnike najpomembnejše, ter struktura celotnega sistema: opis in delovanje strojnih komponent (razdelek 3.1) ter opis in delovanje programskih modulov (razdelek 3.2).

2 UPORABNOST SISTEMA

Ta razdelek opisuje najpomembnejše funkcije sistema e-vratar, ki skrbi za varnost in udobje uporabnikov. To doseže s kombinacijo funkcij, ki so opisane v nadaljevanju.

2.1 Funkcije za zagotavljanje varnosti

E-vratar zna samodejno vklapljati ter izklapljati nadzorni način, v katerem je stopnja varnosti najvišja. Vklopi ga (in hkrati zaklene vrata), ko prostor zapusti zadnja oseba, in ga samodejno izklopi, ko v prostor vstopi prva pooblaščena oseba. S tem zagotavlja večjo varnost, saj izključi človeški faktor pozabljivosti ter tako preprečimo, da bi bili prostori nezavarovani.

Kadar e-vratar deluje v nadzornem načinu, spremlja dogajanje na podlagi več senzorjev. Kamera na tabličnem računalniku, ki gleda v prostor, zaznava gibanje in če ga zazna, sproži alarm. Uporablja tudi senzor za detekcijo poskusa vdora (pospeškomer) ter senzor gibanja. Če zazna gibanje pred vrati ali razbijanje po vratih, z zunanjo kamero posname dogajanje ter uporabniku omogoči, da s pomočjo zajetih fotografij preveri dogajanje. Ob zaznanem poskusu vdora in gibanja v prostoru e-vratar uporabnikom pošlje obvestila preko SMS ali na elektronski naslov, kamor pošlje tudi zajete fotografije.

Kadar pooblaščeni uporabnik želi vstopiti v prostor, se identificira in če je identifikacija uspešna, e-vratar samodejno odklene in odpre vrata. Ko uporabnik vstopi in zapre vrata, lahko e-vratar samodejno zaklene vrata. S tem omogoči večji nadzor nad vstopi in izstopi na podlagi shranjene zgodovine vstopov in izstopov posameznih uporabnikov.

Če uporabnik oceni, da dodatna varnosti, ki jo nudi e-vratar začasno ni potrebna lahko vključi tako imenovani piknik način (način z najnižjo stopnjo varnosti). V tem načinu e-vratar ne beleži zgodovine vstopov in izstopov in ne zahteva identifikacije uporabnika, kar pospeši prehode

skozi vrata: ob zaznanem dotiku kljuke, samodejno odpre vrata. Ta način delovanja uporabnik aktivira z v naprej določenim časovnim intervalom, po preteku le-tega pa se e-vratar samodejno vrne na prejšnji (bolj varen) način delovanja, če uporabnik pred tem ročno ne izključi piknik načina.

2.2 Funkcije za zagotavljanje udobja

Ker sistem E-vratar posnema obnašanje človeškega vratarja, nudi uporabnikom večje udobje in dodatne storitve, kot jih nudi človeški vratar. Udobje uporabe je iz uporabnikovega stališča zelo pomembno, saj sistem uporablja vsak dan in mu ne sme biti v napoto temveč v podporo.

Uporabniki lahko vrata odklepajo na več načinov: z RFID ključem, prstnim odtisom, blutetooth napravo in na pritisk tipke. Ti načini so hitrejši kot odklepanje s ključem in (razen RFID) ne zahtevajo prenašanje identifikacijskega elementa.

Prav tako je mogoče upravljanje e-vratarja na daljavo: preko mobilne aplikacije ali preko spletnega vmesnika. Spletni vmesnik nudi intuitivno spletno stran, za upravljanje z e-vratarjem na daljavo in ponuja enake funkcije, kot aplikacija na tablici. Mobilna aplikacija nudi upravljanje na daljavo v okrnjeni različici vendar za delovanje ne potrebuje internetne povezave. Uporabnik lahko z uporabo mobilne aplikacije odklene vrata, spremeni način delovanja e-vratarja, poizveduje o prisotni ali odstotni uporabnikov, zahteva pomembna obvestila in seznam alarmov ter pokliče tablični računalnik in ga uporabi kot domofon na daljavo.

E-vratar zna posredovati sporočila med uporabniki. Uporabnik lahko za drugega uporabnika (ali zase) posname glasovno ali napiše tekstovno sporočilo. Za vsako sporočilo uporabnik nastavi kdaj in komu naj bo predvajano. Uporabnike, ki imajo prejeta obvestila e-vratar obvesti o čakajočih sporočilih ob vstopu ali pred izstopom. Uporabnik jih lahko potem na zahtevo prebere, posluša in izbriše.

Uporabniki lahko z e-vratarjem komunicirajo tudi v naravnem jeziku. E-vratar deluje v povezavi s sistemom Asistent, ki zna posredovati odgovor na vprašanje v naravnem jeziku. E-vratar in Asistent sodelujeta tako, da E-vratar posreduje vprašanje Asistentu, ki ga obdela in kot odgovor pošlje programe za poizvedbe v podatkovni bazi e-vratarja, izvajanje akcij e-vratarja in oblikovanje odgovora na podlagi poizvedb in zahtevanih akcij. E-vratar izvede poslani program in uporabniku prikaže ali posreduje generiran odgovor v naravnem jeziku. Do storitve Asistenta lahko uporabnik dostopa tudi na daljavo preko spletnega vmesnika ali mobilne aplikacije.

3 ZGRADBA SISTEMA E-VRATAR

E-vratar je strukturno razdeljen na dva dela: prvi del je programska oprema zasnovana okrog aplikacije na tabličnem računalniku, drugi del pa je strojna oprema zasnovana okrog krmilnika, senzorjev in elektro-mehanske ključavnice. Za komunikacijo med krmilnikom in tablico je uporabljen protokolu na osnovi knjižnice Android Accessory. Krmilnik in tablica lahko izvajata osnovne funkcije e-vratarja tudi ob izpadu komunikacije med njima.

Aplikacija na tabličnem računalniku, ki ni priključena na krmilnik lahko izvaja detekcijo gibanja na podlagi slik iz notranje kamere. Prav tako lahko pošilja opozorila in alarme ob morebitnem zaznanem gibanju. Uporabniki si lahko med seboj posredujejo pisna ali govorna sporočila, lahko uporabljajo Asistenta, ki zna odgovarjati na vprašanja, ki se tičejo stanja aplikacije na tabličnem računalniku.

Krmilnik brez komunikacije z tabličnim računalnikom pa zna preverjati identiteto uporabnikov s pomočjo prstnega odtisa ali RFID ključa in na podlagi tega odklepa in zaklepa vrata. Takšna neodvisnost varuje sistem pred popolnim izpadom.

3.1 Strojna oprema

Kot uporabniški vmesnik in platforma za izvajanje centralne logike e-vratarja je uporabljen *tablični računalnik* z operacijskim sistemom Android. Tablični računalnik nudi primerno velik zaslon s podporo upravljanja na dotik ter mikrofon in zvočnike za snemanje ali predvajanje govornih sporočil. Večina tabličnih računalnikov ima vgrajen tudi GSM modul, ki omogoča klicanje in pošiljanje SMS-jev, ter podporo za brezžično povezavo na splet (WiFi). E-vratar lahko uporabi tudi pospeškomer, ki je že vgrajen v večini tabličnih računalnikov. Večina tablic podpira tudi bluetooth, ki se uporablja kot način identifikacije. Tablični računalniki z operacijskim sistemom Android imajo dobro podporo za razvoj in bogate programske knjižnice (zaznavanje obrazov na slikah, text-to-speech, ipd.). Poleg tega so tablični računalniki že zelo razširjeni in dostopni po ugodnih cenah.

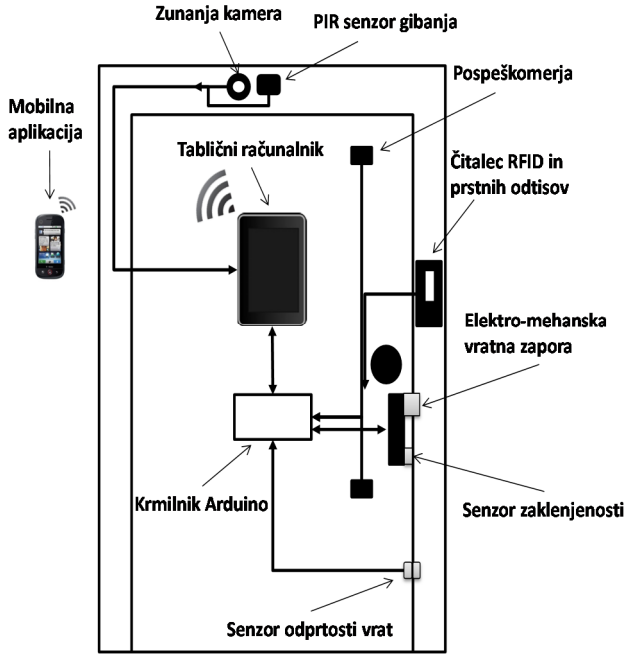
V sistemu e-vratar je uporabljen *krmilnik Arduino*, čigar naloga je, da krmili ključavnico in senzorje ter komunicira s tabličnim računalnikom. Prednosti krmilnika Arduino so, da je cenovno dostopen in ima podporo za operacijski sistem Android ter je odprtokoden. Na tržišču je možno najti veliko senzorjev, ki so kompatibilni z Arduinom, so cenovno dostopni in nudijo potrebne programske knjižnice.

Za odklepanje in zaklepanje vrat je uporabljena *elektro-mehanska ključavnica Roto*, ki se upravlja preko dveh relejev, ta pa sta priključen na krmilnik. Ključavnica lahko sprejme dva ukaza: ukaz za odklepanje in zaklepanje ter ukaz za spremembo režima delovanja. V nočnem režimu delovanja (višja stopnja varnosti) se ključavnica samodejno zaklepa po vsakem zaprtju vrat, v dnevnem režimu delovanja (nižja stopnja varnosti), pa se ključavnica ne zaklepa samodejno.

V sistema e-vratar je vključenih tudi *več senzorjev*: PIR senzor za zaznavanje gibanja, 2 pospeškomera, senzor odprtosti vrat, senzor zaklenjenosti vrat, senzor dotika kljuke, čitalca RFID kartic in prstnih odtisov ter zunanja kamera za snemanje obiskovalcev. Vsi senzorji (razen zunanje kamere) so povezani na krmilnik, ki periodično odčitava njihove vrednosti in ob spremembi podatek pošlje tablici. Zunanja kamera je v osnovi IP spletna kamera, ki je povezana na omrežje in streže trenutno sliko aplikaciji na tablici.

Za upravljaje na daljavo se uporablja *mobilnik* z Android operacijskim sistemom ali *ostale naprave*, z dostopom do spleta in spletnim brskalnikom.

Osnovna izvedba e-vratarja je prikazana na sliki 1. Celotna strojna oprema je zasnovana modularno tako, da lahko uporabnik enostavno menja ali nadgradi komponente.



Slika 1: *Shema glavnih strojnih komponent.*

3.2 Programska oprema

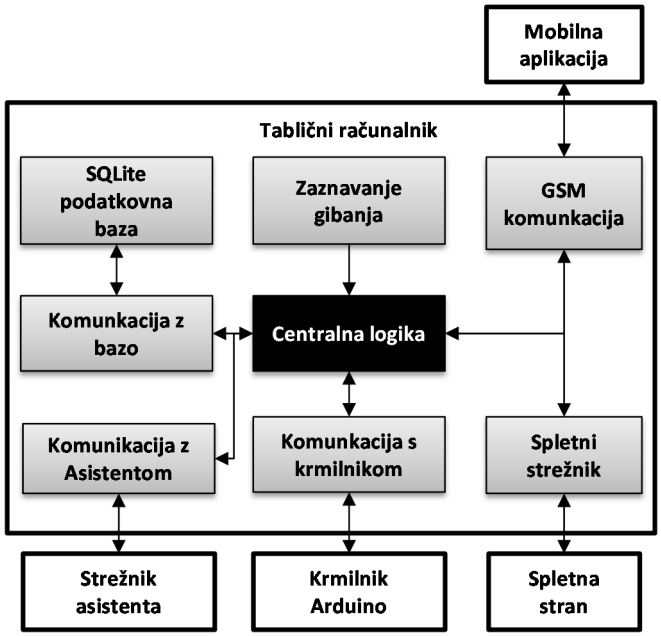
Na tabličnem računalniku teče Android aplikacija, ki služi kot vmesnik med sistemom e-vratar in uporabnikom. Uporabniku nudi intuitiven grafičen uporabniški vmesnik s katerim lahko krmili sistem. Prav tako aplikacija omogoča delovanje centralne logike celotnega sistema e-vratar. Zasnovana je agentno, tako da je nadgradnja relativno enostavna. Aplikacija je razdeljena na več modulov, vsak od njih pa nudi skupino storitev. Glavni programski moduli so prikazani na sliki 2.

3.2.1 Komunikacija s krmilnikom

Na tablici teče servis (proces v ozadju), ki z uporabo protokola na osnovi Android Acessory komunicira s krmilnikom. Krmilnik servisu pošilja vrednosti, ki jih odčitava na senzorjih in identifikacijskih napravah, servis pa jih posreduje aplikaciji. Prav tako aplikacija preko servisa krmilniku posreduje želene ukaze: odklepanje vrat ter spremembo režima delovanja ključavnice.

3.2.2 Spletni strežnik

V sklopu aplikacije v ozadju teče tudi spletni strežnik. Ta je dostopen preko IP naslova tablice na vratih 8080. Streže spletno stran, preko katere je omogočeno upravljanje sistema e-vratar na daljavo (spletni vmesnik). Poleg tega na zahtevo HTTPS streže tudi razpoložljive podatke, ki jih pošlje v formatu JSON in so uporabni za komunikacijo s sistemi v pametni hiši. Za implementacijo strežnika je uporabljen iJetty servis, ki deluje preko povezave HTTPS.



Slika 2: *Shema glavnih programskih modulov.*

3.2.3 Centralna logika

Centralna logika hrani stanje sistema in se odloča na podlagi zbranih senzorskih podatkov. Glavne naloge centralne logike so zaznavanje dogodkov, pošiljanje ukazov za odklepanje vrat, samodejno urejanje seznamov prisotnih in odsotnih uporabnikov, hranjenje seznama dogodkov, predvajanje pozdravov, pošiljanje obvestil. Del centralne logike je implementiran v aplikaciji, del pa v servisu.

Za pošiljanje SMS obvestil skrbijo funkcije, ki so že vgrajene v operacijski sistem Android, za pošiljanje obvestil preko elektronske pošte pa skrbi javanska knjižnica. Centralna logika aplikacije uporablja tudi druge metode, ki so že implementirane v operacijskem sistemu Android. Med drugimi tudi zaznavanje obrazov iz slik - na podlagi števila obrazov na sliki, se sortirajo fotografije v galeriji - in upravljanje z bluetooth vmesnikom. Ta uporabniku omogoča način identifikacije s pomočjo bluetooth naprave.

3.2.4 Strojni vid in zaznavanje gibanja

Algoritem za zaznavanje gibanja iz slike deluje na principu odštevanja ozadja (ang. background subtracting). Gre za algoritem, ki primerja barvo istoležnih pikslov na dveh zaporednih slikah: trenutni in predhodni. Parametra algoritma sta dva praga: maksimalna vrednost za katero se lahko razlikujeta istoležna piksla, da ju še obravnavamo kot enaka, in minimalno število spremenjenih pikslov na trenutni sliki v primerjavi z predhodno, ki zadošča, da algoritem smatra, da je bilo na sliki zaznano gibanje. Algoritem za detekcijo gibanja se uporablja na slikah iz notranje kamere kadar je sistem v nadzornem načinu.

3.2.5 Spletni vmesnik

Spletni vmesnik deluje kot spletna stran, ki jo streže spletni strežnik vgrajen v aplikacijo na tablici in omogoča popolno kontrolo sistema e-vratar na daljavo. Omogoča vse funkcije, ki so na voljo v aplikaciji na tabličnem računalniku. Med drugimi tudi pregled slike iz zunanje in notranje kamere v živo. Spletni vmesnik komunicira s preostalim delom aplikacije na tabličnem računalniku preko vmesnika uporabniškega programa (ang. application programming interface - API). Podatki, ki se pošiljajo med spletnim strežnikom in aplikacijo na tabličnem računalniku so v JSON formatu.

3.2.6 Podatkovna baza

V aplikaciji je uporabljena SQLite podatkovna baza. V bazi so shranjeni vsi podatki, ki jih e-vratar potrebuje za svoje delovanje. V grobem so to podatki o uporabnikih in uporabniške nastavitve, ostale nastavitve e-vratarja, seznam dogodkov in podatki o uporabniških sporočilih.

V bazo e-vratarja se ne shranjujejo slike in glasovna sporočila - shranjena so na zunanjem pomnilniku (SD-kartici). V bazi pa so shranjene datotečne poti do slik in zvočnih datotek na zunanjem pomnilniku. Slike so shranjene v JPEG formatu zvočne datoteke pa v 3gp formatu.

Za dostop do baze, pisanje v bazo ter branje iz baze je uporabljen mehanizem Content Provider, ki je vgrajen v Android operacijski sistem in nudi varen dostop do baze ter varno izvajanje transakcij.

3.2.7 Aplikacija na mobilnem telefonu

Za upravljanje sistema e-vratar na daljavo brez uporabe interneta je bila razvita aplikacija za komunikacijo z e-vratarjem preko SMS sporočil. Aplikacija je namenjena za mobilne naprave z operacijskim sistemom Android in pošilja ter sprejema SMS-e od e-vratarja, ki so zaradi večje varnosti šifrirani.

S pomočjo aplikacije lahko uporabnik poizveduje o stanju e-vratarja, dogodkih, mu spremeni način delovanja, pridobi trenutno sliko na elektronski naslov in sprašuje asistenta v naravnem jeziku. Za upravljanje z aplikacijo skrbi grafični uporabniški vmesnik.

4 ZAKLJUČEK

V prispevku je predstavljen sistem e-vratar, ki sodi v skupino sistemov za zagotavljanje varnosti. Deluje na odprtokodni Android platformi, kar je prednost za nadaljnji razvoj.

Sistem e-vratar v primerjavi s konkurenco sodi med obsežnejše sisteme. Večino funkcionalnosti, ki jih nudijo številni sorodni sistemi, e-vratar vključuje v enovitem sistemu. Prav tako nudi še dodatne inteligentne funkcije in skrbi za udobno in uporabniku prijazno uporabo ter omogoča posredovanje informacij sistemom pametne hiše.

Iz široke palete funkcij, ki jih nudi e-vratar, velja izpostaviti Asistenta in določene inteligentne funkcije. Asistent omogoča komunikacijo z uporabnikom v naravnem jeziku, kar poveča udobje uporabe in uporabnik takšen sistem veliko lažje sprejme v vsakdanje življenje.

Razvoj e-vratarja je še v teku in se bo nadaljeval z dodajanjem funkcij in inteligentnih algoritmov. Med najbolj pomembnimi so naslednje. Razširitev sistema e-vratar na upravljanje z več vhodi in prilagajanje različnim skupinam uporabnikov, s čimer se bo razširila možnost uporabe sistema e-vratar na različne stavbe in delovne organizacije. Načrtovana funkcija samodejnih vremenskih nasvetov, bo uporabnika opozarjali o relevantnih dnevnih vremenskih spremembah. Strojno učenje o načinu in času vstopa uporabnikov, bo povečalo varnost ter omogočilo prepoznavanje nenavadnih vstopov oz. vstopov ob nenavadnem času. Končni cilj sistema e-vratar pa je, da bi zna upravljati s samostojno inteligentno hišo, ki bo stanovalcem nudila varnost in udobje.

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MEMORY BASED LEARNER COUPLED WITH DIFFERENTIAL EVOLUTION FOR NAMED ENTITY RECOGNITION FOR BENGALI LANGUAGE

Sriparna Saha[1], *Asif Ekbal*[1], *Sabreen Syed*[1], *Utpal Kumar Sikdar*[1]
Department of Computer Science and Engineering [1]
Indian Institute of Technology Patna
India
e-mail: {sriparna,asif,sabreen,utpal.sikdar}@iitp.ac.in

ABSTRACT

In this paper we tackled the named entity recognition problem from Bengali language, a resource poor language. Memory based learner (MBL) is used as the underlying classification technique. In order to develop a domain-independent system, the *features are identified and implemented mostly without using any domain specific knowledge*. Several different versions of MBL based classifiers are developed. These are then combined using a differential evolution based classifier ensemble technique. Here the search capability of Differential Evolution (DE) is used to construct a weighted vote-based classifier ensemble for Named Entity Recognition (NER). The main motivation of selection of appropriate weights of votes is that prediction accuracy of each classifier varies over different named entity (NE) classes. Thus, it is necessary to quantify the amount of voting of a particular classifier for a particular output class. Here, an attempt is made to determine the appropriate weights of voting for each class for each classifier using DE. Application of the DE based technique produces the final F-measure of 77.82% on Bengali data.
Keywords: Named Entity Recognition, Differential Evolution, Classifier ensemble, Memory Based Tagger;

I. INTRODUCTION

Named Entity Recognition (NER) targets to identify and classify each word of a given document into some predefined target categories such as person, location, organization, miscellaneous (e.g., date, time, number, percentage, monetary expressions etc.) and none-of-the-above. This has potential applications for solving different tasks of natural language processing including information retrieval, information extraction, machine translation, question-answering and automatic summarization etc. Existing works on NER mainly cover the languages like English and European languages. Some works exist for solving NER problems from Asian languages like Chinese, Japanese and Korean. But there are few works for solving NER problem from Indian languages. India is a multilingual country possessing great linguistic and cultural diversities. In India there are 22 different official languages. These languages derived from different dominant linguistic families. Inspite of this fact there are very few attempts in solving NER problems from Indian languages. This is because of the following difficulties [1]: 1) Capitalization information plays a key role in identifying NEs from English and most of the European languages. This feature is not present in case of Indian languages.
2) There are many diversified Indian person names; many of them appeared in the dictionary with specific meanings.
3) Highly inflectional nature of Indian languages: these are providing one of the richest and most challenging sets of linguistic and statistical features resulting in long and complex word forms.
4) There is no fixed word-order for Indian languages.
5) Resource constrained nature of Indian languages: annotated corpora/training data, name dictionaries, good morphological analyzers, POS taggers etc. are not so easily available.
6) Indian languages are one of the oldest languages in the world, but technology developments for these languages have started very recently.
Some works on NER for Indian languages can be found in [1], [2], [3].

In this paper we use memory based tagger[4] for solving the NER problem from Bengali language. Bengali is ranked as seventh most spoken language in the world, second in India and the national language of Bangladesh. Memory-Based Learning (MBL) [5] is a simple and robust machine-learning method applicable to a wide range of tasks in NLP. In general, memory-based learning algorithms are based on the principles of the k-nearest neighbor algorithm. To train and test the classifiers we use a set of features that are *mostly identified and generated without using any language specific resources or domain specific knowledge*. By varying the feature combinations many different MBL based classifiers are generated. These are then combined using a newly developed differential evolution based classifier ensemble technique. Results show that this DE based technique attains the final F-measure value of 77.82% for Bengali. The proposed approach is compared with the conventional majority and weighted voting techniques. We also compare our proposed method with a genetic algorithm based evolutionary approach for classifier ensemble [1]. Our

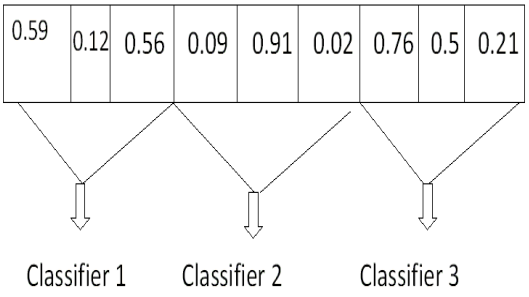


Fig. 1. Chromosome Representation for Weighted Vote Based Classifier Ensemble Selection; Here first 3 positions indicate weights of votes for the first classifier for the three output classes; next 3 positions indicate weights of votes for the second classifier for the three output classes; last 3 positions indicate weights of votes for the third classifier for the three output classes;

analysis shows that the proposed approach can attain superior performance in comparison to the existing methods.

II. Proposed Method for Classifier Ensemble

The weighted vote based classifier ensemble selection is formulated as an optimization problem below.

A. Problem Formulation

Assume there are total N number of available classifiers which are denoted by $C_1, \ldots, C_N$. Let, $\mathcal{A} = \{C_i : i = 1; N\}$. There are a total of M number of classes. Then we have to calculate appropriate weights of votes for these M output classes by these N number of classifiers. The proposed weighted vote based classifier ensemble problem is stated below:

Let V is a real matrix of size $N \times M$ where $V(i, j)$ denotes the weight of votes for the ith classifier for the jth output class. Here $V(i, j)$ will take some bigger values if the classifier i is confident in deciding the output class j; otherwise $V(i, j)$ will take some low value. Our target is to determine the appropriate values of entries of the matrix V such that it can optimize some classification quality measure. These weights take part in combining the outputs of classifiers using weighted voting. We choose F-measure as the objective function to be optimized.

1) Chromosome Representation and Population Initialization: Here weight matrix V is encoded in the form of a chromosome. If the size of matrix V is $N \times M$, then length of the chromosome will be $D = N \times M$. Here chromosome encodes the weights of votes for possible M output classes for each classifier. The entries are of real values. As an example, the encoding of a particular chromosome is represented in Figure 1. Here, $N = 3$ and $M = 3$ (i.e., total 9 votes can be possible). The chromosome represents the following ensemble:

The weights of votes of classifier 1 for 3 different output classes are 0.59, 0.12 and 0.56, respectively. Similarly, weights of votes of classifier 2 for 3 different output classes are 0.09, 0.91 and 0.02, respectively, and weights of votes of classifier 3 for three different output classes are 0.76, 0.5 and 0.21, respectively.

Here real encoding is used. Entries of chromosomes are initialized by generating some random numbers between 0 and 1 by using the Equation $r = \frac{rand()}{RAND_MAX+1}$. All the members of the population are initialized like this. Let us assume population size be P then all these P number of chromosomes of the population are initialized in the same way.

2) Objective Functions Computation: In order to compute the objective functional values the weights encoded in the chromosome are used. Here at first F-measure values of all the available classifiers for each of the output classes are computed using the development data. After that the following steps are executed to compute the objective function:
1) Let total number of available classifiers be N. Suppose $F_i,\ i = 1 \ldots N$s denote the overall F-measure values of these N classifiers on the development data.
2) For each token of the development data there are possible M classes. We have to select any one of the classes from these M classes. In case of weighted vote based classifier ensembling at first we have to calculate the appropriate weights for each class i, where $i = 1 \ldots M$ based on the encoded weights and overall F-measure values of the classifiers. The weight of the output class c provided by the jth classifier is equal to $F_j \times V(j, c)$. Then we can calculate the combined score of a particular class for a particular token t by using the following Equation:

$$f(c_i) = \sum F_j \times V(j, i),$$

$$\forall j = 1 \text{ to } N \text{ and } op(t, j) = c_i$$

Here, $V(j, i)$ is the entry of the chromosome/value of the weight matrix corresponding to the jth classifier and i^{th} class; and $op(t, j)$ denotes the output class provided by the classifier j for the token t. The class having the maximum combined score is selected as the joint decision for this particular token.

Examples: Let us consider the chromosome in Figure 1. Let the three classes be 'PER' (class 1), 'LOC' (class 2) and 'ORG' (class 3). Suppose the final F-measure values of 3 classifiers are 0.8, 0.7 and 0.85, respectively. Then let for a token '*kolkAtA* (Kolkata)' the 3 classifiers give outputs as follows: Classifier 1: 'PER'; Classifier 2:'LOC'; Classifier 3:'LOC'. Then f('PER')=0.8*0.59=0.472; and f('LOC')=0.91*0.7+0.5*0.85=1.062. Henceforth, we have used ITRANS notation [1] to write all the Bengali glosses. Thus final class level selected for this particular token is 'LOC' as f('LOC')>f('PER').

3) Here $F\text{-}measure$ is used as the classification quality measure. The $F\text{-}measure$ value over the development data is used as the objective function. This is maximized using the search capability of DE.

B. Mutation

For each target vector $x_{i,G}$; $i = 1, 2, 3, \ldots, P$, a mutant vector is generated according to

$$v_{i,G+1} = x_{r1,G} + F(x_{r2,G} - x_{r3,G}), \quad (1)$$

here $r1$, $r2$, $r3$ are some random indices belonging to $\{1, 2, \ldots, P\}$. Here P denotes number of chromosome in a population. These are some randomly generated integer values,

[1] http://www.aczone.com/itrans/

different from each other and also different from running index i. Thus the population size in DE should be greater than 4. Here F is a real and constant factor. Here $F > 0$ and $F \in [0, 1]$. We have kept $F = 0.5$ here. F basically controls the amplification of the differential variation $(x_{r2,G} - x_{r3,G})$.

C. Crossover

Crossover operation is applied to introduce the diversity among the mutant parameter vectors. It also has the name recombination operation. Here a trial vector :

$$u_{i,G+1} = (u_{1i,G+1}, u_{2i,G+1}, \ldots, u_{Di,G+1}) \quad (2)$$

is generated, where

$$\begin{aligned} u_{j,i,G+1} &= v_{j,i,G+1} \text{ if } (randb(j) \leq CR) \text{ or } j = rnbr(i) \\ &= x_{ji}; G \text{ if } (randb(j) > CR) \text{ and } j \neq rnbr(i) \end{aligned}$$

for $j = 1, 2, \ldots, D$. Here D denotes length of a particular chromosome, here $D = N \times M$ where N is the number of available classifiers and M is the number of output classes.

In Equation 3, $randb(j)$ belongs to $[0, 1]$, denoting the jth evaluation of an uniform random number generator. CR is termed as crossover constant whose value also belongs to $[0, 1]$. This parameter value has to be determined by the user. Here the value of CR is 0.5. $rnbr(i)$ is a randomly chosen number x belonging to $\{1, 2, \ldots, D\}$. This controls that $u_{i,G+1}$ contains at least one parameter from $v_{i,G+1}$.

D. Selection

During selection we take a decision whether or not the newly generated vector should become a member of generation G+1. Here the fitness value of the trial vector $u_{i,G+1}$ is compared to that of the target vector $x_{i,G}$ using the greedy criterion. If vector $u_{i,G+1}$ generates a smaller fitness value compared to $x_{i,G}$, then $x_{i,G+1}$ is replaced by $u_{i,G+1}$. Otherwise, the old value $x_{i,G}$ is not changed.

E. Termination Condition

In this approach, the processes of mutation, crossover (or, recombination), fitness computation and selection are executed for a maximum number of generations. The best string seen up to the last generation provides the best weights for classifier ensemble selection problem.

III. Language Independent Features for NER

In this paper we have identified features which are based on the different possible combinations of available word and tag contexts. The following features are used for constructing the various models of MBL based classifier. The most important characteristics of our system is the identification of some language independent features. Here we have generated and implemented features which do not use any language specific resources and domain specific knowledge. Because of these language independent properties, the features can be easily identified for almost all the languages. The used features are : Context words, Word suffix and prefix, binary feature checking whether the token is the first word of the sentence or not, length of the word, infrequent word feature, several digit based features, part-of-speech feature and global context feature.

IV. Datasets, Experimental Setup and Evaluation Results

In this section, we report the datasets used for the experiment, experimental setup and evaluation results with necessary discussions. Indian languages are resource-constrained in nature. For NER, we use a Bengali news corpus [2], developed from the archive of a leading Bengali newspaper available in the web. One of the authors manually annotated a portion of this corpus containing approximately 250K wordforms with a coarse-grained NE tagset of four tags namely, PER (*Person name*), LOC (*Location name*), ORG (*Organization name*) and MISC (*Miscellaneous name*). The *Miscellaneous name* includes date, time, number, percentages, monetary expressions and measurement expressions. Entries of this data set are mostly collected from the *National*, *States*, *Sports* domains and the various sub-domains of *District* of the particular newspaper.

In this paper memory based tagger (MBT) [4] which makes use of TiMBL, an open source implementation of memory based learning is used as the underlying classification technique. IGTREE algorithm is utilized for training and testing of the known words [4]. IB1 with the overlap metric and with gain ratio feature weighting is utilized for the unknown words [4]. We have kept number of nearest neighbors (i.e. *K*) equals to 1.

The parameters of the proposed algorithm are selected by conducting a thorough sensitivity analysis on the development data. A part of the training dataset is used as the development set. The parameters of DE are determined based on the development sets. The parameters of DE based technique are as follows: population size = 10, CR (probability of crossover)=0.5, number of generations = 50 and F (mutation factor) = 0.5. We define the following *baseline* ensemble techniques:

1) *Baseline 1*: In this *baseline* model, outputs of all the individual classifiers are merged together into a final system based on the majority voting of the output class labels. In case of ties, output class label is selected randomly.

2) *Baseline 2*: The outputs of all the classifiers are merged together with the help of a weighted voting approach. For each classifier, weight is calculated based on the F-measure value of the 3-fold cross validation on the training data. The final output label is computed based on the class having the highest weighted vote.

Here at first MBL based classifier is executed on the Bengali data set with different feature combinations. We have executed MBL tagger with the default option -p ddfa -P dFapsss. The meaning of this parameters are explained below: $-p$ (feature pattern for known words), and $-P$ (feature pattern for unknown words). Patterns are built up as combinations of the following symbols:

For -p and -P

d Left context (tag), a Right context (ambitag), w Left or right context (word).

For $-p$ only (known words)

f Focus (ambitag for known words), W Focus (word)

For $-P$ only (unknown words)

F Focus (position of the unknown word), c The focus contains capitalized characters, h The focus word contains a hyphen, n The focus word contains numerical characters, p Character at

TABLE I. DIFFERENT MBL BASED CLASSIFIERS WITH DIFFERENT FEATURE COMBINATIONS AND THEIR PERFORMANCE FIGURES. HERE 'R': RECALL, 'P': PRECISION, 'F': F-MEASURE (WE REPORT IN PERCENTAGES)

Classifier	feature	p	r	F
MBT1	All features	52.89	76.53	62.552
MBT2	All suffix and prefix columns with POS	77.61	75.27	76.42
MBT3	All semantic features columns with POS	52.32	76.03	61.98
MBT4	All features except semantic along with POS	74.08	72.93	73.50
MBT5	Last word of the sentence, 2 letter prefix and suffix and POS tag	74.75	74.27	74.51
MBT6	First word, all prefixes and suffixes, word length and POS tag	77.17	75.25	76.20
MBT7	First word, all prefixes and suffixes and POS tag	67.91	76.71	72.04
MBT8	One and two letter suffixes and prefixes, and POS tag	74.91	74.81	74.86
MBT9	First word, and not last word, along with POS tag	74.15	73.48	73.81
MBT10	Features: dot, comma, last word, word frequency,suffixes and prefixes,first word	77.01	74.96	75.97
MBT11	Prefixes and suffixes	78.18	74.99	76.55
MBT12	none	72.09	69.87	70.96

the start of the word, s Character at the end of the word
Different symbols like d, a, w, p, and s can appear more than once to indicate the scope of the context. Symbols which appeared to the left of the focus symbols indicate left context, and symbols which appeared to the right of the focus symbols indicate right context. For known words, the following are a few possible patterns for example: $ddfa$ focus ambitag with two disambiguated tags to the left and one ambitag to the right For unknown words: $psssdFa$ as previous, plus the three last letters of the word to be tagged.

Different versions of MBL based learners are developed varying feature combinations. We construct several memory based classifiers as shown in Table I. The best individual classifier attains the recall, precision and F-measure values of 78.18%, 74.99%, and 76.55%, respectively. Thereafter the DE based classifier ensemble technique is applied on these classifiers to combine their outputs. The *baseline* techniques are also applied on the same set of classifiers. Results are shown in Table II. The DE based classifier ensemble technique attains the recall, precision and F-measure values of 77.70%, 77.95%, and 77.82%, respectively. This is an improvement of 1.27% over the best individual classifier. *Baselines* are performing poorer compared to DE based ensemble. We have also taken results after application of GA based classifier ensemble technique [1] to combine the outputs of different MBL based classifiers. Those are shown in Table II. This again illustrates the effectiveness of DE based ensemble technique. In order to show that the DE based approach really outperforms the best individual classifier, two *baseline* ensembles and GA based technique statistical analysis of variance (ANOVA) [6] is performed, when each is executed ten times. ANOVA tests show that for Bengali language differences in mean recall, precision and F-measure values are statistically significant as p values are less than 0.05 in each of the cases. We have also compared our results with those reported in [2]. In [2] authors reported two models for named entity recognition. These two models attain average F-measure values of 69.33% and 72.3%, respectively, whereas our system attains the F-measure value of 77.82%.

TABLE II. COMPARATIVE EVALUATION RESULTS (IN %)

Classification Scheme	recall	precision	F-measure
Best Individual Classifier	78.18	74.99	76.55
Baseline 1	76.61	76.40	76.5
Baseline 2	76.65	76.45	76.55
GA based ensemble	76.90	76.95	76.92
DE based Approach	77.70	77.95	77.82

V. CONCLUSION AND FUTURE WORKS

In this paper we have solved the named entity recognition problem from a resource poor language named Bengali. An efficient classification technique, memory based learner (MBL) which is based on the concept of K-nearest neighbor classifier is used for solving the NER problem. Different relevant features are extracted. Different versions of MBL classifiers are developed varying the feature combinations. The outputs of these classifiers are then combined together using a DE based classifier ensemble technique. Results are shown for Bengali language, a resource poor language. Comparative results establish the effectiveness of DE based classifier ensemble technique.

Overall evaluation results suggest that there is still room for further improvement. We have to take results on some more resource poor languages like Hindi, Telugu etc. In this work, we have considered the problem of classifier ensemble as a single objective optimization problem. In future, we will develop some multi-objective DE based techniques to solve this classifier ensemble method.

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INTELLIGENT CONTROL OF AGRICULTURAL IRRIGATION SYSTEM BASED ON WIRELESS SENSOR AND ACTUATOR NETWORKS

Hakkı Soy[1], Yusuf Dilay[1], Adem Özkan[1], Cevat Aydın[2], Mehmet Bayrak[3]
Karamanoglu Mehmetbey University, Vocational School of Technical Sciences[1]
Selçuk University, Department of Agricultural Machinery[2]
Mevlana University, Department of Electrical and Electronics Engineering[3]
e-mail: {hakkisoy, ydilay, aozkan}@kmu.edu.tr , caydin@selcuk.edu.tr , mbayrak@mevlana.edu.tr

ABSTRACT

Optimizing water usage is the primary objective of intelligent and eco-friendly agricultural irrigation systems. In irrigation systems, the flow and pressure of water is usually regulated by controlling the position of the valve. The proportioning electronic actuator accepts a signal from the control system and moves the valve to allow the valve to partially open or close. Varying speed of pump motor can also control the usage of water. The integration of wireless sensor and actuator networks (WSANs) into irrigation management promises to overcome the excessive watering problem while providing additional functionality. This paper presents a case study on the use of WSAN for irrigation activities and investigates the application of fuzzy logic based valve aperture control. The results show that the proposed strategy can be effective in water flow control.

1 INTRODUCTION

Modern agriculture needs advanced technologies that can improve crop quality and production efficiency while protecting the environment [1]. Agricultural plants have a water requirement to survive and an optimum annual water requirement for maximum crop production. On the other hand, if the field is irrigated heavily with water, the plant may die due to the excessive irrigation. The key factor is not to add a drop of water more than required and not a drop less than needed for adequate plant growth [2].

Precision agriculture is a management strategy that uses information technologies to take decisions associated with crop production [3]. Many environmental variables that are relevant to precision agriculture, such as crop and soil properties and climate, vary in both time and space. In precision agriculture, one of the popular research topics is the crop irrigation scheduling and water quantity control for increasing water use efficiency. Seasonal water demand and peak daily use vary considerably from crop to crop and from one field to the next. Deciding when to irrigate and how much water to apply are the two most difficult decisions to make in managing irrigation systems [4]. In order to measure the soil moisture content in the active root zone, the soil moisture sensor is connected to an irrigation system controller. Thus the farmers can monitor the individual crop types and potentially identify the various fertilizers, irrigation requirements [5,6].

In recent years, a new promising concept of wireless sensor networks (WSNs) has received much attention by researchers all over the world. WSNs can help the farmers to monitor soil parameters like depth of water, soil water tension (SWT) and system capacity for better crop yield [7,8]. In WSNs, the main objective is to gather raw sensor data or estimate the condition of the environment. The next step in the WSN evolution is their use not only monitoring, but also controlling the environment. WSANs are comprised of networked sensor nodes (SNs) and actuator nodes (ANs) communicating among each other via wireless links to perform distributed sensing and actuation tasks [9].

Intelligent systems operate without human supervision and respond to changes in their external environment. The computational capabilities of WSANs provide intelligence required to satisfy soil moisture requirements, while their wireless communication capabilities permit networking of individual components. In WSAN based smart irrigation monitoring and control system, a group of sensor and actuator nodes cooperate to satisfy the requirements for saving water without human intervention. So, by using collected data from sensors, actuators can perform desired actions accordingly.

In this paper, we describe the WSAN based intelligent irrigation system in detail that can be deployed either in the greenhouse applications or in the open field agriculture. The goal of this system is to monitor soil properties and optimized regulation of water being dispersed to an area. To regulate the watering operations, electronically controlled valves are used in the system and fuzzy control technique was applied to adjust the valve position. The fuzzy model based controllers has a rule base inference mechanism imitating the decision-making process of human brain for performing desired control processes on the systems. So, fuzzy logic offers high performance control of the time-varied nonlinear systems of which mathematical models aren't known.

Our approach that is conceptually different from the traditional irrigation approaches seeks the integration of the proportional control valves actuated within the design process. The remainder of the paper is organized as follows: Section 2 provides an overview of the system model and

describes the suggested WSAN based irrigation system. Proposed fuzzy controller is explained in Section 3. The simulation result of the proposed method are also presented in this section through MATLAB Fuzzy Logic Toolbox. Finally, the paper is concluded in Section 4.

2 SYSTEM OVERVIEW

We consider a WSAN with star topology in which the SNs are regularly deployed in the field. The designed system is applied for controlling drip irrigation as shown in Figure 1. The entire field is first divided into laterals such that each lateral contains only one sensor/actuator pair. So, there are a lot of laterals which are irrigated independently with control valves. In this semi-automated setup, the coordinator node (CN) operates as field controller and ensures the desired amount of water is applied to the crop and allow the user to monitor how the drip irrigation system performs. It is assumed that the CN is close to sensor/actuator pairs and then clearly single-hop communication is the best solution for our scenario. The SNs report data periodically to the CN and the reporting period is fixed. We also assume that each SN has to report one data packet per period. In order to obtain a collision-free schedule, the SNs should select non-overlapping time intervals for transmitting their packets as in the conventional TDMA with round robin fashion.

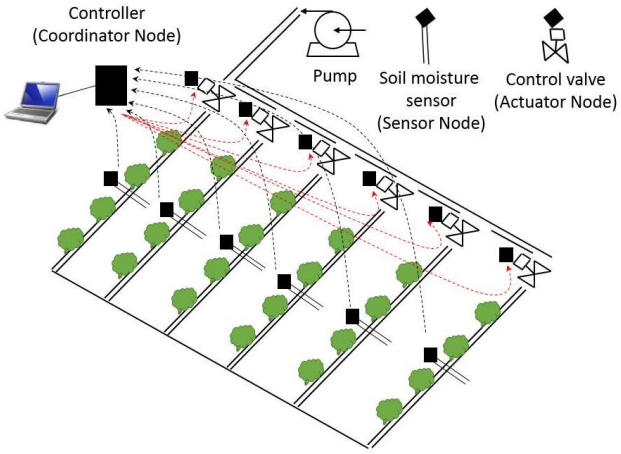


Figure 1: WSAN based drip irrigation system model.

In traditional drip irrigation, sensors are buried in the ground at required depth and control valves are controlled by using automated controller to turn on and off. The purpose of this control loop is to maintain the controlled variable to desired value called as set point. So, the water will be maintained at the constant level until the water will reach the roots by going drop by drop. Once the soil has reached desired moisture level the sensors send a signal to the controller to turn off the relays, which control the solenoid valves. In ordinary solenoid valve only two stages of resolution are possible, fully open or fully closed.

In this paper, we focus on the proportional control. With this form of control, the valve positioned in intermediate positions in proportional to the difference between the set point and the measured real value. So, the actuator continually searches for the proper position from full open to full close. A schematic of the components of the control system is shown Figure 2. The control system operates as follows: The SNs measure the actual values of SWT and water depth collected from soil moisture sensors in the same lateral line and send a signal back along the feedback path to the CN. The CN calculates the difference between the desired value and the measured value is known as the error signal and stimulates the related AN. The ANs respond to a signal received from CN and vary the flow of the water by driving valves. This in turn changes the condition of the process to the desired value.

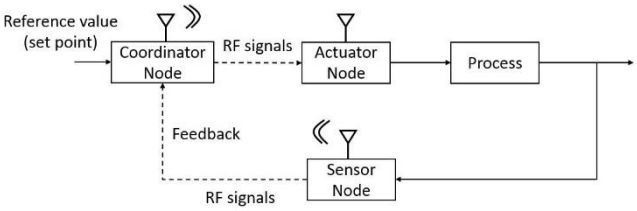


Figure 2: an illustration of signal flow in control system.

3 FUZZY CONTROLLER

Due to fact that the expected performance of traditional methods are not obtained, recent research in agricultural irrigation related soft control techniques like as fuzzy logic can contribute to reduction of waste water. The usual approach is to compute a fuzzy function on the system error by using a set of predefined rules [10]. Figure 3 shows the block diagram of the designed fuzzy PD controller.

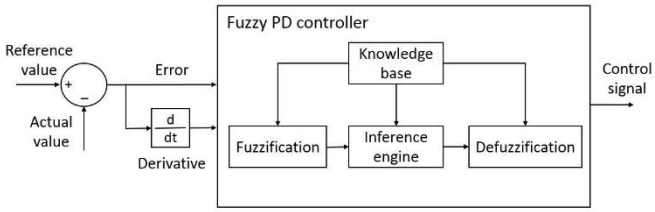


Figure 3: a block diagram of the fuzzy PD controller.

In order to control the water flow in the laterals, we use two parameters water depth error and its derivative. The error variable is calculated by taking the difference between the reference level and the current water depth at certain sampling times. It is expressed as,

$$error(n) = reference(n) - actual(n) \quad (1)$$

where n is discrete sampling time. Error derivative input variable is determined by the ratio of the difference between the current and previous error values to the sampling period. It is given by,

$$derivative(n) = \frac{error(n) - error(n-1)}{\Delta} \quad (2)$$

where Δ is sampling period. If sampling period is chosen as unity, the error derivative variable is simplified as change of error. We assume that the error values typically in the range from 0 to 30 cm and the universe of discourse for error derivative is chosen to be [-2, 2] cm. Since the error value may change depending on the soil type, the controller performance can be increased by setting the sampling period. According to the input variables, the system output is calculated to control the valve opening position.

Membership functions for input and output variables are usually determined with the help of expert experience [10]. Fuzzy sets of the linguistic variables error, its derivative and valve opening are {VS:Very Small, S:Small, M:Medium, L:Large, VL:Very Large}, {N:Negative, Z:Zero, P:Positive} and {C:Closed, HC:Half Closed, M:Medium, HO:Half Open, O:Open}, respectively. Due to the computation simplicity, we have used triangular membership functions for both input and output fuzzy variables as defined in Figure 4, Figure 5 and Figure 6.

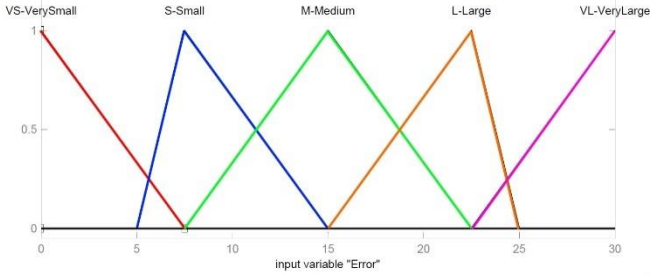


Figure 4: a membership function for error.

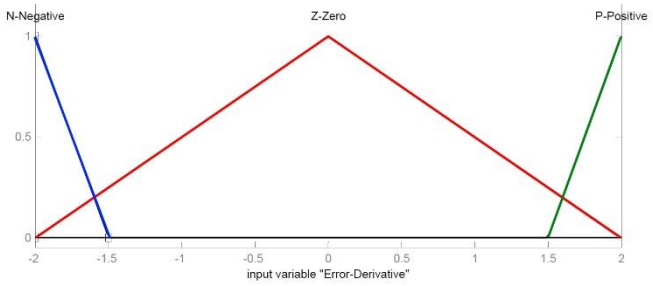


Figure 5: a membership function for error derivative.

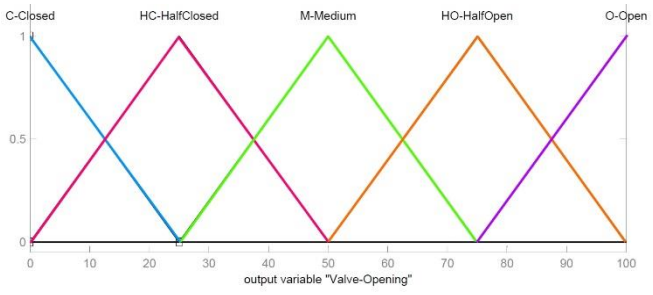


Figure 6: a membership function for valve opening.

Valve Opening			Error				
			VerySmall	Small	Medium	Large	VeryLarge
			VS	S	M	L	VL
Derivative	Negative	N	Closed	Closed	HalfClosed	HalfOpen	Open
	Zero	Z	Closed	HalfClosed	Medium	HalfOpen	Open
	Positive	P	Closed	HalfClosed	HalfOpen	Open	Open

Table 1: a rule base of designed fuzzy PD controller.

Fuzzy inference engine is responsible for decision making according to if-then rules database. The designed fuzzy rule base is given in Table 1. The Mamdani method is used for decision making and the defuzzification is done using mean value of maximum (MOM) method [11,12]. The control surface of designed fuzzy PD controller is represented in Figure 7. This plot gives the percent of valve opening versus error and error derivative.

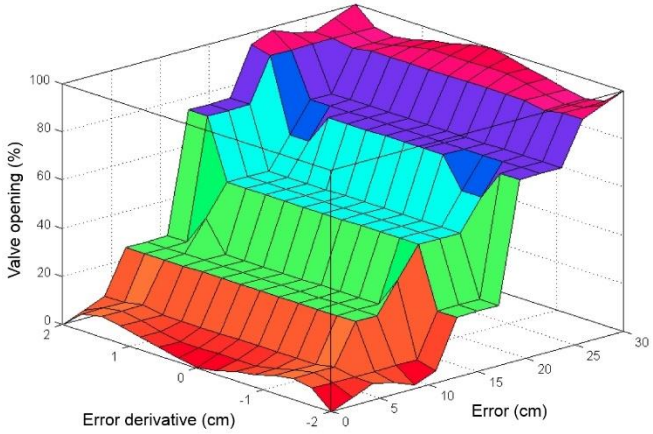


Figure 7: a control surface of designed fuzzy PD controller.

Soil moisture content change is a complex process and it has a certain relationship with the environmental factors. Hence, establishment of the precise mathematical model on the agricultural irrigation is almost impossible. In order to test the performance of proposed fuzzy PD controller, the valve opening control signal was monitored on a test set of water depth values by choosing reference level as 28 cm. As it can be seem from Figure 8, the changes in water level is measured along sampling points and the changes in control signal were obtained.

4 CONCLUSION

In this paper the design of a WSAN based drip irrigation system is proposed, which is a closed loop control system for monitoring and managing activities more efficiently. The proposed intelligent irrigation system is a model to modernize the agriculture and enables farmers to provide irrigation to larger areas of plants with less water consumption and lower pressure. The advantages of using WSAN are having the reduced wiring and piping costs, easier installation and maintenance in large fields. The system is applicable for different crops with small modifications.

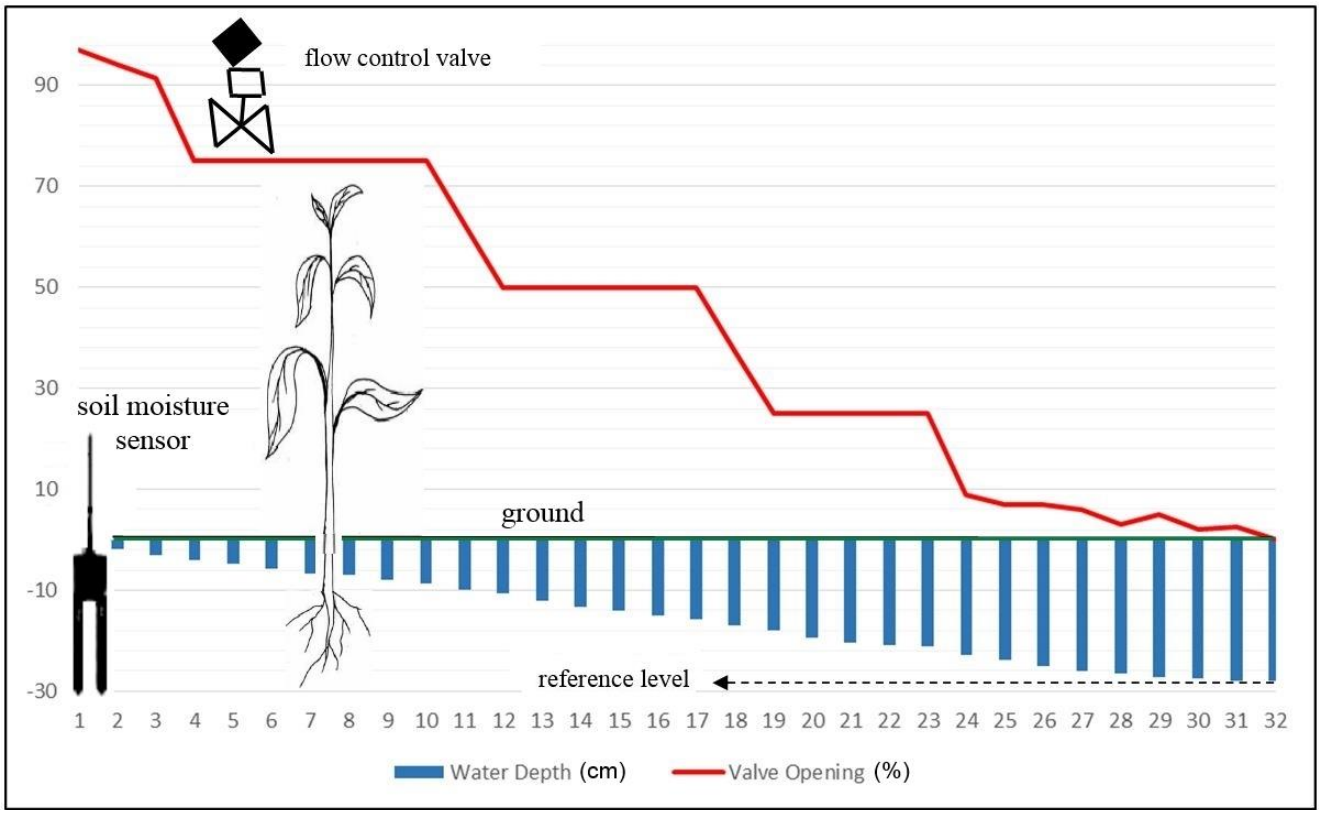


Figure 8: change in the value of water flow valve control signal for the 28 cm reference level on the 32 samples.

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STORITEV E-GOVOREC – GOVORNI BRALNIK SLOVENSKIH BESEDIL V OBLAKU

Tomaž Šef
Odsek za inteligentne sisteme, Institut "Jožef Stefan"
Jamova cesta 39, 1000 Ljubljana
tomaz.sef@ijs.si

POVZETEK

Predstavljamo storitev govornega bralnika slovenskih besedil eGovorec oz. nov sintetizator slovenskega govora v oblaku, ki je preko e-storitve in inteligentne mobilne aplikacije brezplačno na razpolago najširšemu krogu uporabnikov. E-storitev govornega bralnika slovenskih besedil sestavljata sistemski servis in jedro, ki sta nameščena na samostojnem strežniku. Mobilna ali spletna aplikacija želeno besedilo pošlje sistemskemu servisu eGovorec. Ta pretvori besedilo v govor in vrne njegov zvočni zapis.

1 UVOD

Sinteza govora s hitrim razvojem tehnologije postaja vse bolj nujno potrebna različnim področjem multimedije, v telekomunikacijah, informacijskih sistemih, različnih mobilnih aplikacijah (inteligentni turistični vodnik, navigacija), sistemih pametnih zgradb in pametnih mest (inteligentni govorni vmesniki), sistemih za opozarjanje, virtualnih asistentih in nenazadnje pri pomoči invalidom, starejši populaciji in drugim družbenim skupinam, ki so zaradi svojih fizičnih ali drugih ovir omejeni pri dostopu do e-storitev [1, 2]. Kvaliteta umetno generiranega govora je za nekatere jezike dosegla že precej visok nivo, kar je rezultat načrtnih dolgoletnih raziskav in interaktivnega sodelovanja strokovnjakov različnih tehničnih in humanističnih ved. Sistemi so jezikovno odvisni, zato tujih rešitev ni mogoče kupiti oz. ustrezno prilagoditi našim potrebam.

Namen projekta je bil zagotoviti e-storitev, ki ponudnikom najrazličnejših e-vsebin omogoča dinamično podajanje informacij v govorni obliki ter v domačem slovenskem jeziku. V primeru statičnih (nespremenljivih) besedil se le te lahko prebere in posname vnaprej, pri obsežnejših dinamičnih vsebinah (ki se sproti spreminjajo oz. generirajo) pa je to praktično nemogoče. Splošno sprejeta rešitev v takšnih primerih je uporaba sintetizatorjev govora. Takšna rešitev omogoča oz. razširja možnost uporabe najrazličnejših e-storitev še preko drugih komunikacijskih kanalov, ki podpirajo govor.

Cilj projekta je bil izdelati nov sintetizator slovenskega govora v oblaku in omogočiti njegovo brezplačno rabo čim širšemu krogu uporabnikov preko inteligentne mobilne aplikacije in e-storitve. eGovorec bo tako postal sestavni del slovenske infrastrukture za bodoče mobilne aplikacije in podajanje e-vsebin.

2 ARHITEKTURNA REŠITEV eGOVORCA

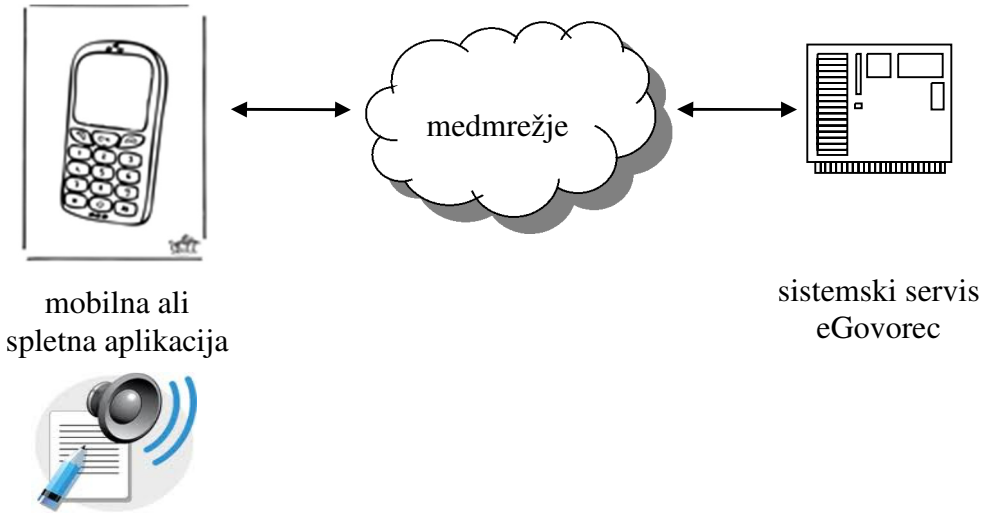
Jedro eGovorca, ki skrbi za samo sintezo slovenskega govora, je ločeno od uporabniškega vmesnika.

Za izvedbo e-storitve govornega bralnika slovenskih besedil je bil izdelan uporabniški vmesnik v obliki sistemskega servisa. Sistemski servis skupaj z jedrom je nameščen na samostojen strežnik. Mobilna ali spletna aplikacija prikazano besedilo na željo obiskovalca pošlje sistemskemu servisu eGovorec. eGovorec pretvori besedilo v govor in vrne mobilni (ali spletni) aplikaciji zvočni zapis govora. Komunikacija med spletno aplikacijo (uporaba HTML 5 in spletnih programskih jezikov) ali mobilno aplikacijo in sistemskim servisom eGovorec poteka preko vtičnic TCP/IP (slika 1); rešitev podpira IPv6 in IPv4 .

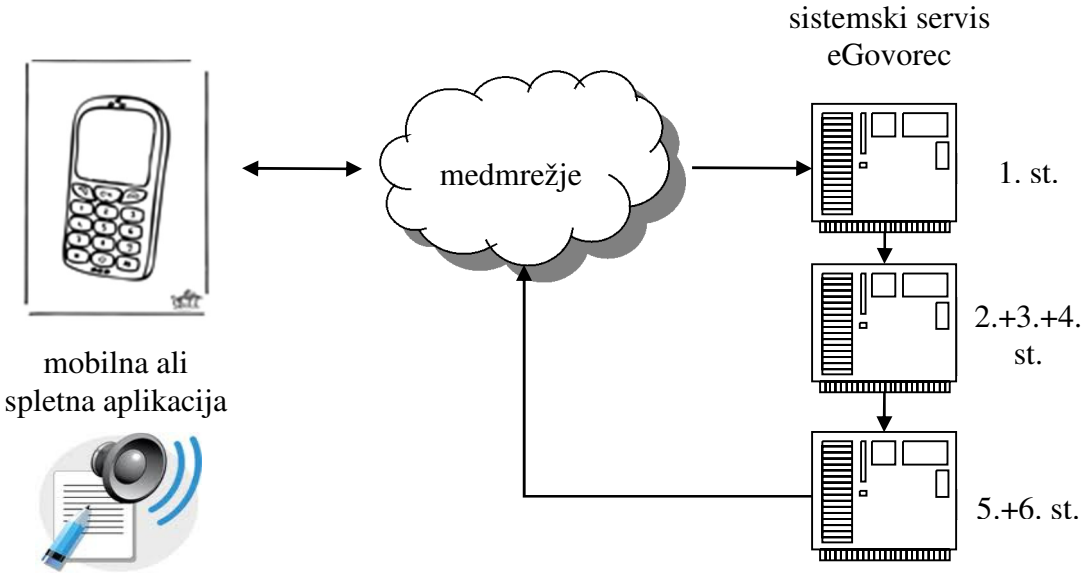
Na takšen način se lahko jedro samega sistema eGovorec zelo enostavno posodablja s čimer se izboljšuje tudi kvaliteta umetno generiranega slovenskega govora. Uporabniku glede tega ni potrebno narediti ničesar; dovolj je, da uporabi narejeno spletno aplikacijo ali si na začetku rabe na svojo mobilno napravo naložil v ta namen razvito mobilno aplikacijo, posodobitve pa se brez vednosti in intervencije uporabnika samodejno izvajajo na strežniku. Uporaba programa je zato povsem preprosta in ne terja posebnega vzdrževanja s strani uporabnika.

Kapaciteta sistema eGovorec na sodobni enoprocesorski delovni postaji je približno velikostnega reda deset sočasnih sintez v realnem času. Jedro sistema eGovorec je zasnovano tako, da se vsaka stopnja pretvorbe besedila v govor izvaja v ločeni asinhroni niti. Taka zasnova omogoča zelo hitro vzporedno obdelavo na večprocesorskih računalnikih. V primeru potrebe je sistem možno namestiti tudi na grozd računalnikov (v oblaku) tako, da vsak računalnik v grozdu obdela le nekaj stopenj pretvorbe (slika 2). Programska zahtevnost posameznih stopenj je različna, zato stopnjam, kjer je potrebna večja procesna moč, dodelimo zmogljivejše računalnike.

Za jedro sistema eGovorec potrebujemo enega ali več računalnikov z operacijskim sistemom Windows. Operacijski sistem je lahko Server ali Workstation. Računalniki so povezani v interno mrežo.



Slika 1 Arhitekturna rešitev na enem strežniku



Slika 2: Arhitekturna rešitev z grozdom

Mobilna aplikacija se lahko izvajala na več različnih platformah (Android, iOS, Windows Phone, Windows 8), poleg tega je sistem dosegljiv tudi preko HTML5 in spletnih programskih jezikov, ki so univerzalno dostopni v brskalnikih na vseh platformah.

3 JEDRO eGOVORCA

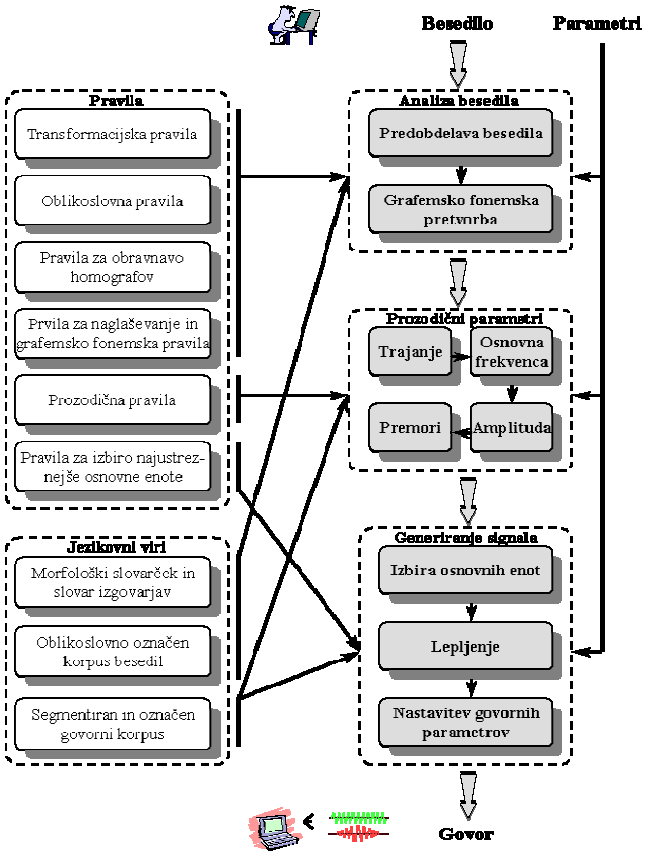
Jedro sistema eGovorec sestavlja več med seboj povezanih in hierarhično urejenih modulov (slika 3) [3]:

- analiza besedila (predobdelava besedila, grafemsko fonemska pretvorba) [4, 5, 6, 7],
- nastavljanje prozodičnih parametrov (trajanje, osnovna frekvenca, amplituda, premori) in
- generiranje govornega signala (izbira osnovne enote, lepljenje, sprememba govornih parametrov).

Modularnost ni omejena le na zgornje tri kategorije, ampak se v veliki meri kaže tudi znotraj njih samih. Tako se lahko posamezne dele sistema izpopolnjuje neodvisno enega od drugega.

Sistem eGovorec pri svojem delovanju uporablja obsežne označene tekstovne in govorne korpuse:

- morfološki slovar in slovar izgovarjav z več kot 5 milijoni različnih besednih oblik,
- oblikoslovno označeni korpus besedil z nad 200 milijoni besed,
- pomenski slovar z nad 50.000 pomeni,
- modul za pomensko in stavčno analizo,
- modul za besedno analizo in obravnavo homografov,
- modul za grafemsko fonemsko pretvorbo.



Slika3: Jedro eGovorca oz. govornega bralnika slovenskih besedil v oblaku

4 SPECIFIKACIJA STORITVE eGOVOREC

WebSpeak API uporabljen v eGovorcu omogoča preprosto vgradnjo sintetiziranega govora v širok nabor odjemalcev.

Odjemalec, ki je bodisi spletna stran bodisi aplikacija, pošlje želeno besedilo na strežnik HTTP. Strežnik pretvori besedilo v govor, ki ga v obliki zvočnega zapisa pošlje nazaj odjemalcu v predvajanje.

Protokol omogoča tudi, da razvijalci aplikacij na strežnik shranijo svoje vnaprej posnete zvoke, ter pripravijo svoje odjemalce, da jih uporabljajo.

V nadaljevanju navajamo nekaj osnovnih funkcij, ki jih spletni servis omogoča.

Funkcija *info*

Namenjena je splošni poizvedbi o verziji govornega strežnika in glasovih, ki so na strežniku nameščeni. Odjemalec praviloma najprej kliče to funkcijo, da lahko po potrebi v svojem uporabniškem vmesniku prikaže spisek glasov, ki so uporabniku na voljo.

Zahteva:

- Parametri *GET*:
  - f=info
- Metoda: *GET*

Odgovor:

- Status: *200 OK* ali druga koda napake
- Vrsta: *application/json; charset=UTF-8*, oziroma *text/plain; charset=UTF-8* v primeru napake
- Vsebina:

```
{
    "version" : <verzija strežnika, niz>,
    "voices" : [
        {
        "id" : <ID glasu 1, niz>,
        "name" : <ime glasu 1, niz>,
        "lang" : <jezik, niz, ISO 639-1>,
        "gender" : <spol, "m"|"f">,
        "age" : <starost,
            "child"|"teen"|"adult"|"senior">
        },
    {
        "id" : <ID glasu 2, niz>,
        "name" : <ime glasu 2, niz>,
        "lang" : <jezik, niz, ISO 639-1>,
        "gender" : <spol, "m"|"f">,
        "age" : <starost,
            "child"|"teen"|"adult"|"senior">
    }, ... ]
}
```

Funkcija *speak*

Namenjena je pretvorbi besedila v govor. Če je tehnično izvedljivo, začne strežnik takoj, ko je mogoče, pošiljati zvočni posnetek po koščkih (*Chunked transfer HTTP/1.1*).

Zahteva:

- Parametri *GET*:
  - f=speak
  - t=<besedilo, ki ga želi odjemalec sintetizirati v zapisu UTF-8>
  - v=<ID glasu, navedemo enega izmed glasov, ki jih vrne funkcija info>
  - o=<želen zvočni zapis odgovora: mp3 = MP3, ogg = OGG Vorbis>
- Metoda: *GET*
- Pomembne glave zahteve:
  - *Accept-Language*: jezik, v katerem želi odjemalec opis napake

Odgovor:

- Status: *200 OK* ali druga koda napake
- Vrsta: *audio/mpeg* ali *audio/ogg*, odvisno od parametra *o*, oziroma *text/plain; charset=UTF-8* v primeru napake
- Vsebina: binarni podatki, ki predstavljajo zvočni posnetek v želenem zapisu ali opis napake v jeziku, ki ga je uporabnik navedel v glavi zahteve *Accept-Language*

Poleg opisanih dveh osnovnih funkcij sistem eGovorec podpira še funkcije za vnaprej pripravljene posnetke. Strežnik eGovorec razvijalcem storitev omogoča, da nanj naložijo vnaprej pripravljene zvočne posnetke. Posnetki so na strežniku shranjeni v mape.

Ponudnik storitve eGovorec za vsakega razvijalca oz. projekt pripravi svojo mapo, v katero se posnetki shranjujejo, in uporabniška imena, s katerimi razvijalci shranjujejo zvočne posnetke na strežnik.

Vsak posnetek ima unikaten identifikator. Prvi del identifikatorja določi ponudnik storitve, drugega razvijalci sami. Ločila v identifikatorjih so poševnice /. Identifikatorji ne smejo vsebovati naslednjih znakov: dvopičje *:*, in *&* ter dvojni narekovaj *"*. Primeri veljavnih identifikatorjev so: *ijs/posnetek2*, *ijs/eTurist/uvodni* ...

Funkcija *store*
Namenjena je shranjevanju zvočnih posnetkov na strežnik.

Funkcija *retrieve*
Namenjena je nalaganju shranjenih zvočnih posnetkov s strežnika.

Funkcija *list*
Namenjena je poizvedbi, kateri posnetki so shranjeni na strežniku.

Funkcija *remove*
Namenjena je izbrisu zvočnih posnetkov na strežniku.

Spletni naslovi storitve eGovorec:

1. spletni servis (sem se pošlje zahteva po API-ju): http://govorec2.ijs.si/, npr. http://govorec2.ijs.si/?f=speak&v=GovRenato&t=Zdravo&o=mp3.
2. testna stran: http://govorec2.ijs.si/test.html
3. dokumentacija: http://govorec2.ijs.si/Doc/WebSpeakAPI-1.0.docx

4 SKLEP

Sistem eGovorec – e-storitev govornega bralnika slovenskih besedil in mobilna aplikacija – je brezplačno na razpolago vsem državljankam in državljanom Republike Slovenije ter vsem ponudnikom e-vsebin in razvijalcem mobilnih aplikacij. eGovorec bo tako lahko postal sestavni del slovenske infrastrukture, kar bo slovenski jezik postavilo ob bok drugim »velikim« jezikom.

Ponudnikom najrazličnejših e-vsebin in mobilnih aplikacij sistem eGovorec omogoča dinamično podajanje informacij v govorni obliki ter v domačem slovenskem jeziku, kar bo omogočilo razvoj številnih novih naprednih aplikacij. Ponudniki e-vsebin lahko sistem uporabijo za enostavno prilagoditev njihovih portalov potrebam slepih in slabovidnih ljudi.

Mobilna aplikacija, delujoča na večjem številu mobilnih platform, dolgoletne raziskave s področja govornih in jezikovnih tehnologij približa slehernemu Slovencu. Izvorna koda mobilnih aplikacij je prosto dostopna in omogoča preprosto dodajanje lastnih vsebin in funkcionalnosti.

Raziskave s področja govornih in jezikovnih tehnologij, s posebnim poudarkom na sintezi slovenskega govora, so ena od dolgoročnih usmeritev/dejavnosti Odseka za inteligentne sisteme, ki deluje v okviru Instituta Jožef Stefan. Metode sinteze umetnega govora se bodo intenzivno razvijale tudi po končanju projekta. eGovorec bo postal neke vrste platforma, preko katere se bodo vse prihodnje raziskave s področja govornih in jezikovnih tehnologij, izvedene na Institutu »Jožef Stefan«, preprosto prenašale v vsakdanjo prakso.

V prihodnjem obdobju nameravamo povečevati zmogljivost sistema glede na potrebno število sočasnih dostopov do e-storitve. Povečalo se bo tudi število podprtih glasov. Nekateri na novo razviti »ekskluzivni« glasovi se bodo tudi tržili. Govorne baze za takšne glasove bodo lahko zelo obsežne, s čimer se znatno izboljša tudi razumljivost in naravnost umetno generiranega govora.

Pričakujemo, da se bo hkrati z izboljševanjem kvalitete umetno generiranega govora krog uporabnikov razvite e-storitve hitro širil. Odprl pa se bo tudi prostor oz. trg za povsem nove mobilne aplikacije in e-storitve. Tudi takšne, ki bodo v pomoč različnim družbenim skupinam, ki so zaradi svojih fizičnih ali drugih ovir omejene pri dostopu do e-storitev.

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Zahvala

Projekt eGovorec je delno financirala Evropska unija, in sicer iz Evropskega sklada za regionalni razvoj, v okviru Operativnega programa krepitve regionalnih razvojnih potencialov za obdobje 2007-2013, razvojne prioritete 3.5.2. Gospodarsko razvojna infrastruktura ter prednostne usmeritve: 3.5.2.2 Informacijska družba.

PROJEKT OPUS: »OPTIMIZACIJA UPRAVLJANJA ENERGETSKO UČINKOVITIH PAMETNIH STAVB«

Tomaž Šef, Rok Piltaver, Tea Tušar
Odsek za inteligentne sisteme, Institut "Jožef Stefan"
Jamova cesta 39, 1000 Ljubljana
{tomaz.sef, rok.piltaver, tea.tusar}@ijs.si

POVZETEK

V okviru projekta OpUS skušamo razviti povsem novo tehnološko rešitev in inovativno e-storitev v oblaku, ki bo zmožna zagotavljati ekološko, energetsko in stroškovno učinkovitost zgradb ob zahtevanem udobju in varnosti v objektih. Urnike, različne scenarije in odzive bo samodejno prilagajala spreminjajočim se življenjskim navadam in potrebam uporabnikov. Sistem bo spremljal obnašanje uporabnikov in se od njih učil. Za to je predvideno (i) dinamično profiliranje uporabnikov in izmenjava uporabniških podatkov s sistemom vodenja (ii) uporabniški vmesnik za enostavno in uporabniku prijazno interakcijo s sistemom ter (iii) optimizacija delovanja sistema glede na odzive uporabnikov in ključne kriterije.

1 UVOD

Obstoječi sistemi hišne avtomatizacije oz. pametnega doma niso tako "pametni", kot to pričakujejo oz. želijo njihovi uporabniki. Preko mreže senzorjev sicer omogočajo spremljanje dogajanja v hiši in krmiljenje hišnih naprav, možno je nastavljati urnike in različne scenarije (prihod, odhod, spanje, zabava ipd.) ter simulirati prisotnost. Nadzor poteka preko različnih pametnih naprav (telefoni, tablice, multimedijski televizorji ipd.), vodi se tudi arhiv dogodkov. Vendar pa se iz preteklega dogajanja in obnašanja uporabnika praviloma ničesar ne naučijo oz. se njihovo delovanje samodejno ne prilagaja uporabnikovim življenjskim navadam. Z energetskega vidika uporaba takšnih sistemov privarčuje kar nekaj energije, večji del potenciala pa še vedno ostaja neizkoriščen.

Različne zahteve uporabnikov pametnih stavb oz. njihovi cilji si med seboj pogosto nasprotujejo: potrebno je zagotavljati udobje in zahtevano stopnjo varnosti, obratovalni stroški morajo biti čim nižji, v zadnjem času pa se čedalje pogosteje izraža tudi zahteva po energetski učinkovitosti in okoljski sprejemljivosti. Manjša poraba energije se ne odraža nujno v nižjih obratovalnih stroških ali večji okoljski sprejemljivost. Optimiranje teh treh dejavnikov pa praviloma negativno vpliva tako na udobje kot varnost.

1. primer – ogrevanje sanitarne vode (segrevanje vode, delovanje obtočne črpalke):

- *udobje*: stalna razpoložljivost tople vode oz. vedno, kadar jo uporabnik potrebuje,
- *energetska učinkovitost*: voda se segreje na želeno temperaturo tik pred uporabo (v tem primeru imamo najmanjše toplotne izgube), obtočna črpalka se vklopi nekaj sekund pred uporabo in ne deluje predolgo,
- *stroškovna učinkovitost*: voda se segreva v času najnižje tarife, upoštevajo se tudi toplotne izgube zalogovnikov,
- *okoljska sprejemljivost: segrevanje v času presežkov energije oz. v času, ko je na razpolago dovolj alternativnih virov.*

Stalna razpoložljivost tople vode zahteva njeno stalno dogrevanje, obtočna črpalka mora delovati ves čas. To pa je energetsko potratno. V kolikor bi znali predvideti/napovedati obnašanje uporabnikov oz. bi se sproti učili njihovih življenjskih navad bi za enako stopnjo udobja lahko porabili bistveno manj energije.

2. primer - osvetlitev prostorov (raba senčil in svetil):

- *udobje*: jakost svetlobe ustreza aktivnosti uporabnikov, pretirano sevanje sonca v prostor ni zaželeno, brez pregrevanja prostorov (čim bolj konstantna temperatura), nezaželeno pogosto spreminjanje nastavitev (za uporabnika je moteče, če se npr. senčila prepogosto spuščajo in dvigajo),
- *varnost*: spuščena senčila dodatno varujejo pred vlomom v objekt, ob odsotnosti uporabnika simulacija njegove prisotnosti (z vklapljanjem in izklapljanjem luči, spreminjanjem položaja senčil ipd.),
- *energetska učinkovitost*: trenutni in pričakovani toplotni dobitki (pozimi so zelo zaželeni, poleti ravno nasprotno), toplotne izgube (večje skozi nezasenčena okna), poraba energije za umetno razsvetljavo,
- *stroškovna učinkovitost in ekološka sprejemljivost*: čim manjša poraba energije za umetno razsvetljavo ter hlajenje oz. gretje.

Pozimi je z energetskega stališča zaželeno, da so okna ob sončnem vremenu v celoti nezasenčena, vendar pa je to v nasprotju z zahtevo po udobju (pregrevanje posameznih prostorov, večja nihanja temperature) in varnostjo (če uporabnikov ni doma). Po drugi strani bi bilo poleti z energetskega vidika najbolje, če bi bila okna v celoti zasenčena (tudi ko so stanovalci prisotni), vendar je to v nasprotju z zahtevo po zadostni (naravni) osvetlitvi.

Zagotavljanje udobja je zelo kompleksen problem; vsak posameznik se počuti udobno glede na različna stanja okolja

sistema (kot so temperatura, vlažnost, osvetljenost, pa tudi občutek varnosti) in samega uporabnika (aktivnosti, ki jih opravlja, vrsta oblačil, ki jih nosi). Po drugi strani pa so želena stanja okolja sistema odvisna tudi od vremena, zunanjih temperatur, letnega časa ipd.

Sistemi v pametnih hišah tako ne morejo samostojno odločati o optimalnih vrednostih za temperaturo prostorov, osvetljenost, temperaturo sanitarne vode, lahko pa spremljajo uporabnike, se od njih učijo ter se v čim večji možni meri prilagajajo njihovim specifičnim zahtevam oz. potrebam. Delovanje takšnega sistema zahteva uporabo množice senzorjev, ki spremljajo trenutno stanje delovanja sistemov, stanje okolja, prisotnost uporabnikov in interakcijo uporabnikov s sistemom.

Na temo energetske učinkovitosti pametnih stavb poteka več projektov v okviru razpisov Artemis in 7. okvirnega programa EU. Raziskave so osredotočene predvsem na zagotavljanje energetske učinkovitosti ob vnaprej določeni stopnji udobja in varnosti. Optimizacijski algoritmi tako ne predvidevajo možnosti, da bi se uporabnik odpovedal določenemu ugodju ali varnosti v zameno za še nižjo porabo energije in večjo ekološko sprejemljivost objekta. Na primer, sistemi uporabniku ne znajo svetovati, da bi ob minimalni in za uporabnika malo moteči spremembi parametrov vezanih na udobje lahko dosegel občutne prihranke. Optimirati znajo le posamezen kriterij, ne pa večjega števila (nasprotujočih si) kriterijev, kar je ključna pomanjkljivost obstoječih pristopov.

Primer: »Pametni« sistem, ki bi optimiral vseh pet kriterijev, bi lahko sprva temperaturo avtomatsko malenkost znižal, iz uporabnikovega odziva pa bi potem razbral, ali je malenkostno znižanje temperature ob občutnih prihrankih zanj še sprejemljivo. V kolikor bi se uporabnik odzval tako, da bi zahteval zvišanje temperature, bi se sistem iz tega nekaj naučil in drugič predlagal drugačno spremembo.

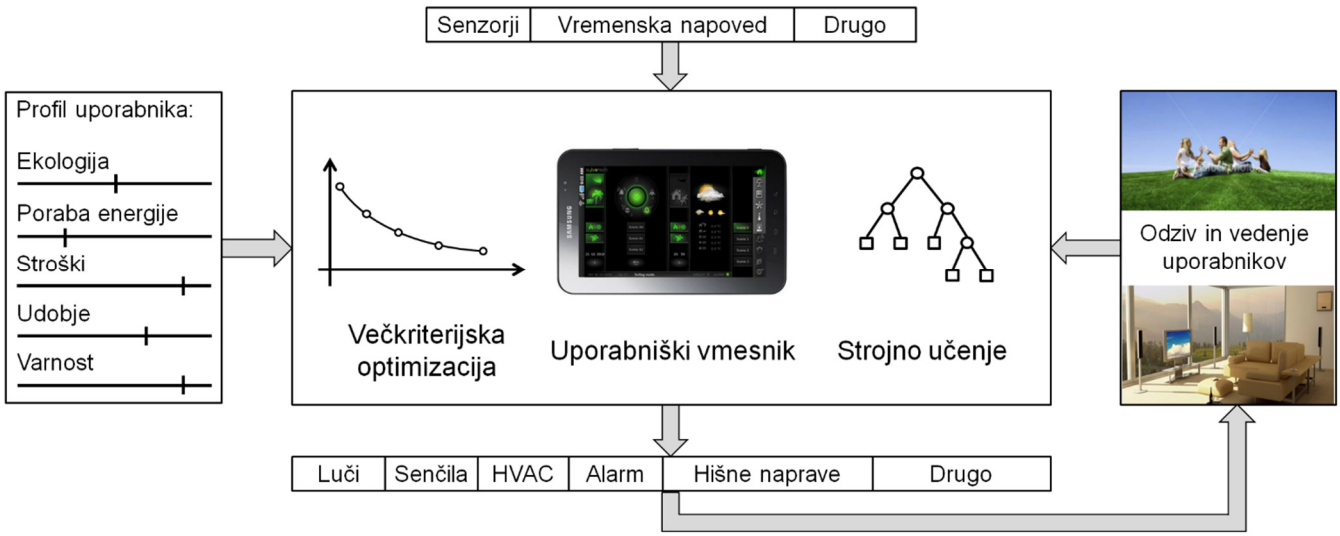
2 OPIS PREDLAGANE REŠITVE

Predlagamo razvoj povsem nove tehnološke rešitve in e-storitve v oblaku, ki bo zmožna zagotavljati ekološko, energetsko in stroškovno učinkovitost zgradb ob zahtevanem udobju in varnosti v objektih ter bo znala urnike in različne scenarije ter zahtevane odzive samodejno prilagajati spreminjajočim se življenjskim navadam in potrebam uporabnikov. OpUS bo spremljal obnašanje uporabnikov in se od njih učil [4]. Delovanje takšne storitve predvideva spremljanje trenutnega stanja delovanja sistemov, stanja okolja, prisotnosti uporabnikov in interakcije uporabnikov s sistemi. Za to je predvideno (i) dinamično profiliranje uporabnikov in izmenjava uporabniških podatkov s sistemom vodenja (ii) uporabniški vmesnik za enostavno in uporabniku prijazno interakcijo s sistemom ter (iii) optimizacija delovanja sistema glede na vse ključne kriterije (slika 1).

2.1 Dinamično profiliranje uporabnikov

Pametna stavba se mora avtomatsko prilagajati uporabnikovim preferencam in pričakovanjem. Zato je potrebno profilirati navade uporabnikov. Glavni namen profiliranja uporabnikov je odkrivanje njihovih želja, potreb in prišakovanj.

Dinamično profiliranje uporabnikov v pametnih stavbah se opisuje z arhitekturo, ki omogoča uporabo kontekstnih informacij v kombinaciji s trenutnimi stanji sistemov in uporabniško interakcijo s sistemom vodenja. Pri tem kontekst, na katerem temeljijo avtonomno izvedene akcije pametnega doma, in funkcije ter informacije, ki jih sistem prikaže uporabniku, predstavljajo: trenutni čas, dan v tednu, prisotnosti ostalih ljudi ter njihove preference in navade, vreme, akcije uporabnika in njegovo obnašanje v bližnji preteklosti itd.



Slika 1 Arhitekturna rešitev projekta OpUS

Dinamično profiliranje uporabnikov pomeni avtomatsko iskanje vzorcev obnašanja (interakcij z napravami v pametni stavbi) in preferenc, ki jih je mogoče izluščiti iz obnašanja, za posameznega uporabnika. Rezultat profiliranja je model uporabnika, s pomočjo katerega je mogoče predvideti, katere akcije (interakcije s komponentami pametne stavbe) bo v določenem kontekstu ta uporabnik želel izvesti oz. naj jih namesto njega samodejno izvede pametna stavba, če so v skladu s potrebami in željami ostalih uporabnikov in splošnih ciljev delovanja pametne stavbe. Dinamično profiliranje pa pomeni, da se model uporabnika, ki je rezultat profiliranja, dinamično spreminja in prilagaja glede na novo pridobljeno znanje ter spreminjajoče se navade in potrebe uporabnika. Bogatejši kot je nabor senzorjev, s katerimi je mogoče zbirati podatke o kontekstu, in inteligentnejši kot so algoritmi, ki so iz teh podatkov sposobni izluščiti relevantne informacije in profile uporabnikov, bolj se lahko pametna stavba prilagodi željam in potrebam uporabnikov ter zagotovi primerno stopnjo udobja, varnosti in energetske učinkovitosti.

Predvsem zanimiva bo uporaba inkrementalnih algoritmov strojnega učenja, ki so sposobni dinamično dopolnjevati svoje znanje, in delno nadzorovanega (angl. semi-supervised) ter nenadzorovanega (angl. unsupervised) učenja, pri katerem ne potrebujemo uporabnikovega sodelovanja v postopku učenja. Obstoječe algoritme [3] je potrebno prilagoditi za delovanje v realnem času in delovanje na strojni opremi z omejenimi pomnilniškimi in procesorskimi kapacitetami ter delovanje na strežniku v oblaku.

2.2 Uporabniški vmesnik

Uporabniški vmesnik za pametne stavbe mora biti intuitiven in preprost za uporabo. Ker pametne stavbe uporabljajo tudi invalidi in ostareli, je zaželena možnost prilagajanja njihovim posebnim potrebam (veliki gumbi, dovolj veliko in berljivo besedilo, prikazovanje le osnovnih funkcionalnosti ipd.).

Z vidika raziskovalno razvojnega dela je še posebej zanimiva možnost dinamičnega prilagajanja vmesnika glede na pričakovane/napovedane potrebe uporabnika ter dinamičnega izbiranja prikazanih podatkov glede na njihovo aktualnost in relevantnost za določenega uporabnika v določenem kontekstu. Pomembno je, da uporabniški vmesnik uporabnika ne obremenjuje z nepotrebnimi in nerazumljivimi podatki ter številnimi funkcijami, temveč da mu ponudi le relevantne informacije, ki jih sistem samodejno izlušči iz surovih podatkov, in funkcije, ki jih bo uporabnik glede na svoje potrebe in poudarjene informacije verjetno želel uporabiti v določenem kontekstu.

2.3 Optimizacija delovanja OpUSa

Ob večjih spremembah v okolju bo moral sistem spremeniti nastavitve vanj vključenih naprav tako, da bo sočasno optimiral vseh pet kriterijev. Medtem ko so kriteriji stroškovne učinkovitosti, ekološke sprejemljivosti in energetske učinkovitosti objektivni in izračunljivi s poznanimi modeli, bo za ocenjevanje subjektivnih kriterijev udobja in varnosti uporabljal v ta namen razvite modele, pridobljene med profiliranjem uporabnikov.

Optimizacijo bomo izvajali s pomočjo evolucijskih večkriterijskih optimizacijskih algoritmov, ki so sposobni učinkovito optimirati več kriterijev hkrati [2], [5]. Znano je, da so ti algoritmi uspešni le pri optimiranju dveh ali treh kriterijev, medtem ko je njihovo delovanje občutno slabše v primeru štirih ali več kriterijev. Raziskave na področju optimizacije delovanja OpUSa so zato usmerjene k snovanju novega algoritma, ki bo optimiral vseh pet danih kriterijev bolje od obstoječih algoritmov.

Rezultat novega optimizacijskega algoritma bo množica najboljših rešitev z različnimi kompromisi med posameznimi kriteriji. Izmed vseh bomo za končno rešitev (novo nastavitev naprav) izbrali tisto, katere kriteriji bodo najbolj ustrezali željam uporabnika.

3 UPORABLJENE TEHNOLOŠKE REŠITVE

Ambientalna inteligenca v pametnem domu integrira sisteme in tehnologije, razvite za vodenje vsakdanjih opravil, z namenom izboljšanega upravljanja domačega okolja in nudenja novih storitev. Cilj raziskav s področja ambientalne inteligence je izboljšati vsakodnevno uporabniško izkušnjo in postaviti človeka v središče bodoče družbe temelječe na znanju ter podprte s številnimi informacijskimi in komunikacijskimi tehnologijami. Pri tem so naprave, ki zagotavljajo inteligentne storitve, skrite v uporabnikovo okolje in zato zanj ne predstavljajo dodatnih obremenitev ali motenj. Ambientalna inteligenca predstavlja premik iz preproste avtomatizacije po urniku proti inteligentnim storitvam, ki jih sistem samodejno ponudi ali izvede glede na uporabnikov kontekst in profil.

Nove tehnologije/inovacije:

- *večkriterijska optimizacija parametrov* pametne hiše/ objekta, skupine objektov, celih mest, npr. stohastične večkriterijske optimizacijske metode [6];
- *strojno učenje uporabnikovega obnašanja*, ugotavljanje življenjskih navad, analiza dogodkov in njihovih posledic na obratovanje objekta oz. na ključne dejavnike/kriterije, napovedovanje bodočih potreb uporabnikov (npr. metode za analizo časovnih vrst [1]);
- *prilagajanje glede na odzive uporabnikov*;
- *procesiranje časovnih vrst (senzorskih podatkov)* za luščenje relevantnih informacij;
- *komunikacija z uporabnikom* v njegovem domačem jeziku (dostop do novih uporabnikov: invalidi, starejši, otroci), dinamično prilagajanje uporabniškega vmesnika glede na pričakovane želje uporabnika.

Rešitev bo vsebovala strežniški del in uporabniški del. Strežniški del rešitve bo vseboval bazo podatkov s parametri o delovanju posameznega objekta ter tehnike in metode za njihovo analizo. Implementiran bo v različici Jave J2EE ter nameščen v računalniškem oblaku. Z ostalimi deli rešitve bo komuniciral preko šifriranega varnega kanala, kjer bo vsak uporabnik avtentificiran. Poleg tega bo omogočal oddaljeno komunikacijo s pametnimi napravami, priključenimi na internet stvari.

Uporabniški del prototipa bo implementiran in dostopen na dva načina: a) v oblaku bo implementiran v HTML5 platformi in dostopen preko interneta; b) na mobilnih platformah bo implementiran kot domorodni prototip. Za implementacijo uporabniškega dela bomo uporabili posebna orodja, ki omogočajo implementacijo z uporabo dokaj enotne izvorne kode na večjem številu platform, torej na HTML5 in mobilnih platformah.

Strežnik in spletna aplikacija bosta podpirala standarda IPv6 in IPv4. To bomo zagotovili z neodvisnostjo lastne programske opreme od omrežnega sloja ter primerno izbiro strežniškega operacijskega sistema in druge strežniške programske opreme. Glede na to, da večina tovrstne programske opreme podpira oba standarda, tu ne pričakujemo težav.

Pri implementaciji uporabniškega dela bomo posvetili pozornost tudi uporabnikom s posebnimi potrebami.

4 SKLEP

Predlagani sistem OpUS predstavlja inovativno e-storitev v oblaku, ki bo zmožna zagotavljati ekološko, energetsko in stroškovno učinkovitost zgradb ob zahtevanem udobju in varnosti v objektih. Projekt je inovativen iz več vidikov:

- *funkcionalni vidik*: intuitivna možnost nastavljanja uporabniških preferenc glede udobja, varnosti, stroškov, porabe energije in ekologije;
- *tehnični vidik*: dinamično profiliranje uporabnikov, napredna optimizacija delovanja sistema glede na vse ključne kriterije;
- *organizacijski vidik*: vrhunska raziskovalno razvojna institucija usmerja potek raziskovalno razvojnega dela, večino raziskovalno razvojnega dela pa opravi podjetje samo;
- *poslovni vidik*: ogromna količina podatkov o življenjskih navadah prebivalcev (o uporabniku izvemo veliko več, kot če zgolj spremljamo njegovo obnašanje na internetu), možnost osebnega svetovanja glede nakupa izdelkov in storitev.

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ZAHVALA

Projekt OpUS delno financira Evropska unija, in sicer iz Evropskega sklada za regionalni razvoj.

MODELIRANJE NAVAD UPORABNIKOV PRI VODENJU PAMETNIH HIŠ

Aleš Tavčar[1], Rok Piltaver[1], Domen Zupančič[2], Tomaž Šef[1], Matjaž Gams[1]
Odsek za inteligentne sisteme [1]
Institut »Jožef Stefan«
Jamova cesta 39, 1000 Ljubljana, Slovenija
Robotina d.o.o. [2]
OIC-Hrpelje 38
SI-6240 Kozina, Slovenija
e-mail: {ales.tavcar, rok.piltaver, domen.zupancic, tomaz.sef, matjaz.gams}@ijs.si

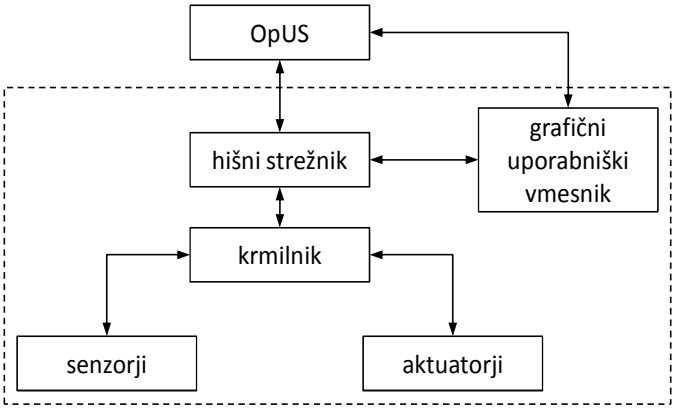
POVZETEK

Obstoječi sistemi hišne avtomatizacije oz. pametnih stavb niso tako "pametni", kot bi pričakovali njihovi uporabniki. Trenutne rešitve omogočajo zgolj spremljanje stanja sistemov in okolja v hiši ter krmiljenje hišnih naprav preko različnih stikal in spleta. Sistemi se iz opazovanja obnašanja uporabnika in zbranih zgodovinskih podatkov praviloma ne učijo in zato niso zmožni prilagajati delovanje glede na življenjske navade in potrebe uporabnikov. V pričujočem prispevku so predstavljeni načini za nadgradnjo sistemov hišne avtomatizacije z inteligentnimi metodami. Sistemi, izboljšani na predlagan način, bodo zmožni spremljanja obnašanja uporabnikov, se bodo od njih učili in prilagajali delovanje glede na spreminjajoče se življenjske navade in potrebe.

1 UVOD

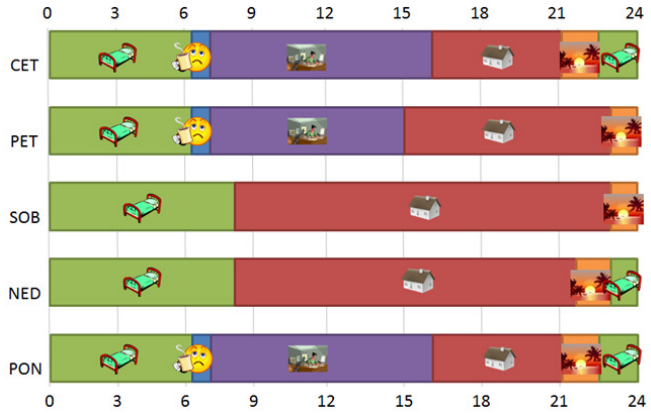
Pregled obstoječih sistemov hišne avtomatizacije je pokazal, da obstoječi tržni sistemi večinoma ponujajo zgolj nadzor in krmiljenje hišnih naprav ter razmer v hiši. Nadzor poteka preko različnih t.i. pametnih naprav in spletnih vmesnikov. Nastavljanje urnikov in scenarijev je prepuščeno samim uporabnikom, iz česar običajno sledi, da so urniki nastavljeni površno in zato neučinkovito. Poleg tega se navade uporabnikov neprestano spreminjajo. Uporabniki lahko npr. začnejo prihajati domov kasneje; ob nespremenjenem urniku, to pomeni, da se začne ogrevanje hiše prezgodaj. Take rešitve so neustrezne iz energetskega vidika, saj povečajo porabo energije in s tem povezane stroške ter negativen vpliv na okolje. Problem je mogoče rešiti s sistemom, ki bo sposoben sprotnega spremljanja dogajanja v hiši, učenja navad uporabnikov in prilagajanja delovanja glede na spremenjene življenjske navade in potrebe uporabnikov.

Sistem OpUS, ki bo razvit v okviru projekta e-storitve za gospodarstvo, rešuje zgoraj omenjene probleme. OpUS bo neodvisna, samostojna in robustna rešitev, ki se bo lahko vgradila na široko paleto obstoječih sistemov hišne avtomatizacije. Slika 1 prikazuje način povezave sistema OpUS z obstoječim sistemom pametne hiše. OpUS pridobiva senzorske podatke, stanje sistema in zgodovinske podatke iz hišnega strežnika (ang. home server). Na osnovi teh podatkov sprejema odločitve o spremembah delovanja sistema. Uporabnika o spremembah obvešča preko grafičnega uporabniškega vmesnika (ang. GUI). V primeru, da uporabnik spremembe potrdi, OpUS sporoči strežniku nova navodila glede načina vodenja pametne stavbe.



Slika 1: Vključitev sistema OpUS v obstoječe sisteme hišne avtomatizacije.

Za definiranje in urejanje urnika se OpUS poslužuje scen. To so prednastavljene množice pravil, ki poskrbijo, da se delovanje vseh naprav v hiši enostavno prilagodi konkretnim potrebam določene (pogoste) situacije. Spanje je ena takih pogostih situacij in zanjo je mogoče razmeroma enostavno določiti parametre delovanja stavbe: nižja temperatura, malo tople vode, tema v spalnici, spuščena senčila, ipd.



Slika 2: Urnik sestavljen iz različnih scen.

Na sliki 2 je prikazan primer urnika, ki je sestavljen iz različnih scen: spanje, jutro, odsotnost, prisotnost, večer. Takšen urnik je osnova za učenje in predlaganje popravkov.

3 SORODNI SISTEMI

Pregled sodobnih sistemov vodenja v pametnih zgradbah je opisal Dounis et.al [1]. Za razliko od klasičnih načinov vodenja, je za optimalno, prediktivno ali adaptivno vodenje potrebno imeti model zgradbe. Računska inteligenca v zgradbah se je pričela uporabljati leta 1990, najprej z uporabo nevronskih mrež, kasneje pa z vpeljavo mehkih krmilnikov (ang. fuzzy controller), pravil in drugih metod strojnega učenja ter z uporabo genetskih algoritmov ipd. za doseganje primernega razmerja med termalnim udobjem, rabo energije, vizualnim udobjem in naravno ventilacijo. Pregled literature povezane z uporabo optimizacijskih metod na področju rabe obnovljivih virov energije in trajnostnega razvoja so naredili Baños et.al [2] in ugotovili, da je od leta 1990 do danes opazna eksponentna rast števila znanstvenih prispevkov na temo rabe optimizacijskih tehnik pri obnovljivih virih energije.

Vodenje sistemov z uporabo podatkov in znanj o uporabnikih in okolju predstavlja nove smernice raziskav in razvoja tako imenovanega vseprisotnega in prodornega računalništva (ang. ubiquitous computing, pervasive computing), saj sodobne naprave, senzorji in aktuatorjih, ki se vse bolj množično pojavljajo v zgradbah (senzorji prisotnosti, senzorji gibanja, senzorji odprtosti oken, senzorji na mobilnih telefonih, osebne vremenske postaje itd.) omogočajo beleženje najrazličnejših informacij in kopičenje znanj tako o obnašanju posameznega uporabnika, kot o obnašanju sistema. Uporaba takšnih znanj se izkorišča v sistemih, ki spodbujajo uporabnike k zmanjšanju porabe energije s spodbujanjem k na primer nižanju želenih temperatur ogrevanja ali pa k izbiri primernih prostorov v službi za potrebe sestankov (manj ljudi - manjši prostor - manj energije za ogrevanje) [3]. Znanje o uporabnikih se izkorišča za gradnjo modelov uporabnikovega obnašanja in uporabo le-teh pri vodenju in adaptaciji sistemov ogrevanja, razsvetljave, prezračevanja in ogrevanja sanitarne vode [4,5]. Prihranki energije se gibljejo med 5-30%.

Veliko projektov na temo izvedbe testnih pametnih hiš in stanovanj je bilo že dokončanih. Leta 1990 so izdelali Neural Network House [6], kjer so uporabljali nevronske mreže za inteligentno vodenje sistemov. Sledila sta IHome[7] in MavHome[8], temelječa na inteligentnem več-agentnem pristopu nadzora in vodenja sistemov z uporabo tehnik za modeliranje in napovedovanje uporabnikovega obnašanja in akcij. Gator Tech Smart House [9] je splošno uporaben študijski projekt za raziskavo tehnik vseprisotnega računalništva (ang. pervasive computing). Eden zadnjih projektov - ThinkHome [10] uporablja širok nabor podatkov o okolju, vremenu in uporabniku za namene študije vodenja pametnih domov.

Vsi sistemi se povečini osredotočajo zgolj na določene vidike upravljanja stavbe. ThinkHome, na primer, poskuša predvidevati temperaturo, ki bo za uporabnika najudobnejša. Poleg tega poskuša predvidevati, kdaj bo nek uporabnik prisoten. Sistem OpUS je obširnejši, saj poskuša modelirati in upravljati večje število parametrov pametne hiše obenem pa v algoritme vodenja vključuje znanja o vedenju uporabnika stanovanja.

Soroden pristop k učenju in identifikaciji gibanja so predstavili Piltaver in ostali [11]. Uporabljali so RTLS sistem za lokalizacijo ljudi v prostoru in na podlagi pozicije, konteksta in akcij, ki so jih opazovani ljudje opravljali so odkrivali sumljive in nenavadne dogodke.

4 UČENJE

Učenje je eden ključnih delov sistema OpUS, saj omogoča prilagajanje delovanja sistema specifičnim uporabnikom. Pametno predlaganje sprememb in optimiziranja urnikov prinaša več pozitivnih učinkov: (i) poveča se udobje za uporabnika, saj so vzpostavljeni ustrezni pogoji ob ustreznem času. Na primer, uporabnik ne pride v mrzlo stanovanje, zjutraj je dovolj tople vode itd. (ii) Poveča se energetska učinkovitost, saj se sistem zaveda odsotnosti uporabnikov in zmanjša porabo energije v hiši na minimalno raven.

Za vzpostavitev zanesljivega sistema je potrebno zagotoviti več učinkovitih načinov učenja, ki so opisani v naslednjih razdelkih.

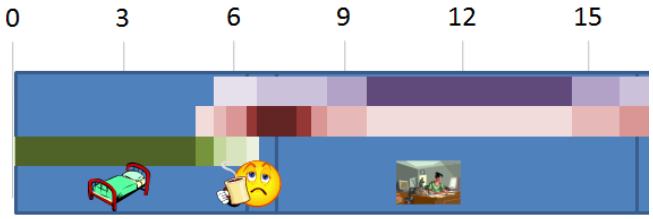
4.1 Učenje navad

Učenje navad uporabnika poskuša zgraditi model obnašanja uporabnika na podlagi opazovanja prisotnosti v hiši in v posameznih sobah. Zgrajeni model lahko za določeno obdobje napove verjetnost, da uporabnik spi, verjetnost, da je buden in prisoten, verjetnost, da bo potreboval večje količine tople vode ipd.

Sistem dlje časa opazuje senzorske podatke o prisotnosti in sproti gradi verjetnostni model navad uporabnika. Dejanske senzorske podatke o prisotnosti primerja s prednastavljenim urnikom in ugotavlja ali prihaja med njima do opaznih razlik.

Na sliki 3 je prikazan urnik, kateremu so dodane "mehke" meje med posameznimi scenami. Zelena barva

predstavlja sceno Spanje, rdeča barva predstavlja sceno Jutro in vijolična sceno Odsotnost. Intenziteta posamezne barve pa označuje verjetnost, da je prepoznano vedenje uporabnikov v tem času zahtevalo določeno sceno.



Slika 3: Učenje uporabniških navad.

V primeru, da je med delovanjem scene Spanje, določene z urnikom, v jutranjih urah zaznano gibanje v različnih prostorih hiše in da se zazna uporaba večje količine tople vode, sistem sklepa, da je uporabnik že buden in je nastavljena scena napačna. Sistem si zabeleži v katerem časovnem intervalu je prišlo do potrebe po spremembi scene in v primeru pogostega neskladja nastavljene scene z dejanskimi potrebami, opozori uporabnika in predlaga popravek časa preklopa scene na zgodnejšo uro. S tem se uporabniku poveča udobje, saj so nastavitve hiše primernejše (temperature, količina tople vode itd.). Podobno lahko spreminjanje urnika zmanjša porabo in stroške, saj sistem zazna, da ni potrebe po ogrevanju in topli vodi, če uporabnika ni v hiši.

Pri učenju navad ostaja še nekaj odprtih vprašanj, na katere bomo lahko odgovorili z eksperimenti in uporabo različnih metod strojnega učenja. Prvo vprašanje je smiselnost uporabe regresijskih ali klasifikacijskih metod. S prvo napovedujemo točen čas, ko naj bi se končala določena scena, pri drugi skupini metod pa razdelimo urnik na večje število intervalov, za vsakega od njih pa klasifikator napove ali scena še velja ali ne. Tako prevedemo problem na binarni klasifikacijski problem, ki je običajno točnejši pri napovedovanju. Naslednje odprto vprašanje ostaja izbira metod učenja, ki jih bomo uporabljali: transparentne metod, ki poleg napovedi omogočajo tudi razlago odločitve, ali točnejše metod, ki take razlage ne ponujajo.

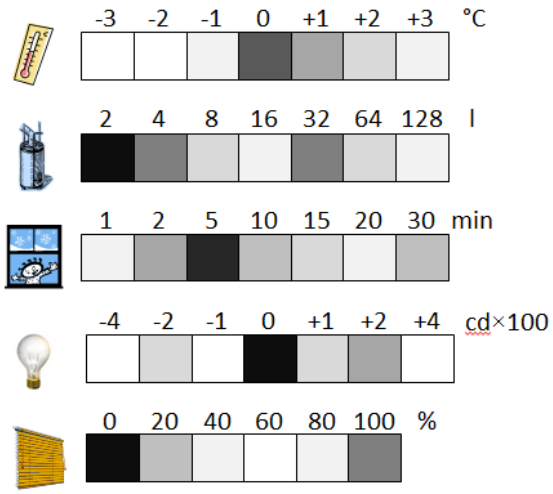
4.2 Učenje akcij uporabnikov

Poleg učenja navad je v sistemu OpUS, za zagotavljanje večje zanesljivosti in uporabnosti, predvideno tudi učenje akcij uporabnikov.

Uporabnikove akcije so običajno posledica neudobja. Ob mrazu uporabnik poveča temperaturo prostora za nekaj stopinj, ob sončnem vremenu uporabnik spusti senčila, zvečer lahko poveča osvetljenost itd. Sistem mora take spremembe beležiti in ugotoviti relacije med okoljskimi dejavniki, uporabnikovo aktivnostjo in izvedeno akcijo. Zaradi tega je pomembno, da ima sistem na razpolago čim več virov informacij. Eden takih virov je zagotovo vremenska napoved in trenutno stanje vremena (temperatura, vlažnost itd.).

Na sliki 4 so prikazane nekatere akcije, ki jih uporabnik lahko izvede, in način predstavitve sprememb v naučenih modelih. Zvezne akcije je potrebno najprej mehko diskretizirati na ustrezne intervale (sprememba temperature diskretizirana s korakom 1°C, odprtost senčil diskretizirano s korakom 20% itd.). Sistem nato beleži akcije uporabnika in okoliščine v katerih je do akcij prišlo. Tako zbrani podatki so na voljo učnim algoritmom, ki lahko inkrementalno gradijo odločitvene modele. Pomembno je, da imajo algoritmi na razpolago čim več podatkov iz katerih se učijo. Poleg same količine in raznolikosti senzorskih podatkov je pomembno tudi število in kvaliteta atributov na podlagi katerih se iz zbranih podatkov izluščijo zakonitosti in pravila, ki opisujejo relacije med okoljskimi parametri, uporabnikovo aktivnostjo in akcijami.

Učenje akcij uporabnika je tesno povezano s kontekstom v katerem je do spremembe prišlo. Glede na sam kontekst se pogojna verjetnost akcije razlikuje. Če spremembo temperature opazujemo iz konteksta trenutne temperature, opazimo, da pri različnih temperaturah pride do različnih sprememb. Pri nizki trenutni temperaturi bo uporabnik večinoma temperaturo povečal. Pri visoki trenutni temperaturi pa uporabnik ne bo vnašal sprememb ali pa bo temperaturo znižal. V primeru, da spremembo temperature opazujemo iz konteksta trenutne scene lahko dobimo informacijo, da uporabnik v večini primerov temperaturo poveča v sceni Prisoten in zmanjša v sceni Spanje. Tak pogled je verjetno preveč poenostavljen, saj lahko znotraj scen prihaja do večjih sprememb s strani uporabnika. Spremembo temperature lahko opazujemo tudi iz konteksta trenutnega časa in tako dobimo drug model. Uporabnik lahko temperaturo znatno poveča zjutraj, čez dan jo zniža in zvečer spet poveča. Podobno lahko za vse akcije uporabnikov določimo kontekst, vendar je pri določenih akcija pomembna ena vrsta konteksta, pri drugih pa druga. Eksperimentalno moramo določiti najprimernejši kontekst za vsako akcijo, saj je od tega odvisna kvaliteta napovedovanja modelov.



Slika 4: Učenje uporabniških akcij.

5 ZAKLJUČEK

V pričujočem članku smo opisali enega od ključnih delov sistema OpUS – učenje navad in akcij uporabnikov. Nabor funkcij, ki jih učenje omogoči v sistemu hišne avtomatizacije je širok. Dinamično prilagajanje urnikov prinaša uporabnikom večje udobje, saj sistem na podlagi učenja sam identificira spremembe v navadah uporabnikov in ustrezno predlaga popravke urnika. Podobno lahko sistem sam zazna kakšne spremembe je potrebno uvesti v način vodenja posameznih scen, glede na akcije, ki jih uporabnik izvaja.

Takšen prilagodljiv in inteligenten sistem lahko znatno zniža porabo in s tem stroške inteligentne hiše. S tem pa vzpodbuja ekološko ozaveščenost uporabnikov in zmanjšuje negativne vplive na okolje.

Obstoječi tržni sistemi hišne avtomatizacije predstavljenih rešitev ne uporabljajo. Deloma zaradi višjih stroškov razvoja, kar se direktno preslika v ceno takega sistema, deloma pa zaradi trenutno nezanesljivega in nerobustnega delovanja, ki ga vključitev takih metod v sistem povzroči. Predvidevamo, da se bo projekt OpUS uspešno spopadel z navedenimi težavami in da bo razviti sistem, ki bo z uporabniškega stališča koristen in prijazen za uporabo.

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DECISION SUPPORT SYSTEM FOR MANAGEMENT OF WATER SOURCES

Nejc Trdin[1, 2], Marko Bohanec[1], Mitja Janža[3]
Department of Knowledge Technologies, Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia[1]
Jožef Stefan International Postgraduate School, Jamova 39, 1000 Ljubljana, Slovenia[2]
Geological Survey of Slovenia, Dimičeva ulica 14, 1000 Ljubljana, Slovenia[3]
e-mail: {nejc.trdin, marko.bohanec}@ijs.si, mitja.janza@geo-zs.si

ABSTRACT

Meeting the quality criteria for drinking water is one of the areas which require constant monitoring. The monitoring in Slovenia is currently done by experts. Due to large amounts of data collected while monitoring water adequacy, an expert carries a large burden and also his decisions are prone to errors. In this paper we present a decision support system for controlling the adequacy of drinking water. The approach is based on the qualitative multi-criteria modeling method DEX. We developed two different models – one for general monitoring and another for a specific location and specific pollutant, when a major pollution is discovered. The models and the developed software is presented and evaluated with a case study of Ljubljansko polje aquifer.

1 INTRODUCTION

Drinking water must meet many chemical and microbiological criteria to be appropriate for drinking. All these criteria need to be regularly controlled and monitored.

Presently in Slovenia, the monitoring is done by water experts in a manual way. The expert compares measured concentrations of pollutants in the water with the reference maximal concentrations. If the measured concentrations are larger than maximal reference concentrations, the expert must suggest a measure to make water adequate. Since large amounts of data are collected, the expert is prone to making errors in their decisions. Therefore, some kind of decision support would be a large help to the expert.

The goal of this work was to develop a decision support system (DSS) that would monitor water quality and suggest measures that need to be taken in case of pollution. The measures suggested should be as similar as possible to the ones of the decision maker. In the DSS, the assessment of measures is carried out by a qualitative multi-criteria model, developed using the method DEX.

This paper is structured as follows. The second section gives introductory facts about water sources. DEX methodology is described in section 3, and the DSS in section 4. Evaluation of the DSS is presented in section 5.

2 WATER SOURCES

Drinking water is monitored with a purpose of securing the health of people from harmful effects of water pollutants. Drinking water is, by definition [4], water in its prime state or after preparation, meant for drinking, cooking, and production, preparation and transport of food, regardless of it being supplied from water supply networks, water tanks or as bottled water.

Drinking water is wholesome by chemical and microbiological criteria when following criteria are met [4]:

- Water does not contain microorganisms, parasites and their developmental forms in numbers, which can be harmful to health of people.
- Water does not contain substances in concentrations, which alone or in combination with other substances can present danger to people's health.
- Water measurements are in line with the regulatory maximal pollutant concentrations tables in [4].

The main source of drinking water in Slovenia is groundwater; 97 % of the country's population depends on groundwater for its water supply. This work is concerned only with the most important Slovenian drinking water source, *Ljubljansko polje* aquifer. Monitoring network, used in this study consists of 20 abstraction and observation wells – locations where water is monitored.

Regulation policy [4, 6] for monitoring drinking water requires that at each monitoring location, water needs to be monitored at least three to five times a year, evenly distributed through the year. In case of increased concentrations of the pollutants, additional monitoring is needed. In Slovenia, data monitored within the framework of the national monitoring of groundwater for the past six years is available online [5, 11].

3 DEX METHODOLOGY

DEX is a qualitative multi-criteria decision making methodology [1, 2, 3, 10]. DEX facilitates development of qualitative multi-attribute models, with which decision alternatives are evaluated and analyzed. Evaluation criteria are represented by a hierarchy of qualitative attributes. The evaluation of alternatives is carried out using decision rules. More specifically, a DEX model consists of:

- Attributes: variables that represent basic features and assessed values of decision alternatives.
- Hierarchy of attributes: represents the decomposition of the decision problem and relations between attributes; higher-level aggregated attributes depend on lower-level ones. The lowest-level attributes are basic attributes, which represent basic measurable properties of alternatives. One or more top attributes are called roots.
- Scales of attributes: these are qualitative and consist of a set of words, such as: 'excellent', 'acceptable', 'inappropriate', etc. Usually, scales are ordered preferentially, i.e., from bad to good values.
- Decision rules: tabular representation of a mapping from lower-level attributes to higher-level ones. In principle, a table should specify a value of the higher-level attribute for all combinations of values of its lower-level attributes (as in Table 1).

Evaluation of alternatives is done in a bottom-up manner. Alternative's values are first assigned to basic attributes, then aggregation functions are progressively computed until all attributes obtain their corresponding values. The final evaluation of alternative is the value in the root attribute.

Because of its nature, DEX is an ideal methodology for developing decision support systems. After a model has been developed, it can be used numerous times for evaluating different alternatives, without additional expert's input. Many decision making methodologies, particularly outranking multi-criteria methods, do not have this property and require additional preference information, e. g. pair-wise comparison of alternatives [10].

4 DSS FOR WATER SOURCE MANAGEMENT

Construction of the DSS builds on results of the INCOME project [7]. The starting point is a flow of events on which the monitoring of water must look upon [7, 8, 9]. The flow of events is constructed for a general case of water monitoring, but it can also be specified for a specific pollutant and location of monitoring. The scheme requires four binary input data items for the analysis:

- Is regulatory margin of pollutant exceeded?
- Is there an unfavorable trend of past concentrations?
- Location type: abstraction or observation well.
- Is additional monitoring currently performed?

The event flow is applied on every measured pollutant and for every location. Measures are applicable only for that particular pollutant and location.

4.1 Requirements

As input data the DSS should get the five input values: location, pollutant, date, concentration and if additional monitoring is performed. This data were collected in the INCOME project [7]. From input data, the DSS should produce a set of measures which need to be taken, so that the water would be adequate in the future.

The DSS should facilitate an easy addition of actions for specific pollutants and locations, since not all actions are known at development time. The DSS must be able to store previous measurements in its data structures, and it must be able to add new measurements to the data structures.

A wrapper program which forms a bridge between DEX models and stored data is needed. Also, it should support command line options and a suitable GUI for plotting time series of measurements, trend lines and regulatory margins.

4.2 DEX models

We firstly developed one model for a general case of pollution; it can be applied for any location or pollutant. The model is completely based on the event flow [7, 8, 9]. However, the measures after pollution may differ between pollutants and locations, therefore more specific models must be created. In principle, one model should be developed for each location/pollutant pair. In this work so far, we constructed one specific model for pollutant *tricloroethene* and location *AMP Hrastje*.



Figure 1: Hierarchy of the general model.

4.2.1 General Model

This model contains four input attributes and one root attribute (Figure 1). The input attributes are logically constructed from attributes in section 4 and have two values: *yes* or *no* – except the *Location type*, which can be *abstraction* or *observation well*.

The root parameter of the model is named Action and has the following values, sorted by the severity of the action: Regular monitoring; Activate the well into network; Repeat measurement; Increase measurement frequency; Finding reasons for bad state and remedial measures; Implementation of measures to achieve good state; Deactivation of well. The decision rules for Action are presented in Table 1.

4.2.2 Model for Hrastje and tricloroethene as pollutant

When a major pollution is discovered it is possible to suggest specified measures for a specific pollutant and location. This model suggests measures for *Hrastje* wells and pollutant *trichloroethene*. In comparison with the general model, the specified model has the same structure (Figure 1), but decision rules (Table 1) differ so that some general actions from the general model are replaced by more specific actions in the specific model. *Remedial measures* in the general rules were changed to:

- Ventilation.
- Combination of ventilation with carbon absorption.
- Ventilation of soil.
- Ventilation in the borehole.
- Biological removal.
- Heating of soil or borehole.
- Removal with hydrogen.

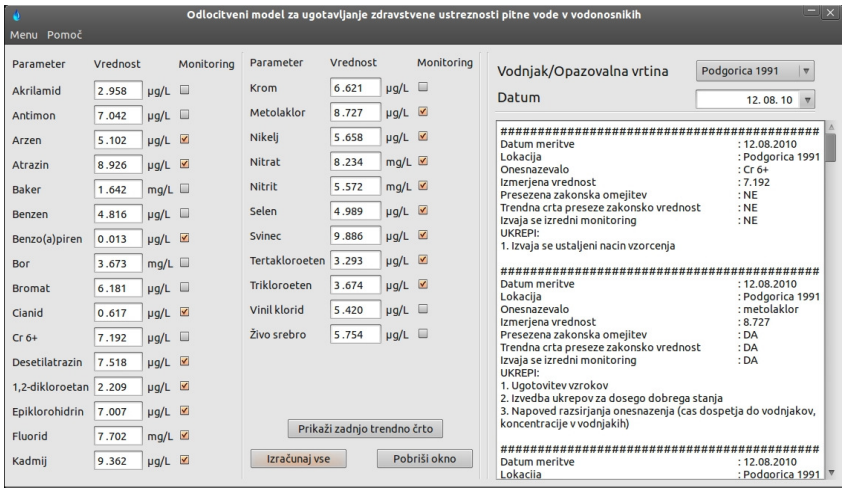


Figure 2: The main graphical user interface of the DSS. Data are input on the left, the results are shown on the right.

Exceeded regulatory margin	Unfavorable trend line	Location type	Additional monitoring	Action
YES	YES	Abstraction well	YES	Deactivation of well
YES	YES	Abstraction well	NO	Deactivation of well
YES	YES	Observation well	YES	Finding reasons; Remedial measures
YES	YES	Observation well	NO	Repeat measurement; Increase measurement frequency
YES	NO	Abstraction well	YES	Deactivation of well
YES	NO	Abstraction well	NO	Deactivation of well
YES	NO	Observation well	YES	Finding reasons; Remedial measures
YES	NO	Observation well	NO	Repeat measurement; Increase measurement frequency
NO	YES	Abstraction well	YES	Activate well
NO	YES	Abstraction well	NO	Measure implementation
NO	YES	Observation well	YES	Finding reasons; Remedial measures
NO	YES	Observation well	NO	Measure implementation
NO	NO	Abstraction well	YES	Activate well
NO	NO	Abstraction well	NO	Regular monitoring
NO	NO	Observation well	YES	Regular monitoring
NO	NO	Observation well	NO	Regular monitoring

Table 1: Decision rules of the general DSS model

4.3 User interface

The DSS was primarily developed for command line use. Thus, the core of the DSS is a command-line program that connects data and DEX model, and governs the processing.

On top of the command-line program, there is a graphical user interface (Figure 2). It supports entering of concentrations for all pollutants and declaring if the additional monitoring is being performed. It also supports selecting the date and the location from a drop down list. Plotting regression trend lines and loading and saving measurement data is also available. A sample plot is shown in Figure 3. Measurements are plotted with dots, the decreasing line represents the declining trend of the measurements and the horizontal line represents the regulatory margin for this particular pollutant.

4.4 Evaluation of one measurement

The DSS expects five arguments on its input: Monitoring location, pollutant, pollutant concentration, is additional monitoring performed and the date of measurement.

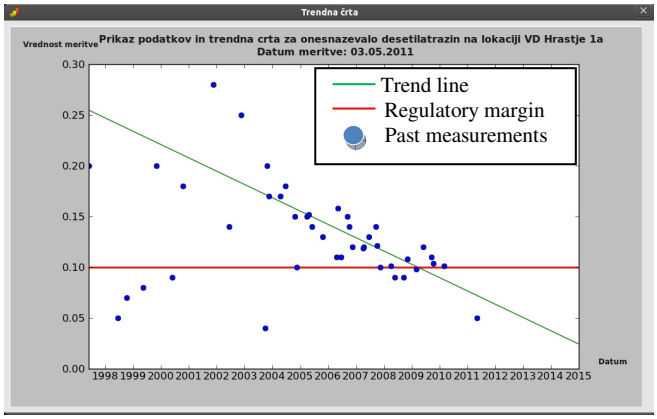


Figure 3: Window showing a decreasing trend line for deethylatrazine on VD Hrastje 1a location. Dots show past measurements; the horizontal line is the regulatory margin.

The input arguments are then transformed to qualitative values as follows:

- *Exceeded regulatory margin* is *yes* when the measured concentration is equal or higher than the regulation margin.
- *Unfavorable trend line* is set to *yes* if the linear trend line, extrapolated from past five-year measurements, is expected to reach the regulation margin in year 2015.
- *Location type* is set to *abstraction well* if 'VD' is in the name of the location; otherwise the location is *observation well* [9].
- *Additional monitoring* is supplied to the program with an explicit argument.

Actual evaluation is performed by an external DEXiEval utility [3], which evaluates the alternative on the specific model (if it exists), otherwise on the general model.

5 EVALUATION

In order to evaluate the DSS, we constructed two test cases. The first test case is evaluation of all locations with all pollutants. With it, we can assess chemical status of *Ljubljansko polje* aquifer. The second test case is an evaluation of *trichloroethene* pollution, discovered in *Hrastje* wells. After applying the DSS on both cases, we discussed the results with a water-management expert.

5.1 General model

For each of the 20 locations in *Ljubljansko polje* aquifer, we collected all last measurements for each of the most important pollutants [5]: *Cr6+*, *deethylatrazine*, *metolachlor*, *nitrates*, *tetrachloroethene* and *tricloroethene*. Because the data on performing additional monitoring was not available, we performed two assessments for each location-pollutant pair – one with additional monitoring assumed and one without. We applied the general model.

From the results we concluded that the state of the aquifer is almost perfect. On all 5 abstraction and 15 observation wells we got the measure of *Regular monitoring* for almost all pollutants, regardless of additional monitoring. However, there were a few exceptions: on location *AMP Mercator V2* with pollutant *deethylatrazine*, on *VD Hrastje 1a* with *deethylatrazine*, on *Hrastje V1* with *tetrachloroethene*, and on *OP-1* with *deethylatrazine*. In the case of *AMP Mercator V2, both* the regulatory margin and unfavorable trend line were breached. The second case *VD Hrastje 1a* indicated problems because of the regulatory margin. The remaining two cases, *Hrastje V1* and *OP-1*, both indicated problem because of the unfavorable trend lines.

5.2 Hrastje model

The evaluation set up was the same as with the previous case. We only collected data for four locations: *Hrastje V1*, *Hrastje V2*, *Hrastje V3* and *Hrastje V4*, and *tricloroethene* as pollutant. We selected it, as it is one of the most important pollutants in *Ljubljansko polje*.

In this case, all evaluations were non-problematic – the DSS suggested *Regular monitoring*. No regulatory margins were breached and no unfavorable trends were identified.

5.3 Expert opinion

We presented every aspect of the DSS to the expert and also all the experiments were discussed. He positively accepted the features and results of the DSS. About the evaluation of the aquifer, based on the DSS's recommendations, he said: "Results are logical and show relatively good chemical status of the aquifer, which in turn ensures the adequacy of the water source for pumping drinking water."

6 CONCLUSION

In this work we developed a decision support system for controlling adequacy of water sources in Slovenia, but with emphasis on the *Ljubljansko polje* aquifer. The work was based on the results of the INCOME [7] project. Two decision models were developed with DEX methodology, one general model and one specific model for *AMP Hrastje* location with pollutant *trichloroethene*. A wrapper program for querying available measurement data and interaction with the models was developed. For easier interaction, a graphical user interface was implemented. Finally, the system was assessed on two test cases: evaluation of the whole aquifer with the general model, and assessment of *AMP Hrastje* location with *trichloroethene* as pollutant. The results were consistent with the expert's expectations and indicated a relatively good state of the aquifer.

In the future work, more specific models need to be created for other locations and pollutants. Also a connection with a geographic information system would be a great advantage to the end-user.

Acknowledgement

The first author thanks his formal B.Sc. thesis advisor Prof. Dr. Andrej Bauer for his suggestions and advice. Part of the study was done in the frame of the project INCOME (LIFE07 ENV/SLO/000725).

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APLIKACIJA E-PEDIUS ZA PODPORO MNOŽIČNEMU SESTAVLJANJU FRAGMENTOV STENSKIH POSLIKAV

Tea Tušar[1]*, Bogdan Filipič*[1]*, Erik Dovgan*[1]*, Blaž Mahnič*[1]*, Gregor Čepin*[1,2]*,*
Jelka Kuret[3]*, Petra Benedik*[3]*, Asparuh Mihailov*[3]*, Gregor Berginc*[4]*, Daniel Vladušič*[4]

[1]Odsek za inteligentne sisteme, Institut "Jožef Stefan", Jamova cesta 39, 1000 Ljubljana
[2]Fakulteta za računalništvo in informatiko, Univerza v Ljubljani, Tržaška cesta 25, 1000 Ljubljana
[3]Restavratorski center, Zavod za varstvo kulturne dediščine Slovenije, Poljanska 40, 1000 Ljubljana
[4]XLAB d.o.o., Pot za Brdom 100, 1000 Ljubljana
E-pošta: tea.tusar@ijs.si

POVZETEK

Restavriranje stenskih poslikav iz ometnih fragmentov je zaradi velikega števila fragmentov, njihovih poškodb in manjkajočih delov težavno in zahteva leta ročnega dela strokovnjakov. Pomemben del tega postopka lahko pohitrimo z vključevanjem množice nestrokovnjakov, saj je sestavljanje fragmentov v prvotno poslikavo podobno igri sestavljanja sestavljank. V prispevku predstavljamo spletno in mobilno aplikacijo e-Pedius, ki je kot igra sestavljanja fragmentov dostopna množici uporabnikov in jim poleg sestavljanja fragmentov v nove postavitve omogoča tudi nadaljevanje postavitev drugih uporabnikov in njihovo ocenjevanje.

1. UVOD

Poslanstvo Zavoda za varstvo kulturne dediščine Slovenije (ZVKDS) je ohranjanje slovenske kulturne dediščine, kar med drugim obsega tudi rekonstrukcijo umetnin, ki so bile uničene zaradi časovnega propadanja, nesreč ali katastrof (potresi in vojne). Na arheoloških najdiščih pogosto najdemo stenske poslikave, ki so pomembni elementi kulturne dediščine, a so večinoma fragmentirane in potrebujejo temeljito obnovo. Restavriranje stenskih poslikav iz ometnih fragmentov je zaradi njihovega velikega števila (tudi več tisoč), različnih oblik in velikosti ter poškodb in manjkajočih fragmentov zelo težavno in zahteva leta ročnega dela strokovnjakov.

Postopek restavriranja fragmentiranih stenskih poslikav obsega naslednje faze:

- odstranjevanje nečistoč in recentnih plasti s fragmentov,
- utrjevanje barvne plasti,
- morebitno preventivno obšivanje ali kitanje kritičnih mest,
- utrjevanje prhkih nosilnih ometov,
- *sestavljanje fragmentov v prvotno poslikavo v peskovniku*,
- nanos zaščitne armature v treh plasteh na lice poslikave,
- odstranjevanje odvečnega ometa s hrbtišča,
- priprava sredstva za armiranje hrbtišča,
- izdelava večplastne armature hrbtišča,
- odstranjevanje zaščitne armature z lica poslikave,
- izdelava nosilca in montaža poslikave na nosilec,
- oblikovanje dekorativnega ometa, kitanje poškodb in prilagajanje kita strukturi površine poslikave,
- tonsko podlaganje in barvno povezovanje poškodovanih mest ter
- retuširanje.

Medtem ko je za večino teh faz neizbežno rokovanje s fizičnimi fragmenti, se lahko faza sestavljanja fragmentov v prvotno poslikavo izvede najprej elektronsko, z digitalnimi slikami fragmentov. Šele ko na ta način najdemo zadovoljivo elektronsko postavitev, fizične fragmente sestavimo skupaj v peskovniku.

Razvili smo dve računalniški aplikaciji, ki podpirata elektronsko sestavljanje fragmentov in tako bistveno pohitrita postopek restavriranja stenskih poslikav. Računalniška aplikacija *Pedius* restavratorjem omogoča digitalizacijo, evidentiranje in pomoč pri sestavljanju fragmentov v prvotno stensko poslikavo [6, 4], medtem ko je spletna in mobilna aplikacija *e-Pedius* zasnovana kot igra, ki sestavljanje fragmentov prepusti množici [3, 2].

V nadaljevanju prispevka se posvečamo le najnovejši aplikaciji e-Pedius. Naslednji razdelek na kratko predstavi dva druga dobro znana primera uporabe množičnega izvajanja, medtem ko 3. razdelek podrobneje opiše vse tri glavne dele aplikacije e-Pedius: sestavljanje, ocenjevanje in profil uporabnika. Prispevek se zaključi s sklepom v 4. razdelku.

2. MNOŽIČNO IZVAJANJE

Izvajanje nekega opravila s strani množice nestrokovnjakov namesto (maloštevilnih in preobremenjenih) strokovnjakov je v računalništvu vedno pogosteje uporabljano; pravimo mu *množično izvajanje* (angl. crowdsourcing). Izmed njegovih številnih primerov praktične uporabe podajamo dva, ki sta posebej razširjena in zanimiva.

Google-ova storitev reCAPTCHA [7, 8] uporablja množično izvajanje za digitalizacijo starih knjig. Uporabniki spleta morajo včasih zato, da dobijo dostop do določene sple-

tne strani, vtipkati besede, ki jih prikazuje slika. Storitev reCAPTCHA za to uporablja skenirane besede iz knjig, ki jih programska oprema za prepoznavanje znakov ni razpoznala. Ko več uporabnikov isto skenirano besedo pretipka v isto besedo, se šteje, da je bila beseda pravilno prepoznana. Na ta način so spletni uporabniki pomagali digitalizirati že številne stare knjige, njihovo število pa se veča vsak dan.

Aplikacija Foldit [5, 1] Univerze v Washingtonu uporablja množično izvajanje za napovedovanje strukture proteinov, ki ima za cilj ustvariti točne modele strukture proteinov. Aplikacija vsebuje tradicionalne računalniške algoritme, ki se uporabijo za iskanje začetnih struktur proteinov. Nato nestrokovnjaki preoblikujejo te strukture tako, da se kakovost modela poveča. Foldit je implementiran kot računalniška igra, ki spodbuja tako tekmovanje kot sodelovanje med uporabniki. Foldit oz. prispevek njegovih uporabnikov je omogočil že nekaj odmevnih prebojnih odkritij na tem področju.

Tudi v primeru sestavljanja fragmentov stenskih poslikav ima množično izvajanje potencial, da poleg nudenja razvedrila uporabnikom (namesto navadnih sestavljank sestavljajo slike fragmentov) poskrbi za napredek – v našem primeru napredek pri restavriranju kulturne dediščine.

3. APLIKACIJA E-PEDIUS

Mobilna in spletna aplikacija e-Pedius, poimenovana po rimskem slikarju Quintusu Pediusu, je dostopna vsem zainteresiranim uporabnikom tabličnih, prenosnih in namiznih računalnikov in tudi nestrokovnjakom omogoča sestavljanje fragmentov v nove postavitve, nadaljevanje sestavljanja obstoječih postavitev in ocenjevanje postavitev. Zasnovana je kot mobilna igra, pri kateri se točkuje prizadevnost uporabnikov, vodi lestvica najboljših in spodbuja sodelovanje med uporabniki.

Trenutno aplikacija vsebuje dva *projekta sestavljanja*, ki sta nadalje razdeljena na več posameznih *nalog sestavljanja*. Prvi projekt imenovan "Štirje letni časi" je testni primer, za katerega poznamo prave postavitve fragmentov, saj smo poslikave digitalno fragmentirali samo za ta namen. Drugi projekt imenovan "Turška mačka" pa je pravi, zelo obsežen in zahteven projekt s številnimi nalogami sestavljanja.

Projekt "Štirje letni časi" Štirje poslikani medaljoni so bili odkriti leta 1985 na stopnišču stanovanjske hiše v Ulici Moše Pijadeja 34 (sedaj Kolodvorska) v Ljubljani, ki je bila predvidena za rušenje. Izpod beležev odkrite stenske poslikave v tehniki olja so bile del dekoracije kasetiranega stopnišča. Vsi štirje medaljoni so bili sneti ter očiščeni beležev in nečistoč, barvna plast je bila utrjena. Odkriti prizori predstavljajo upodobitev štirih letnih časov. Vsak od medaljonov predstavlja svojo nalogo sestavljanja.

Projekt "Turška mačka" Projekt "Turška mačka" je dobil ime po starem gostišču v Celju, pod katerim so leta 1978 odkrili bogato arheološko najdišče iz rimskih časov. Najden bivalni prostor je nastal v prvem stoletju našega štetja in je hkrati del rimskega mesta Celeia. V podolgovatem prostoru velikosti 13×4 m, ki je bil ogrevan s hipokavstom, je bil tlak okrašen s črno-belim mozaikom z enostavnim vzorcem rozet, stene pa so bile bogato okrašene s freskami. Fragmenti so različnih barv (npr. bela, rdeča, zelena, modra, črna in rumena), nekateri vsebujejo motive, kot so živali in rože, razločimo lahko številne različne vzorce. Tudi ometne plasti se med seboj razlikujejo tako po sestavi kot po debelini. Izkopani fragmenti se sedaj nahajajo v Restavratorskem centru ZVKDS v Ljubljani, kjer so že pred leti šli skozi prve faze restavriranja fragmentov. Zaenkrat meri rekonstruirana površina trikrat po približno 200 cm v dolžino in od 30 do 90 cm v širino. Ostalo je še 9521 fragmentov, shranjenih v 166 zabojčkih. Glede na obseg in izredno kakovost poslikave, ki je redka za območje Slovenije, so se odločili, da bi bil smiseln poskus rekonstrukcije preostalih fragmentov in njihova predstavitev.

Fragmenti projekta "Turška mačka" so tako *vzorčasti* (takšni, ki vsebujejo vzorce, črte ali kombinacije barv) kot *enobarvni*. Zaradi velikega števila vseh fragmentov je bilo potrebno sestavljanje razdeliti na več manjših nalog. Strokovnjaki so določili več kot 80 nalog sestavljanja na podlagi vzorčastih fragmentov, medtem ko se za preostalih (več kot 5000) enobarvnih fragmentov ne ve točno, h kateri nalogi sodijo. Zato je aplikacija e-Pedius zasnovana tako, da lahko uporabnik h katerikoli nalogi doda poljubno število barvno ustreznih enobarvnih fragmentov.

V nadaljevanju opisujemo tri glavne funkcionalnosti aplikacije e-Pedius: sestavljanje in ocenjevanje postavitev ter vpogled v profil uporabnika.

3.1. Sestavljanje

Glavna funkcionalnost aplikacije je sestavljanje fragmentov v nove postavitve. Da lahko začne sestavljati, mora uporabnik najprej izbrati projekt in nalogo sestavljanja ter postavitev, s katero bo začel. Na izbiro ima:

- začeti na novo (s prazno postavitvijo),
- nadaljevati katero izmed svojih preteklih postavitev in
- nadaljevati postavitve drugih uporabnikov.

Nadaljevanje postavitev drugih uporabnikov je omogočeno zato, da bi lahko več uporabnikov z medsebojnim sodelovanjem skupaj našlo boljše rešitve kot vsak posebej.

Ko je začetna postavitev izbrana, se uporabniku prikaže zaslon za sestavljanje (glej primer na sliki 1), sestavljen iz platna (glavni sredinski del), levega in desnega žepa ter spodnjega menija. Ker naloge sestavljanja lahko vsebujejo več skupin vzorčastih fragmentov, je levi žep namenjen izbiri takšne skupine fragmentov. Če želi uporabnik k nalogi dodati še enobarvne fragmente[1], se tudi skupine enobarvnih fragmentov prikažejo v levem žepu. Posamezni fragmenti izbrane skupine se pokažejo v desnem žepu.

Uporabnik fragmente iz desnega žepa lahko premakne na platno in jih tam premika in vrti. Dodatne funkcionalnosti na fragmentih, kot so na primer združevanje in razdruževanje

[1]Za več informacij o postopku iskanja podobnih enobarvnih fragmentov glej [2].

fragmentov ter brisanje fragmentov s platna, so mu na voljo preko spodnjega menija. Poleg tega uporabnik lahko približuje in oddaljuje pogled na platno, razveljavlja in ponovno uveljavlja zadnje spremembe, spreminja barvo platna ipd. Ko uporabnik doseže postavitev, s katero je zadovoljen, jo lahko pošlje v ocenjevanje.

3.2. Ocenjevanje

Da lahko razlikujemo med dobrimi in slabimi postavitvami, jih moramo oceniti. Odločili smo se za ocene v obliki od ene (slaba postavitev) do pet zvezdic (dobra postavitev). V testnem projektu "Štirje letni časi" si uporabniki pri ocenjevanju lahko pomagajo s poznanimi pravilnimi postavitvami, medtem ko v projektu "Turška mačka" to ni mogoče. Zato smo za vsak projekt razvili svoj način ocenjevanja.

V projektu "Štirje letni časi" se ocenjevanje izvede avtomatsko. Vsakič, ko uporabnik postavitev pošlje v ocenjevanje, se ta postavitev primerja s pravilno. Bolj kot ji je podobna, boljšo oceno dobi.

V projektu "Turška mačka" vsako postavitev oceni n drugih uporabnikov. Končna ocena se izračuna glede na povprečje teh ocen. Ker želimo uporabnike spodbuditi k čim bolj korektnemu ocenjevanju postavitev drugih uporabnikov, smo vsakemu uporabniku pripisali *karmo*, ki je sorazmerna s kakovostjo njegovega ocenjevanja. Karma uporabnika se povečuje, ko se njegove ocene skladajo z ocenami drugih uporabnikov, in zmanjšuje v obratnem primeru. Od karme uporabnikov je odvisna tudi vrednost n – število uporabnikov, ki morajo oceniti postavitev. Če so neko postavitev ocenili uporabniki z nizko karmo, n za to postavitev povečamo. Slika 2 prikazuje zaslon za ocenjevanje postavitev drugih uporabnikov. Če uporabnik neke postavitve ne želi oceniti, jo lahko preskoči. Ker postavitve ocenjujejo drugi uporabniki, ocenjevanje v tem projektu ni končano v trenutku (kot v projektu "Štirje letni časi").

Ocenjevanje postavitve upošteva samo "pravilnost" postavitve, ne pa tudi števila fragmentov. Ker želimo preko aplikacije e-Pedius pridobiti čim boljše postavitve za obsežne naloge sestavljanja projekta "Turška mačka", število fragmentov v postavitvi upoštevamo pri končnem točkovanju postavitve:

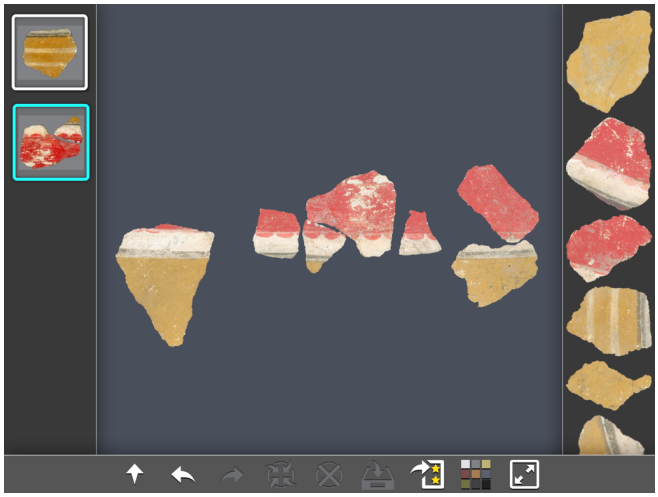
$$\text{število točk} = \text{povprečna ocena} \times \text{število fragmentov}$$

Če je uporabnik nadaljeval postavitev drugega uporabnika, se v zgornji formuli upošteva samo število fragmentov, ki so bili na novo dodani k postavitvi.

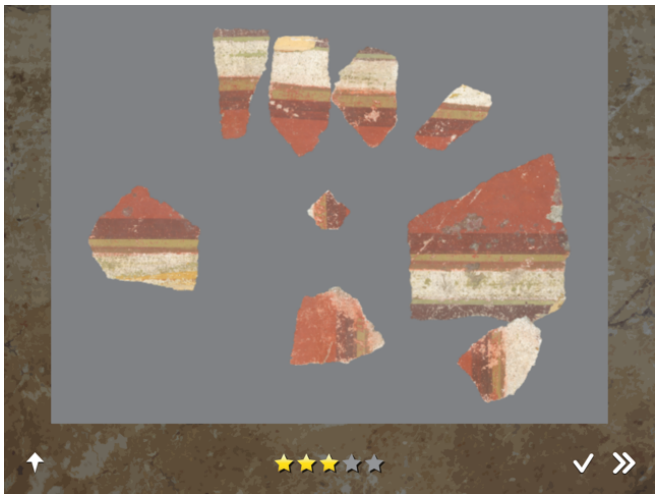
Uporabnik lahko sestavi več postavitev za vsako nalogo. K skupnemu številu točk se šteje le najbolje točkovana postavitev za vsako nalogo. Uporabnik se z drugimi uporabniki lahko primerja na lestvici, kjer so skupaj zbrane točke za oba projekta.

3.3. Profil uporabnika

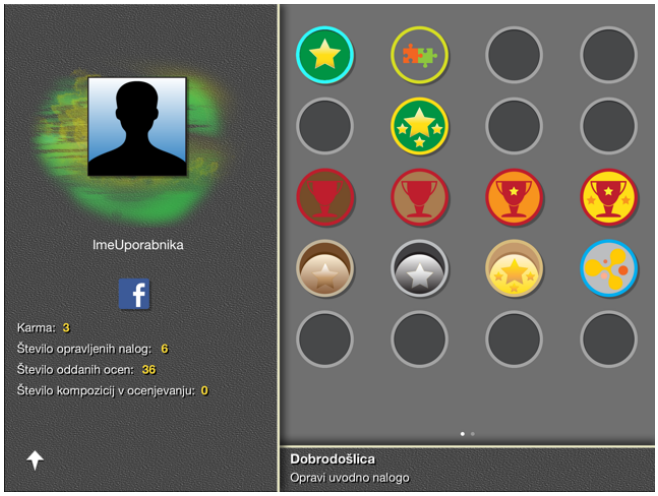
Profil uporabnika na enem mestu združuje informacije o uporabniku in njegovi uspešnosti pri sestavljanju in ocenjevanju



Slika 1: Sestavljanje fragmentov



Slika 2: Ocenjevanje postavitev drugih uporabnikov



Slika 3: Profil uporabnika z doseženimi značkami

postavitev (slika 3). Omogoča mu tudi spreminjanje vzdevka in prijavo v aplikacijo preko računov za Google ali Facebook. Brez prijave lahko uporabnik uporablja vse funkcionalnosti aplikacije, a svojega uporabniškega profila ne more prenašati med napravami.

Na prikazu profila uporabnika so navedene naslednje informacije:

- karma,
- število opravljenih nalog,
- število oddanih ocen in
- število postavitev v ocenjevanju.

Na desni strani zaslona uporabnik lahko vidi bodisi osvojene značke bodisi lestvico vseh uporabnikov glede na skupno število doseženih točk in svoje mesto na njej. Aplikacija omogoča osvojitev 20 značk, ki uporabnika spodbujajo k sestavljanju in ocenjevanju postavitev:

- dobrodošlica (ko opravi uvodno nalogo),
- pridna mravljica 1/2/3/4 (ko opravi 5/10/50/100 nalog),
- začetnik/navdušenec/poznavalec (ko doseže 100/300/500 točk v eni postavitvi),
- ostro oko 1/2/3/4 (ko je 1/5/10/20 postavitev ocenjenih s petimi zvezdicami),
- zlata/srebrna/bronasta medalja (ko na lestvici doseže 5./20./50. mesto),
- nesebičnež 1/2/3 (ko oceni 5/50/500 postavitev drugih uporabnikov),
- super restavrator (ko opravi vse naloge projekta "Turška mačka") in
- nirvana (ko doseže najvišjo možno karmo).

4. SKLEP

V prispevku smo predstavili aplikacijo e-Pedius, ki postopek sestavljanja fragmentov stenskih poslikav približuje množicam. Uporabniki lahko z aplikacijo sestavljajo fragmente v nove postavitve, nadaljujejo postavitve drugih uporabnikov in sodelujejo tudi pri ocenjevanju postavitev. Svoj napredek lahko spremljajo preko lestvice točk in doseženih značk. Poleg nudenja zabave uporabnikom ima aplikacija e-Pedius tudi praktično uporabno vrednost, saj bodo lahko restavratorji tako dobljene najboljše postavitve uporabili za osnovo pri fizični rekonstrukciji danih poslikav.

V prihodnosti želimo v aplikacijo dodati tudi druge projekte sestavljanja, ki bodo istega tipa kot projekt "Turška mačka". To pomeni, da pravilne postavitve fragmentov ne bodo znane in bomo množično izvajanje uporabili za pomoč pri restavriranju poslikav tudi v teh projektih.

Bralce vabimo k sodelovanju pri množičnem sestavljanju fragmentov stenskih poslikav – aplikacija e-Pedius je na voljo na `http://e-pedius.si`.

Zahvala

Opisano delo je bilo opravljeno v okviru projekta e-Pedius, izbranega na javnem razpisu za sofinanciranje projektov razvoja e-storitev in mobilnih aplikacij za javne in zasebne neprofitne organizacije 2012–2013. Projekt so sofinancirali Republika Slovenija, Ministrstvo za izobraževanje, znanost in šport, Evropska unija, Evropski sklad za regionalni razvoj, Institut "Jožef Stefan" in Zavod za varstvo kulturne dediščine Slovenije.

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PREGLED INTELIGENTNIH ALGORITMOV ZA PROCESIRANJE SENZORSKIH PODATKOV

Vedrana Vidulin, Rok Piltaver, Matjaž Gams
Odsek za inteligentne sisteme
Institut »Jožef Stefan«
Jamova cesta 39, 1000 Ljubljana, Slovenija
e-pošta: {vedrana.vidulin, rok.piltaver, matjaz.gams}@ijs.si

POVZETEK

V prispevku je predstavljen pregled inteligentnih algoritmov za gradnjo modelov namenjenih sklepanju iz senzorskih podatkov. Opisi takšnih algoritmov se najbolj pogosto pojavljajo v kontekstu pametnega okolja, v katerem imajo glavno nalogo sklepati o stanju in obnašanju uporabnika. Pregled je motiviran znatnim porastom raziskovalnih aktivnosti na tem področju in se lahko uporabi kot izhodišče za implementacijo inteligentnih algoritmov za procesiranje senzorskih podatkov.

1 UVOD

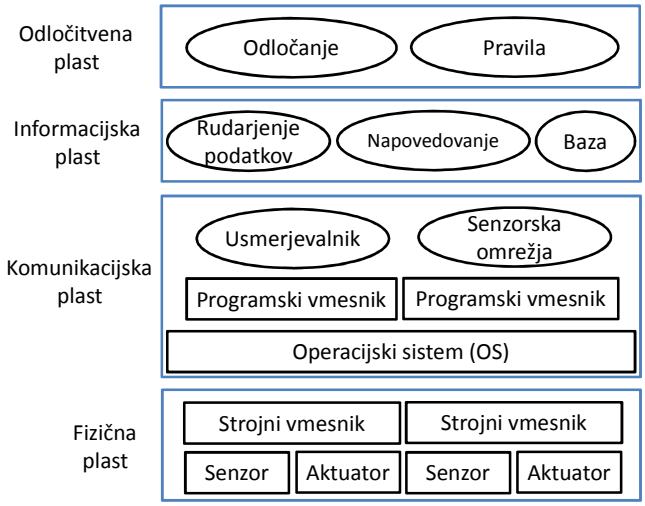
Pametno okolje (ang. smart environment) je krovni pojem, ki vključuje različna področja uporabe inteligentnih algoritmov za procesiranje senzorskih podatkov. V literaturi je pametno okolje opredeljeno kot tisto, ki je sposobno pridobiti znanje o trenutnih okoliščinah in ga uporabiti, da prebivalcem okolja ponudi nove ali izboljšane storitve [12].

Slika 1 prikazuje najbolj razširjeno arhitekturo pametnega okolja [3]. Avtomatizacija v pametnih okoljih poteka kot cikel zaznavanja stanja okolja, sklepanja, ki temelji na zaznanem stanju, odločanja, katere akcije je potrebno izvesti za dosego zaželenih ciljnih stanj, in izvajanja teh akcij.

Zaznavanje okolja je proces, ki poteka od spodaj navzgor: informacije o stanju okolja (npr. zaznana prisotnost pred vrati, prebrani prstni odtis, zaznan dotik kljuke), ki jih sistem pridobi s pomočjo senzorjev (fizična plast), z uporabo komunikacijskih protokolov (komunikacijska plast) shrani v bazo. Algoritmi za sklepanje (informacijska plast) podatke iz baze pretvarjajo v uporabne podatke in znanje, ki je predstavljeno v obliki modela akcij, vzorcev ipd. Na podlagi pridobljenih podatkov in znanja algoritmi za odločanje (odločitvena plast) izbirajo potrebne akcije sistema.

Izvajanje akcij je proces, ki poteka v nasprotni smeri, torej od zgoraj navzdol: izbrane akcije se pošljejo aktuatorjem, ki akcije izvedejo v fizičnemu okolju (npr. odklepanje ključavnice na vratih).

Odločanje je običajno zelo odvisno od domene uporabe in ga ob dobrem razumevanju domene ni težko razviti. Izvajanje akcij je običajno odvisno od dobro dokumentiranih komunikacijskih protokolov in aktuatorjev. Zato teh dveh področij ne bomo obravnavali podrobneje.



Slika 1: *Arhitektura pametnega okolja.*

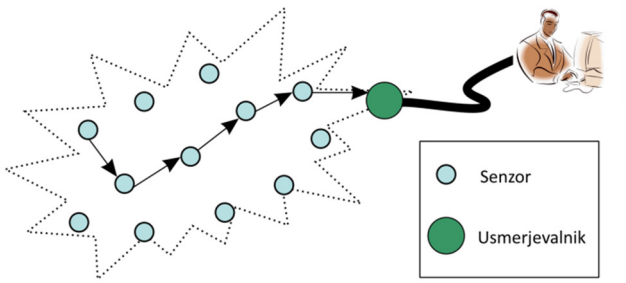
Prispevek se osredotoča na pregled dveh delov pametnega okolja, ki sta tesno povezana s sklepanjem in zahtevata dodatna znanja za implementacijo. Predstavljen je pregled inteligentnih algoritmov za sklepanje, ter senzorskih sistemov, ki se uporabljajo za zbiranje informacij na katerih temelji sklepanje.

2 SENZORSKI SISTEMI

Sistem pametnega okolja informacije o trenutnem stanju pridobi s pomočjo senzorjev, ki so primerno razporejeni v tem okolju. Senzorje je v sistem možno povezati na dva načina. Prvi način je *centraliziran*: senzorji so povezani na centralno procesorsko enoto (CPE), ki zbira in obdeluje podatke iz vseh senzorjev sistema ter opravlja naloge sklepanja in odločanja. V takšnem sistemu so komunikacijska, informacijska in odločitvena plast (Slika 1) implementirane znotraj ene same procesorske enote. Drugi način je *decentraliziran*: t.i. pametni senzorji (ang. motes) zbirajo in obdelujejo podatke lokalno, na CPE pa se

pošljejo že obdelani podatki. V takšnem sistemu so komunikacijska, informacijska in odločitvena plast (Slika 1) lahko razdeljene v različnih razmerjih med pametnimi senzorji in CPE. Razliko med načini povezovanja je mogoče opisati na primeru senzorja pospeška na vratih, ki se npr. uporablja za zaznavanje poskusa udora. V centraliziranem sistemu senzor zazna pospeške v treh med sabo pravokotnih smereh in jih sporoči CPE, ki jih analizira in zazna morebiten poskus vdora. V decentraliziranem sistemu pa pametni senzor sem ugotovi, ali je prišlo do vdora, in CPE pošlje le informacijo o svoji ugotovitvi. V literaturi so decentralizirani pristopi pogosto označeni kot bolj zanesljivi, hkrati pa predstavljajo osnovno za prenos dela inteligentnega procesiranja na vgrajene naprave.

Brezžična senzorska omrežja (BSO, ang. wireless sensor networks) so primer decentraliziranega sistema. Sestavljena so iz skupine pametnih senzorjev, razporejenih v okolju (Slika 2) [1]. Pametni senzorji, kot so opredeljeni s standardom IEEE 1451 [7], so majhni senzorji z nizko porabo energije, ki poleg modula za zaznavanje okolja vsebujejo tudi module za procesiranje zbranih podatkov, sklepanje, odločanje in brezžično komunikacijo. Vsak senzor ostalim komponentam omrežja nudi storitev obveščanja o različnih tipih informacij, ki jih senzor ima na voljo: direktno zaznane vrednosti in rezultati sklepanja na osnovi zbranih podatkov.



Slika 2: *Najbolj pogosta topologija BSO.*

Poglavitna prednost BSO je samoorganizacija komponent omrežja s ciljem izvajanja nalog. Kot primer samoorganizacije lahko navedemo uravnavanje temperature prostora z vklopom klimatske naprave. Za ta namen sistem lahko uporabi temperaturni senzor, postavljen v prostoru. Lahko pa uporabi tudi katerikoli drugi pametni senzor, kot je senzor temperature v mobilnem telefonu, ki se trenutno nahaja v tem prostoru. Prednosti takšnega pristopa so očitne: v primeru okvare enega od senzorjev, lahko njegovo nalogo prevzame drugi senzor.

Omejitev BSO je zahteva po nizki porabi energije in posledično potreba po racionalizaciji procesiranja senzorskih podatkov. Da bi senzorji bili avtonomni, morajo imeti lasten vir napajanja, ki je tipično baterija. BSO imajo zato pogosto vgrajen mehanizem, ki končnemu uporabniku omogoča, da izbere želeno razmerje med časom delovanja komponent BSO in količino ali kakovostjo podatkov, ki jih omrežje daje na voljo. Problem je mogoče rešiti z izbiro primernih algoritmov za procesiranje podatkov znotraj omrežja (npr. zlivanje podatkov - ang. data fusion), ki iz dostopnih senzorjev zahtevajo samo tiste podatke, ki so v dani situaciji nujni za sklepanje in odločanje.

Uporaba BSO v praksi zahteva izbiro skupine senzorjev, ki podpirajo isti standard, ter enega izmed operacijskih sistemov za senzorska omrežja. Uveljavljenih je več standardov, ki specificirajo BSO: WirelessHART, IEEE 1451, ZigBee/802.15.4, ZigBee IP in 6LoWPAN. Obstoječi sistemi, zasnovani na različnih standardih, niso združljivi. Prav tako je na voljo več operacijskih sistemov, prilagojenih delu z BSO. TinyOS je prvi sistem namenjen BSO [4]. Zasnovan je na modelu dogodkovnega programiranja (ang. event-driven programming), pri čemer so programi sestavljeni iz upraviteljev dogodkov in nalog, ki se kontinuirano izvajajo od začetka do konca. V primeru dogodka (npr. podatek je prispel s senzorja, paket podatkov je prispel iz omrežja), TinyOS sporoči primernemu upravitelju, da začasno ustavi kontinuiran proces in obdela prispeli dogodek. Alternativni sistemi so LiteOS [2], Contiki [9] in RIOT [6].

3 INTELIGENTNI ALGORITMI NA SENZORSKIH SISTEMIH

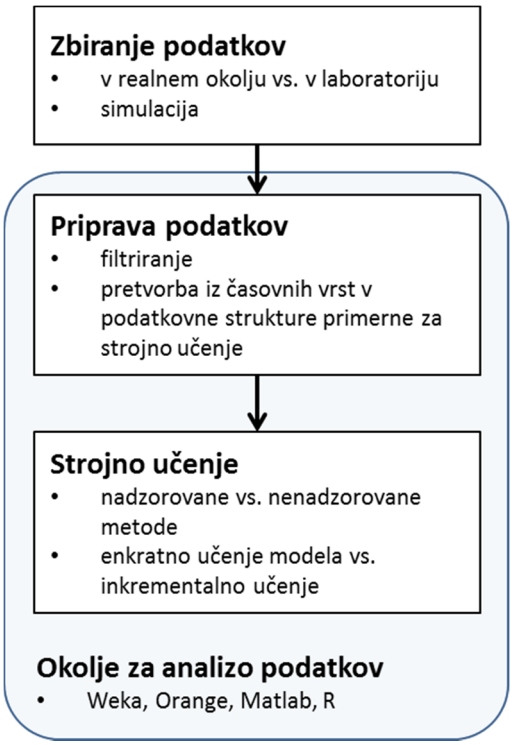
Inteligentni algoritmi se v pametnem okolju uporabljajo predvsem za potrebe modeliranja obnašanja uporabnikov. Točen model obnašanja omogoča, da se okolje bolj prilagodi željam in potrebam uporabnikov, tako npr. ohrani želen nivo varnosti prebivalcev, ali optimizira porabo energije [3]. Namesto modela obnašanja samih uporabnikov se lahko inteligentni algoritmi učijo tudi drugih modelov opazovanega dogajanja, npr. naravni pojavi, delovanje naprav, odvisnosti med zaznanimi dogodki v opazovanem okolju ipd.

Omenjeni algoritmi spadajo na področje odkrivanja zakonitosti v podatkih in (ang. knowledge discovery) in podatkovnega rudarjenja (ang. data mining) oz. širše področje strojnega učenja (ang. machine learning), katerih cilj je iz velike količine podatkov izluščiti zanimive vzorce ali znanje. Najdeni vzorci morajo biti novi, veljavni, uporabni in pogosto tudi razumljivi. Gre torej za sklepanje iz konkretnih primerov na splošne zakonitosti ali pravila (indukcija).

Gradnja modela poteka v treh korakih (Slika 3): 1) zbiranje podatkov; 2) priprava podatkov za strojno učenje; 3) gradnja modelov z različnimi algoritmi in izbira algoritma strojnega učenja, ki je najbolj primeren za določeno problemsko domeno.

Zbiranje podatkov poteka v realnem okolju ali v laboratoriju. Npr. podatke o prihodih in odhodih prebivalcev lahko zberemo tako, da senzorje namestimo na vhod v stanovanje ali iste senzorje namestimo na vratih v laboratoriju. Prvi pristop ponuja bolj realne podatke, drugi pa pogosto omogoča lažjo implementacijo in boljši nadzor nad kakovostjo zbranih podatkov. Poleg zbiranja dejanskih

podatkov s senzorji je mogoče potrebne podatke tudi simulirati, če imamo na voljo dovolj natančen simulator – ta možnost je običajno najhitrejša in najcenejša.



Slika 3: *Koraki gradnje modela.*

Priprava podatkov zajema obdelavo surovih senzorskih podatkov z metodami za filtriranje in pretvorbo iz časovnih vrst v podatkovne strukture (npr. ang. attribute value description, items vectors), ki so primerne kot vhod za algoritme strojnega učenja. S *filtriranjem* se odpravlja šum iz senzorskih podatkov. Primeri filtrov so nizkopasovni (ang. low-pass) in visokopasovni (ang. high-pass) filter, tekoče povprečje in tekoča mediana ter Kalmanov filter. Nizkopasovni filter zmanjša ali odstrani vpliv naglih sprememb v vrednostih senzorskih podatkov. Visokopasovni filter nasprotno poudarja nagle spremembe v vrednostih. Tekoče povprečje je primerno za glajenje signala zaradi konstantnega šuma, medtem ko je tekoča mediana primerna za odstranjevanje občasnih večjih napak v izmerjenih vrednostih. Kadar je mogoče analitično opisati pričakovan potek merjenega signala kot linearen dinamičen sistem, je smiselno uporabiti Kalmanov filter, ki zagotavlja statistično optimalno filtriranje šuma, če je le ta Gaussov.

Algoritmi strojnega učenja gradijo modele iz podatkovnih struktur v obliki tabele, v kateri so vrstice (ang. instances) primeri dogodkov (npr. vstop) in stolpci značilke (ang. attributes, features), ki opisujejo lastnosti posameznega dogodka. Najbolj pogost pristop za pretvorbo signala iz časovne vrste v obliko primerno za strojno učenje je z uporabo *tehnike drsečega okna* (ang. sliding-window technique), pri čemer se določi časovno okno (npr. 1 sekunda), v katerem vse izmerjene vrednosti (podatki iz senzorja) predstavljajo podatke za izračun značilk enega primera dogodka. Časovna okna se lahko tudi prekrivajo: npr. druga polovica predhodnega okna hkrati predstavlja prvo polovico naslednjega okna. V tem primeru se tehnika imenuje *tehnika prekrivajočega drsečega okna* (ang. overlapping-sliding-window technique). Za vsak primer se izračunajo značilke, kot so povprečje, mediana, standardna deviacija, minimalna in maksimalna vrednost, število lokalnih ekstremov (minimumov, maksimumov), strmina linearne interpolacije, ujemanje s pričakovanim potekom signala na podlagi evklidske razdalje ali dinamičnega ukrivljanja časa (ang. dynamic time-warping) ipd.

Algoritme strojnega učenja lahko razdelimo na *nadzorovane* (ang. supervised) in *nenadzorovane* (ang. unsupervised). Pri nadzorovanemu učenju so znane vhodne (atributi) in izhodne vrednosti (razred), cilj pa je poiskati preslikavo med njimi oz. model. V primeru, da želimo zgraditi model za napovedovanje nenavadnosti vstopa osebe v nadzorovani prostor, mora biti vsak primer dogodka vstopa (vhodne vrednosti določene z vrednostmi značilk) označen kot običajen ali nenavaden (izhodna vrednost). V tem primeru bi bil cilj algoritma strojnega učenja zgraditi model, ki bo čim bolj točno napovedal, ali je vstop običajen ali navaden, na osnovi podanih vrednosti značilk za prej še ne videne primere. Značilka z izhodno vrednostjo oz. oznako nenavadnost vstopa se imenuje *ciljna vrednost* (ang. target value). Če je ta značilka diskretna, se proces učenja in uporabe modela za napovedovanje imenuje *klasifikacija*. V nasprotnem primeru, ko je ta značilka numerična, se proces imenuje *regresija*. Pri nenadzorovanemu učenju ciljna vrednost ni določena. Tipična tehnika, ki se uporablja, je *gručenje* (ang. clustering). V primeru prepoznavanja nenavadnosti vstopov lahko zgradimo model tudi če ne poznamo ciljne vrednosti. V ta namen se izračuna podobnost novega dogodka s preteklimi dogodki vstopa določene osebe: če oseba vstopi na način, ki je se dovolj razlikuje od preteklih vstopov te osebe, se dogodek označi kot nenavaden sicer pa kot običajen. Med nenadzorovane metode spada tudi iskanje asociacijskih pravil (ang. association rules), kjer je cilj najti relacije, ki se pogosto pojavljajo v učnih podatkih in držijo z veliko verjetnostjo. Ko gre za podatke v obliki časovnih vrst (ang. time-series), pa se za nenadzorovano učenje uporabljajo metode za iskanje časovnih vzorcev (ang. sequential patterns).

Model je mogoče zgraditi *enkrat samkrat pred začetkom uporabe le-tega* (ang. batch learning). Druga možnost pa je pristop z *inkrementalnim učenjem* (ang. incremental learning), kjer se model po zaznavi vsakega novega dogodka osveži in na ta način zajame tudi nove vzorce. Prednost prvega pristopa je, da v fazi delovanja sistema ni obremenjen z dodatnimi operacijami nujnimi za posodabljanje modela. Slabost pa je, da v primeru spremembe vzorcev obnašanja sklepanje in napovedovanje na osnovi starega modela ni več točno in lahko povzroči izbiro neprimernih akcij sistema.

Za primerjavo primernosti različnih algoritmov strojnega učenja na določeni problemski domeni se običajno uporablja okolje za analizo podatkov, kot je WEKA (Waikato Environment for Knowledge Analysis) [11], Orange [5], Matlab [10], ali R [8]. Našteti programski paketi omogočajo pripravo podatkov, gradnjo klasifikacijskih in regresijskih modelov, gručenje, asociacijska pravila, vizualizacijo podatkov in modelov, ter evaluacijo zgrajenih modelov in primerjanje uspešnosti različnih algoritmov strojnega učenja. Weka in Orange za večino od teh nalog ponujata grafični uporabniški vmesnik. Vsi od naštetih paketov pa ponujajo programske knjižnice v različnih programskih jezikih: Weka-Java, Orange-Python, Matlab-Matlab, R-R, ki jih je možno uporabiti v lastnih implementacijah inteligentne programske opreme.

4 ZAKLJUČEK

V članku je predstavljen pregled inteligentnih algoritmov, ki se uporabljajo za sklepanje iz senzorskih podatkov. Jedro prispevka predtavlja pregled dobrih praks na področjih senzorskih sistemov in inteligentnih algoritmov na način, da se rezultati lahko uporabijo kot izhodišče za implementacijo teh algoritmov v konkretni aplikaciji.

Pri senzorskih sistemih se priporoča decentralizirani pristop brezžičnih senzorskih omrežij. Priporočen pristop je bolj zanesljiv in omogoča lažjo nadgradnjo z naprednimi storitvami z večjo dodano vrednostjo. Pri izbiri senzorjev omrežja je treba biti pozoren na to, da se izberejo senzorji, ki podpirajo isti standard, ter na izbiro operacijskega sistema, ki podpira želene lastnosti.

Pregled inteligentnih algoritmov v prispevku je osredotočen na postopke od zajemanja podatkov iz senzorjev do gradnje in uporabe modelov, ki se uporabljajo za delovanje pametnega okolja. Podani so primeri okoliščin, v katerih so omenjeni algoritmi primerni, in reference na zbirke opisanih inteligentnih algoritmov.

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VMESNIK ZA POVEZAVO SIMULIRANEGA SISTEMA STAVBNE AVTOMATIKE Z VEČ AGENTNIM SISTEMOM VODENJA

Domen Zupančič[1,2], Matjaž Gams[3],Mitja Luštrek[3]
Mednarodna Podiplomska šola Jožefa Stefana, Jamova39, 1000 Ljubljana, Slovenija[1]
Robotina d.o.o., OIC-Hrpelje 38, SI-6240 Kozina, Slovenija[2]
Inštitut Jožef Stefan, Jamova 39, SI-1000 Ljubljana, Slovenija[3]
e-mail: {domen.zupancic, matjaz.gams, mitja.lustrek}@ijs.si

POVZETEK

Uporaba metod umetne inteligence je ključna pri sodobnih sistemih vodenja pametnih hiš. Cilji vodenja so nasprotujoči: doseganje čim manjša porabe energije na eni strani in čim večja stopnja udobja na drugi strani. Umetna inteligenca se pojavlja na več stopnjah: upravljanje senzorskih omrežij, luščenje podatkov iz množice senzorjev, uporaba strojnega učenja za izdelavo modelov napovedovanja (npr. prisotnosti) ali za izdelavo dinamičnih modelov sistema (npr. dinamični model spreminjanja temperature v prostoru), več agentni sistemi. Predstavljeni vmesnik za povezavo simulacijskega sistema z več agentnim sistemom za vodenja omogoča vpeljavo metod umetne inteligence v pametno stavbo na modularen način.

1 UVOD IN SORODNO DELO

Sistemi stavbne avtomatike (BAS - Building Automation System), še posebno vodenje takšnih sistemov (BEMS - Building Energy Management Systems) je zelo interesantna tema, saj za razliko od preteklih let te tehnologije bolj in bolj prodirajo na trg tudi za privatna stanovanja. Centralni nadzorni sistemi se uporabljajo že dalj časa, posebno v poslovnih prostorih in v objektih zahtevnejših in predvsem premožnejših lastnikov.

Poleg transparentnega pregleda delovanja sistemov in interakcije z uporabnikom, sodobni sistemi s pomočjo zmogljivih računalniških sistemov omogočajo zahtevnejše pristopke k vodenju tako enostavnih, še posebej pa kompleksnih sistemov, kjer gre za vodenje množice naprav - aktuatorjev na podlagi informacij, ki jih zbira množica senzorjev.

Problemi, ki jih morajo reševati sistemi vodenja v stavbah so: energija, udobje in zanesljivost vodenja. Pregled takšnih sistemov je izvedel Dounis et al. [1] in poudarja, da je umetna inteligenca pri vodenju eden izmed ključnih pristopov k učinkovitemu vodenju, poleg tega pa omogoča vključitev uporabnika v sistem vodenja. Veliko je bilo izdelanih študij, kjer so uporabljali agentni pristop k vodenju sistemov, posebno na področju upravljanja stavb [5], upravljanja obremenitev električnih omrežij [6], upravljanja porabe virov [7], upravljanje senzorskih omrežij [8], idr.

V prispevku bo prikazana združitev simulacijskega sistema in sistema vodenja s programskimi agenti. Simulacijski model je izdelan v programu EnergyPlus[2], sistem vodenja je izdelan v okolju JADE [3], simulacija pa teče v okolju BCVTB [4].

2 SIMULACIJSKI MODEL SISTEMA

Simulacijski model sistema vsebuje fizikalni model zgradbe, izdelan v programskem okolju EnergyPlus. EnergyPlus model zgradbe vsebuje simulacijske parametre, kot so: časovni korak, časovni okvir simulacije, katerega priredimo glede na podatke o vremenu in podatke o prisotnosti (podatki morajo biti datumsko in časovno usklajeni), podatke o lokaciji objekta, konstrukcijske podatke o materialih oken, sten, stropov in pripadajoče parametre podatke o izolaciji, geometrijske podatke ter podatke o orientaciji objekta glede na smer neba, podatke o notranji opremi posameznih prostorov - pohištvo, podatke o električnih napravah in močeh delovanja, parametre termostatov posameznih grelnih teles v povezavi s sistemom HVAC z pred nastavljenimi vrednostmi, parametri posameznih grelcev ter nastavitve za izmenjavo podatkov z zunanjimi programi, kot so BCVTB in formate poročil ob koncu simulacije. Poleg tega model vsebuje tudi parametre regulatorjev, na podlagi katerih EnergyPlus regulira stanja sistema glede na želene vrednosti in glede na vrednosti stanj v prejšnjem časovnem koraku. EnergyPlus torej izvaja regulacijo in simulacijo. Težava, s katero se soočamo, je nastavljanje želenih vrednosti v pravem časovnem trenutku, čimer pravimo vodenje sistema.

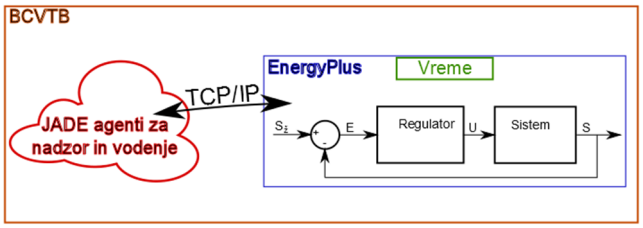
3 POVEZAVA SIMULACIJSKEGA SISTEMA Z AGENTNIM SISTEMOM VODENJA

Regulacija in vodenje enostavnega sistema je shematično prikazano na sliki 1, kjer je Sž želena vrednost stanja, S je dejanska vrednost stanja, E je razlika med dejansko in želeno vrednostjo stanja (napaka).

Modri okvir predstavlja simulacijski del, rdeči oblak predstavlja agentno arhitekturo za vodenje in nadzor sistemov, vse skupaj pa se nahaja v simulacijskem okolju BCVTB, ki združuje oba sistema. Komunikacija med EnergyPlus modelom sistema in med več agentnim

sistemom vodenja poteka preko TCP/IP komunikacijskih vtičnic, ki skrbijo za zanesljivo povezavo. Zanesljiva povezava je najbolj pomembna zaradi časovne sinhronizacije. Vsak časovni korak:

- EnergyPlus izračuna stanja sistema in jih posreduje agentom
- agenti izračunajo želena stanja in jih vrnejo modelu EnergyPlus

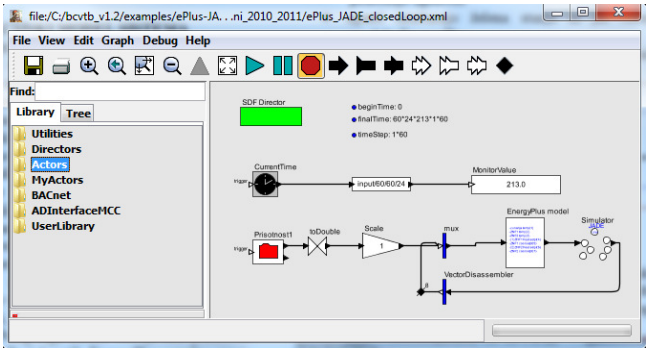


Slika 1: Povezava sistema vodenja s simulacijskim sistemom

BCVTB skrbi za komunikacijo v primernih časovnih trenutkih. Simulacijsko okolje BCVTB je izdelano za programsko okolje Ptolemy II [12], v katerem modul "Simulator" skrbi za vzpostavitev povezave zunanjega programa in za komunikacijo.

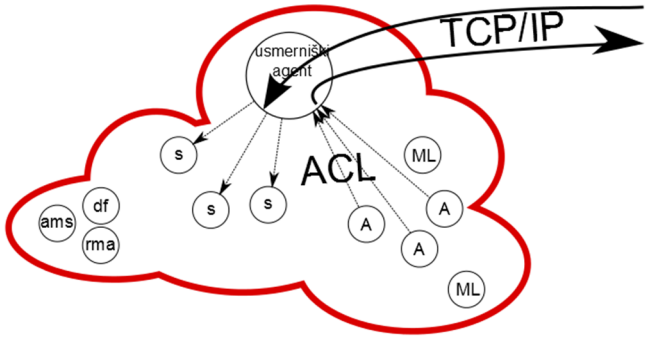
3.1 Usmerniški agent

Usmerniški agent je izdelan za transformacijo sporočil iz TCP/IP protokolnega sklada v ACL sporočila in je izdelan po vzoru, ki ga je predstavil Wetter [4] za ko-simulacijo z drugimi programi (EnergyPlus, Matlab, Dymola,...) ter predstavlja vlogo usmerjevalnika. Ob zagonu simulacije na shemi, ki je predstavljena na sliki 2, vsak od modulov "EnergyPlus model" in "Simulator JADE" izdela pripadajočo konfiguracijsko datoteko, v kateri zapiše podatke o gostitelju in vratih ter izdela strežniško vtičnico. Zatem kliče pripadajoč program - odjemalec, kateri uporabi zgoraj zapisano datoteko za izdelavo odjemalčeve vtičnice. Odjemalec se izvaja, dokler ne pride do napak ali do konca simulacije.



Slika 2: Ko-simulacija: EnergyPlus model sistema in vodenje z JADE agenti v okolju BCVTB

Usmerniški agent posreduje stanja simuliranega sistema EnergyPlus senzorskim agentom. Senzorski agenti posredujejo informacije aktuatorskim agentom. Aktuatorski agenti pa glede na algoritem vodenja vračajo želene vrednosti (eng. set-points) preko JADE usmerniškega agenta simuliranemu sistemu EnergyPlus. EnergyPlus na podlagi modela sistema izračuna nova stanja sistema in simulacijski korak se zaključi. Podrobnejši prikaz oblaka agentov je prikazan na sliki 3. Poleg treh agentov AMS, DF in RMA, ki so nujni za delovanje JADE platforme, se v oblaku nahajajo še senzorski agenti (S), aktuatorski agenti (A), agenti za strojno učenje (ML) in usmerniški agent. Vsi agenti med seboj lahko komunicirajo z uporabo Agentnega Komunikacijskega Jezika (eng. Agent Communication Language - ACL), ki je definiran v FIPA specifikacijah [13].



Slika 3: Usmerniški, senzorski, aktuatorski, ML in JADE agenti

Usmerniški agent preko ACL sporočil komunicira samo z senzorskimi in aktuatorskimi agenti, ki so opisani v naslednjih podpoglavjih. Med pripravo simulacijskega sistema je potrebno definirati povezave med stanji, ki jih oddaja EnergyPlus in senzorji. V ta namen moramo kreirati datoteko *variables_mapping.cfg*, ki ima XML strukturo, prikazano na sliki 4, v kateri se vidi primer povezave dveh aktuatorskih agentov *jadename* s spremenljivko *bcvtbname*, definirano v EnergyPlus in dveh senzorskih agentov *jadename* s spremenljivko *bcvtname*. Vir aktuatorskih spremenljivk - *source* je v usmerniškemu agentu (*JadeGateway*), medtem ko je vir senzorskih spremenljivk v simulatorju EnergyPlus (BCVTB, *Ptolemy*).

Velikost vhodnega oziroma izhodnega vektorja modulov, prikazanih na sliki 2, je odvisna od števila senzorjev in aktuatorjev in je skladna s konfiguracijsko datoteko, opisano zgoraj. Ravno tako pa je odvisna velikost BSD sporočila med usmernikom in simulatorjem, ki se izmenjuje preko TCP/IP komunikacijskih vtičnic. Format BSD sporočila katerega usmerniški agent prejme oziroma pošlje je definiran na spletni strani [13] in vsebuje naslednje vrednosti, ločene s presledkom:

- verzija okolja Ptolemy,
- zastavica, ki govori o tipu sporočila (normalna operacija, konec simulacije, napaka),
- število vrednosti tipa *double*,
- število vrednosti tipa *integer* (vedno 0),
- število vrednosti tipa *boolean* (vedno 0),
- simulacijski čas v sekundah,
- vrednosti tipa double
- konec, določen z znakom "\n".

3.2 Senzorski agent

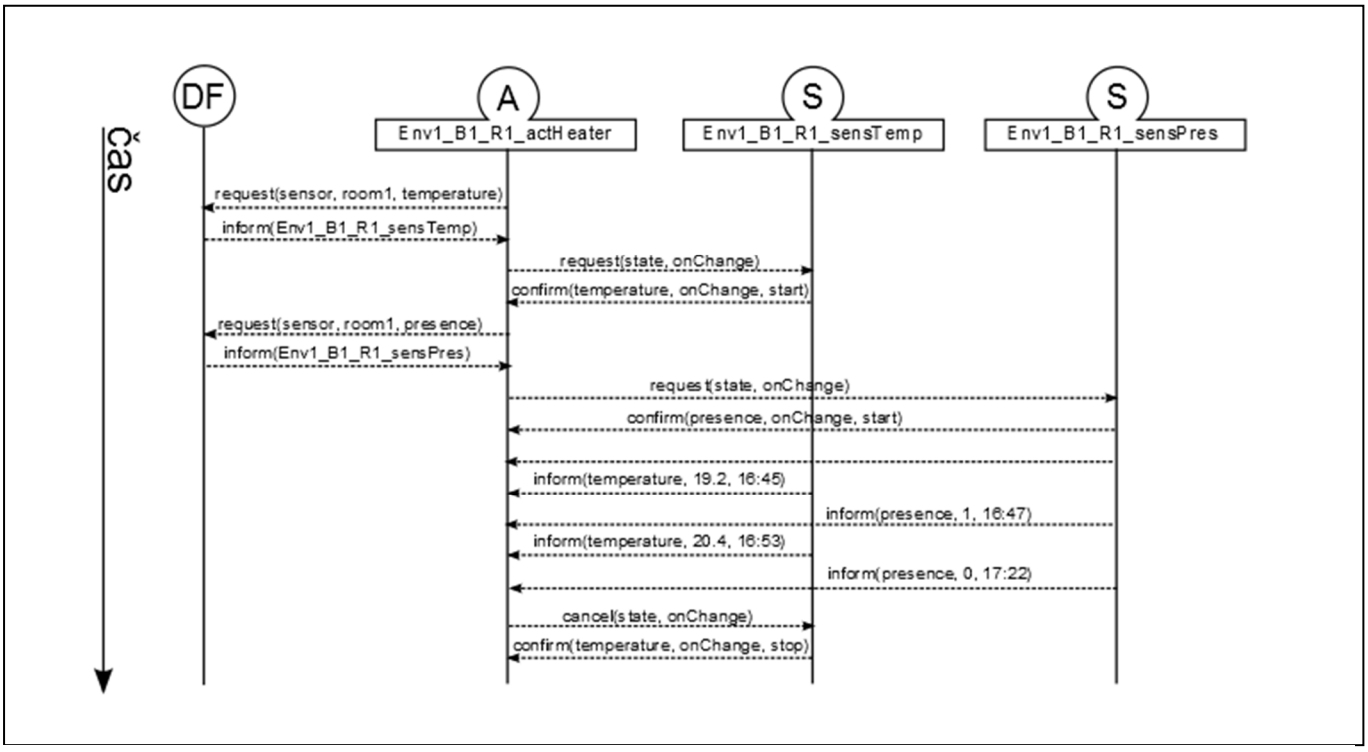
Senzorski agent (v nadaljevanju senzor) ima vlogo računalniškega predstavnika fizične naprave - senzorja. Ima dve nalogi: Prejemanje informacij o stanjih sistema (temperatura, vlaga, prisotnost, itd.) od simulatorja preko usmerniškega agenta in posredovanje teh informacij agentom, kateri te informacije zahtevajo ali s katerimi ima sklenjeno pogodbo o obveščanju. Pogodbe sklepajo z aktuatorskimi agenti, ki zahtevajo informacije v vsakem simulacijskem trenutku.

3.3 Aktuatorski agent

Aktuator vsebuje več možnih stanj, vendar ima v vsakem stanju nalogo, da v vsakem časovnem trenutku izračuna

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<BCVTB-variables>
<!-- The next elements receive the variables from JADE gateway - setpoint values -->
       <variable source="JadeGateway">
              <JadeGateway bcvtbname="TSetHeat1" jadename="Env1_B1_Room1_ActHeater"/>
       </variable>
       <variable source="JadeGateway">
              <JadeGateway bcvtbname="TSetCoo1" jadename="Env1_B1_Room1_ActChiller"/>
        </variable>
       .....
<!-- The next elements send the sensor states from BCVTB (EnergyPlus) to JadeGateway -->
       <variable source="Ptolemy">
              <JadeGateway bcvtbname="ENVIRONMENT" jadename="Env1_OutdoorTemperature"/>
       </variable>
       <variable source="Ptolemy">
              <JadeGateway bcvtbname="ZSF1" jadename="Env1_B1_Room1_SensTemp"/>
       </variable>
       .....
</BCVTB-variables>
```

Slika 4: *Izsek iz konfiguracijske datoteke variables_mapping.cfg, ki povezuje spremenljivke stanja s senzorskimi agenti in želene vrednosti z aktuatorskimi agenti*



Slika 4: *Časovni potek iskanja primernih senzorjev s pomočjo DF agenta, sklepanje pogodb med senzorji in aktuatorji, obveščanje senzorjev o stanjih ter prekinitev pogodbe*

želeno vrednost. Mogoča so različna stanja, ki predstavljajo algoritme vodenja, kot so: urnik, vključeno, izključeno, glede na trenutno senzorsko stanje enega senzorja in s pravili, glede na klasifikacijski model in trenutna senzorska stanja več senzorjev, itd. Na začetku stanja, v katerem se agent pojavi, s primernimi senzorji, katere pridobi preko DF agenta, sklene pogodbo o obveščanju. Vsak časovni korak v simulaciji tako pridobi informacije o senzorskih vrednostih in glede na algoritem stanja priredi aktuatorske vrednosti, ter jih preko usmerniškega agenta pošlje simulatorju. Slika 5 prikazuje časovno zaporedje sporočil, med aktuatorjem, DF agentom in dvema senzorjema. Aktuator potrebuje za delovanje podatke o prisotnosti in temperaturi. Najprej pri DF agentu dobi imena senzorskih agentov, ki nudijo te informacije. Potem z vsakim od teh senzorjev sklene pogodbo o obveščanju. Ko ne potrebuje več informacij, prekine pogodbo.

3.4 ML agent

ML agent je namenjen strojnemu učenju. Kadar aktuator za svoje delovanje potrebuje klasifikacijski model, sporoči ML agentu vir informacij, na osnovi katerih naj bo klasifikacijski model zgrajen. ML poišče informacije, zgradi model in aktuatorju vrne lokacijo datoteke. Aktuator potem ta model uporabi v algoritmu za izračunavanje želenih vrednosti.

4 ZAKLJUČEK

Sistem smo preizkusili z simulacijskim modelom stanovanjske stavbe, pridobljenim z okoljem BCVTB, ki smo ga modificirali za naše potrebe. V simulacijo sistema smo vključili podatke o prisotnosti uporabnika stanovanja [9,10] in vremenske podatke za Ljubljana-Brnik za obdobje 2010-2011. Sistem deluje zanesljivo in omogoča modularno združevanje simulacijskih modelov z več agentnimi sistemi vodenja.

Zahvala

"Operacijo delno financira Evropska unija, in sicer iz Evropskega socialnega sklada. Operacija se izvaja v okviru Operativnega razvoja človeških virov za obdobje 2007 - 2013, 1. razvojne prioritete: Spodbujanje podjetništva in prilagodljivosti, prednostne usmeritve 1.1.: Strokovnjaki in raziskovalci za konkurenčnost podjetij."

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PROJEKT ACCUS: ADAPTIVNA KOOPERATIVNA KONTROLA URBANIH PODSISTEMOV

Jernej Zupančič, Boštjan Kaluža, Matjaž Gams
Institut Jožef Stefan – Odsek za inteligentne sisteme
Jamova cesta 39, 1000 Ljubljana
E-pošta: {jernej.zupancic, bostjan.kaluza, matjaz.gams}@ijs.si

POVZETEK

V prispevku je predstavljen mednarodni projekt ACCUS, v sklopu katerega bomo razvili platformo za medsebojno povezovanje in sodelovanje urbanih podsistemov, kot so javna razsvetljava, oskrba z energijo, nadzor in upravljanje prometa itd. Z optimizacijo procesov, ki se tičejo več podsistemov, bomo dosegli zmanjšanje porabe energije in onesnaževanja okolja, zmanjšali stroške obratovanj mest itd. Omogočili bomo tudi simulacije dogodkov, ki zajemajo več podsistemov hkrati.

1 UVOD

Javna razsvetljava, javni prevoz, oskrba z energijo (elektrika, toplovod in plin), javni vodovod in nadzor prometa z video kamerami so samo nekateri izmed obsežnih sistemov v modernih mestih. Omenjeni sistemi delujejo neodvisno drug od drugega, čeprav bi s sodelovanjem lahko bistveno izboljšali tako svoje delovanje kot tudi delovanje mesta kot celote. Sistem za upravljanje s signalizacijo v prometu, ki bi upošteval podatke o vremenu (ko dežuje, ljudje vozijo počasneje) ter stanju na cestah (iz slik za video nadzor prometa, bi lahko razbral, kje je gneča in katere ceste niso prometne), bi lahko bolje usmerjal promet – sistemi za navigacijo bi predlagali alternativno pot, semaforji v križiščih pa bi promet prepuščali glede na obremenjenost cest (smer, ki je bolj obremenjena, ima dlje časa zeleno luč). To bi zmanjšalo čas potovanja udeležencev v prometu, znižalo porabo energije za pogon vozil in s tem onesnaženost zraka itd.

Naprave v sistemih je potrebno povezati in jim omogočiti komunikacijo in dostop do podatkov drugih naprav. Le tako bodo lahko sodelovale med sabo in ponujale najboljše rešitve, ki bi uporabnikom olajšale življenje. Nekatere naprave so že sedaj povezane v sisteme, ki jim bomo rekli podsistemi. Primeri podsistemov so pametne hiše, sistemi za učinkovito izrabo energije v zgradbah in prej omenjeni energetski sistemi, javna razsvetljava, javni prevoz in nadzor prometa, informacijski sistemi, sistemi za pomoč pri nesrečah itd. Ti podsistemi običajno niso povezani med sabo. Glavni nalogi projekta ACCUS (ang. **A**daptive **C**ooperative **C**ontrol in **U**rban (sub) **S**ystems) sta: vzpostaviti platformo, ki jo bodo sestavljali obstoječi podsistemi, in omogočiti komunikacijo med podsistemi.

Prispevek je sestavljen sledeče: v razdelku 2 predstavimo sorodno delo in omenimo uporabna raziskovalna področja za projekt ACCUS, v razdelku 3 natančneje opišemo koncepte projekta ACCUS in arhitekturo platforme, ki bo v času projekta nastala, v razdelku 4 zaključimo sestavek.

2 SORODNO DELO

Povezava podsistemov je že bila predmet preteklih in tekočih projektov, ko so raziskovalci med sabo združili nekaj storitev različnih podsistemov. Primeri so npr. projekt SAMURAI [2], za razvoj inteligentnega sistema za nadzorovanje z video kamerami, projekt eDIANA [3], za upravljanje energetskih sistemov, projekt ME3GAS [4], za omogočanje nadzora nad energetsko porabo naprav, projekt SEAM4US [5], na podlagi katerega so razvili metode za učinkovito delovanje sistemov prezračevanja, razsvetljave in delovanja vlakov podzemne železnice v Barceloni.

Projekt ACCUS bo uporabil ugotovitve na različnih raziskovalnih področjih, kot so:

- sistemi nadzorovanja [6], pri čemer je potrebno upoštevati kompleksno in razširjeno strukturo sistemov [7],
- sistemi upravljanja, kjer je pomembna povezava med fizičnim svetom in napravami [8] in možnost povezovanja v velike sisteme, kar je bilo opazovano pri projektu EMMON [9],
- povezani večagentni sistemi, ki omogočajo učinkovito razdeljevanje nalog [10, 11],
- ugotavljanje vzorcev obnašanja in lastnosti pojavov v nekem okolju ter obravnava številnih možnih situacij [12],
- prilagodljivost sistemov, kar bo omogočalo hiter in kvaliteten odgovor na nepričakovane dogodke, ki se v realnosti pogosto dogajajo in
- prilagodljivo iskanje rešitev – za obstoječe algoritme za iskanje rešitev se običajno predhodno ve, kako bodo uspešni ter koliko časa bodo potrebovali za izračun, pri projektu ACCUS pa bi radi obravnavali situacije, ko se bo moral sistem sam odločiti, ali je bolj pomemben hiter izračun ali kvaliteta iskane rešitve [13, 14].

2.1 Sistem sistemov

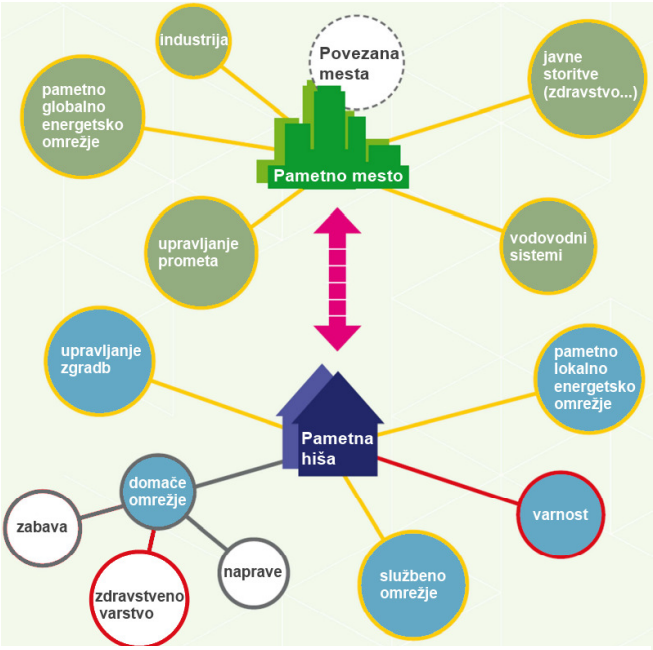
Pri projektu ACCUS se nimamo namena ukvarjati s posameznimi podsistemi, temveč želimo ustvariti okolje, v

katero bo mogoče obstoječe podsisteme zlahka vključiti. Ideja se sklada Maierjevo teorijo Sistema sistemov [15]. Maier je definiral lastnosti Sistema sistemov:

1. neodvisno delovanje – vsak podsistem lahko deluje neodvisno od drugih, ima svoj cilj in je uporaben,
2. samostojno upravljanje – vsak podsistem vodi drug organ in
3. neodvisen razvoj – vsak podsistem se razvija in raste neodvisno od drugih.

Poleg tega so podsistemi tudi geografsko različno razporejeni in imajo zaradi njihove neodvisnosti različne vzorce obnašanja [16]. Dodatne lastnosti po DeLaurentisu [17] so še: heterogenost (področja delovanja podsistemov so različna), zmožnost tvorjenja medsebojnih povezav ter interdisciplinarnost (za uspešno delovanje je potrebno povezovanje ugotovitev iz različnih ved, kot so inženirstvo, ekonomija itd.). Primere uporabe Sistema sistemov običajno najdemo v vojski [18], prometu – inteligenta vozila (C2C [19]), pametnih domovih (SmartHome [20]) in pri ambientalni inteligenci [21]. Teorija Sistema sistemov se torej ukvarja s povezovanjem podsistemov v celoto, kar omogoča novo funkcionalnost, ki je noben podsistem sam ne more doseči. Vse to je popolnoma v skladu z idejami projekta ACCUS.

Primer povezave različnih sistemov je prikazan na sliki 1.



Slika 1: Pametne hiše in skupnosti prihodnosti, iz [22]

Slika 1 prikazuje nekaj podsistemov (pametno globalno energetsko omrežje, vodovodni sistem, upravljanje prometa, javne storitve itd.), ki so del modernega mesta. Projekt ACCUS želi te podsisteme združiti v skupni Sistem sistemov, kar bi omogočalo Pametno mesto. Poleg javnih podsistemov želimo v Pametno mesto vključiti tudi uporabnike. Vsak dom, ki ga že sestavljajo sistemi za energetsko učinkovito porabo energije, sistemi za zabavo (domači kino, igralni sistemi) itd., je lahko obravnavan kot podsistem. Pri vključitvi v celoten sistem je potrebno upoštevati varnost in zasebnost uporabnikov. Povezanost, kot je prikazana na sliki 1, je eden izmed glavnih ciljev projekta ACCUS.

3 PROJEKT ACCUS

Vizija projekta ACCUS je večja od vseh doslej znanih sistemov. Cilj projekta je združiti obstoječe samostojne podsisteme in omogočiti medsebojno sodelovanje v smislu Sistema sistemov. To bo možno doseči z novo razvito arhitekturo, metodologijo in orodji, ki bodo v ospredje postavljali ravno uporabnost povezav med različnimi podsistemi. Z zmožnostjo spremljanja pojavov preko različnih podsistemov si bo mogoče ustvariti večjo sliko dogajanja in ukrepati na več nivojih hkrati. Posledice tega bodo boljša odzivnost in kvalitetnejše storitve podsistemov, ki imajo sami zase dostop samo do nekaterih informacij. Z učinkovito zgradbo Sistema sistemov in stalnim izvajanjem optimizacije postopkov bomo dosegli bolj prilagodljivo, učinkovito, varno in robustno delovanje podsistemov.

3.1 Osnovni principi sistema

Ena izmed glavnih lastnosti Sistema sistemov je neodvisnost podsistemov, zato moramo pri snovanju arhitekture platforme, ki bo te sisteme povezovala, to upoštevati. Operativna in vodstvena neodvisnost podsistemov bosta vodila do pogajanj med njimi za dostop do storitev in za sredstva, ki bodo na voljo platformi. Neodvisnost razvoja posameznega podsistema pa zahteva, da delovanje celotnega sistema ni preveč odvisno od delovanja posameznega podsistema. Še več, v delovanje sistema želimo vključiti metode, ki bodo pričakovale nepredvideno obnašanje in omogočale takojšnjo reorganizacijo delovanja. Želimo torej, da sistem deluje po principu »Plug-and-play«, kar pomeni, da komponente sistema redno optimizirajo svoje parametre in algoritme delovanja glede na zaznane nove podsisteme ali pa nove storitve, ki jih obstoječi podsistemi omogočajo. Novejši način samoorganizacije temelji na kognitivnih mrežah (ang. cognitive networks) in agentnih sistemih.

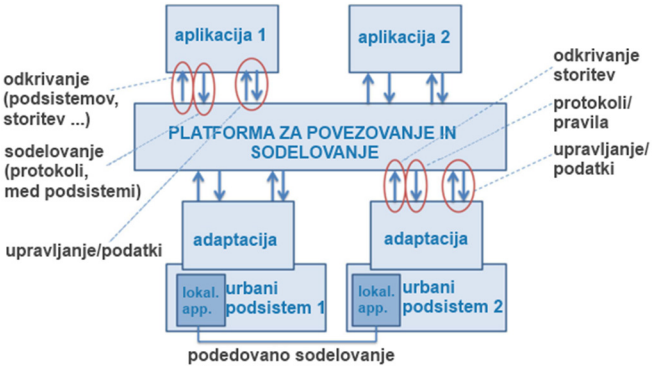
3.2 Arhitektura sistema

Urbane podsisteme sestavljajo povezani namenski sistemi (ang. embedded systems), ki opravljajo funkcije različnih pomembnosti (npr. javna razsvetljava, upravljanje prometa in prometne signalizacije) na način, kot je bil določen ob izgradnji teh podsistemov. Zaradi njihove različnosti direktna komunikacija med podsistemi običajno ni mogoča. Potrebno je osnovati tako metodo adaptacije, ki bo omogočala povezavo med platformo in podsistemi. Komunikacija med platformo in podsistemi mora biti semantično povezljiva (ang. semantic interoperability), to pomeni, da platforma razume funkcije in storitve, ki jih lahko vsak podsistem opravlja, obratno pa velja, da vsak sistem ve, katere podatke lahko pridobi od platforme. Ker direktno upravljanje zaradi heterogenosti podsistemov običajno ni mogoče, lahko na delovanje vplivamo s pravili oz. protokoli (ang. policy), upravljanje in dostop do

podatkov pa sta možna s storitvami (ang. services), ki so semantično povezljive.

Ker se funkcionalnosti podsistema stalno spreminjajo, mora njihova priključitev na platformo temeljiti na semantičnih opisih storitev podsistema. Za dogodke, ki se tičejo več podsistemov, je brezhibna komunikacija med vključenimi podsistemi nujna, tudi če prihaja do sprememb funkcionalnosti podsistemov, sprememb na nivoju Sistema sistemov ali pa sprememb obnašanja uporabnikov oz. naprav. Zmožnost stalnega prilagajanja sistema je ena ključnih lastnosti platforme ACCUS.

Projekt ACCUS poskuša podsisteme združiti v celoto. Ideja arhitekturnega modela sistema ACCUS je prikazana na sliki 2.



Slika 2: Arhitektura sistema ACCUS, iz [1]

Urbani podsistemi (to so podsistemi, ki se pojavljajo v modernih mestih) bodo preko metod adaptacije povezani s platformo. To bo omogočalo deljenje informacij, ugotavljanje storitev posameznih podsistemov in njihovo koordinacijo. Preko adaptacije bo možno dostopati do podsistemov in jih z opisom protokolov tudi upravljati. Poleg tega bo možno graditi aplikacije, ki bodo za svoje delovanje potrebovale več različnih podsistemov. Aplikacije bodo sestavljene iz modulov, ki bodo omogočali dostop do platforme. Dostop bo sestavljen iz treh delov: en del dostopa bo odgovoren za odkrivanje priključenih podsistemov in ugotavljanje storitev, ki jih ti podsistemi omogočajo, drugi del bo podpiral sodelovanje med podsistemi, tretji pa bo omogočal upravljanje sistemov in izmenjavo informacij. Sodelovalni del dostopa do platforme aplikacijam omogoča vzpostavitev povezav med podsistemi in predlaganje protokolov ter definicij vzorcev obnašanja. Aplikacija je lahko tudi skupek opazovanih pravil, ki običajno vsebuje neka pravila obnašanja, in jih je smiselno upoštevati, če želimo optimalno delovanje sistema.

3.3 Porajajoče vedenje

Delovanje obstoječih podsistemov lahko opazujemo že nekaj časa. Iz pridobljenih podatkov lahko ugotovimo vzorce in pravila obnašanja. Toda kaj se bo zgodilo, ko bodo ti podsistemi povezani med sabo? Kljub temu da poznamo osnovna pravila delovanja podsistemov, je skoraj nemogoče napovedati vedenje Sistema sistemov. Temu pojavu rečemo porajajoče vedenje (ang. emergent behaviour). Goldstein [23] definira porajajoče vedenje kot: »...nastajanje novih in skladnih struktur, vzorcev in lastnosti v procesu samoorganizacije kompleksnega sistema.« Porajajoče vedenje ni razvidno direktno iz lastnosti posameznih komponent sistema, temveč se poraja kot posledica interakcij med komponentami sistema – podsistemi [25].

Primer porajajočega vedenja je npr. let jate ptic v formaciji. Z opazovanjem leta ene same ptice ni mogoče napovedati leta jate. Potrebno je upoštevati še pravila interakcij med pticami: npr. paziti je potrebno, da se ptici ne zaletita, ptica leti v isti smeri kot sosednje ptice v jati, ptica leti približno v središču med sosednjimi pticami (v masnem središču sosednjih ptic). Na podlagi teh pravil je Reynolds [24] predstavil program Boids, ki simulira let ptic. Idejo so uporabili v številnih igrah in animacijah, kjer je potrebno simulirati gibanje jate ptic in rib ali tropa živali npr. Batman Returns (1992) in Half-Life (1998).

Platforma ACCUS bo med sabo povezovala veliko število podsistemov, ki bodo že sami sestavljeni iz številnih namenskih sistemov. Nemogoče je predvideti kako bodo povezave vplivale na delovanje podsistemov, zato moramo pri snovanju platforme zagotoviti, da posledice ne bodo škodljive ali celo nevarne za celoten sistem, mesto ali končne uporabnike.

Produkt projekta ACCUS bo tudi simulator okolja. Z njim bo možno simulirati procese in dogodke, ki se tičejo več podsistemov. Simulator bo moral biti realističen in zanesljiv, saj bodo od njegovih rezultatov odvisne odločitve o implementaciji novih konceptov v sistem. Dogajanje bo moral tudi vizualizirati na način, ki bo omogočal vpogled v nastale spremembe v sistemu. Posebej pomembne bodo mešane simulacije (ang. mixed-reality simulations), kjer se uporabi resnične podatke, npr. o gibanju ljudi, vremenu itd. Prav tako bo simulator moral podpirati integracijo več samostojnih simulatorjev. To pomeni, da bo v simulacijo delovanja platforme ACCUS enostavno integrirati simulatorje podsistemov.

4 RAZPRAVA IN ZAKLJUČEK

V sestavku smo predstavili tekoči mednarodni projekt ACCUS. Cilji projekta so ambiciozni:

1. proučitev delovanja obstoječih urbanih podsistemov ter iskanje rešitve za integracijo podsistemov v Sistem sistemov,
2. povezavo, komunikacijo in sodelovanje med sistemi bo omogočala platforma ACCUS, prav tako bo možna izdelava aplikacij, ki bodo preko storitev in metod adaptacije dostopale do podatkov in storitev podsistemov, katerih funkcionalnost in dostopnost se bo lahko pogosto spreminjala,
3. razvoj tehnike za razumevanje semantičnih opisov storitev, ki jih podpirajo sistemi, in protokolov, preko katerih lahko aplikacije vplivajo na delovanje podsistemov, pri tem je potrebno obravnavati varnost, zaščito in zasebnost uporabnikov,
4. razvoj mehanizmov, ki bodo omogočali samo-optimizacijo podsistemov,

5. razvoj simulatorja, ki bo omogočal vizualizacijo rezultatov simulacij ter dopuščal tudi mešano simulacijo,
6. razvoj orodij za dejansko priključitev obstoječih podsistemov na platformo ACCUS,
7. koncept ACCUS, priključitev obstoječih podsistemov v Sistem sistemov in preizkus delovanja v vsaj dveh mestih.

Da bomo dosegli te cilje, bomo uporabili ugotovitve različnih področij, nekatere smo omenili v razdelku 2. Poleg tega bo potrebnih tudi nekaj inovacij:

- platforma, ki bo omogočala povezovanje in sodelovanje obstoječih urbanih podsistemov ter izgradnjo aplikacij, ki bodo za delovanje uporabljale več podsistemov,
- arhitektura delovanja Sistema sistemov, ki bo omogočala prilagodljivost in sodelovanje podsistemov, ter algoritmi za optimizacijo sodelovanja podsistemov,
- metodologija in orodja za razvoj realno-časovnih aplikacij, ki bodo izkoristili vse prednosti Sistema sistemov.

Namen projekta ACCUS je poenostaviti življenje v mestih; optimizirati pretok prometa, zmanjšati skupno porabo energije, omejiti onesnaževanje, pomagati pri intervenciji v primeru nesreč in naravnih katastrof itd. Skoraj vsaka oseba že ima mobilno napravo z veliko računsko močjo, prav tako so številne namenske naprave nameščene na različnih mestih. S povezovanjem vseh teh naprav lahko iščemo globalno najboljše odgovore na vsakdanje probleme in vprašanja ter ustvarimo boljšo prihodnost.

Zahvala

To delo delno financirajo ARTEMIS Joint Undertaking in Ministrstvo za gospodarski razvoj in tehnologijo kot del projekta ACCUS, številka pogodbe C2130-13-090115.

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MERE USPEŠNOSTI V SISTEMIH ZA E-IZOBRAŽEVANJE

Jernej Zupančič[1], *Erik Dovgan*[1], *Bogdan Filipič*[1], *Rok Pirnat*[2]

[1]Odsek za inteligentne sisteme, Institut "Jožef Stefan"
Jamova cesta 39, 1000 Ljubljana
E-pošta: {jernej.zupancic, erik.dovgan, bogdan.filipic}@ijs.si

[2]B2 d.o.o., Tržaška cesta 42, 1000 Ljubljana
E-pošta: rok.pirnat@b2.eu

POVZETEK

V prispevku predlagamo nove mere, s katerimi poskušamo objektivno oceniti uspešnost učenca ali skupine učencev v e-izobraževanju in ugotoviti napredek pri razumevanju podajane snovi. S pomočjo teh mer lahko posredno spremljamo tudi kakovost gradiv, ki se pojavljajo v sistemih za e-izobraževanje.

1. UVOD

Računalniki spreminjajo način komuniciranja, iskanja informacij in učenja. Čeprav zagovorniki klasičnega načina izobraževanja na šolah poudarjajo prednost osebnega stika med učencem in učiteljem pred izobraževanjem na daljavo preko spleta, je e-učenje v porastu. Zaradi številnih dobrih lastnosti – učenec se lahko uči kadarkoli in kjerkoli, s tempom, ki mu ustreza, ni mu potrebno vsak dan potovati do šole, pridobljeno znanje je primerljivo z znanjem iz klasičnega izobraževanja – obstaja veliko ponudnikov tako formalnega kot neformalnega e-izobraževanja. Na razpolago so tudi orodja za spremljanje učenja, ki omogočajo, da učitelj, čeprav z učencem nima osebnega stika, spozna učenca in njegove učne navade ter mu ustrezno svetuje in ga spodbuja pri učenju. Podrobna analiza učenja s sledenjem klikom, sprotnimi vprašanji in zbiranjem različnih vrst podatkov omogoča vpogled v učne navade, ki v klasičnem izobraževanju ni mogoč.

Mere oz. numerični kazalniki za merjenje uspešnosti različnih vrst uporabnikov sistemov za e-izobraževanje najpogosteje niso dokumentirane, raziskovalnih člankov, ki bi se ukvarjali z merami uspešnosti, pa ni veliko. Zato predlagamo mere, ki merijo uspešnost in napredek učenca ali skupine učencev. Definiramo jih tako, da omogočajo primerjavo med različnimi skupinami učencev. Na osnovi opazovanja uporabe gradiv lahko s primerno mero tudi ocenjujemo, ali je hitrost podajanja snovi enakomerna, zahtevnost pa ne niha preveč. Tako merimo kakovost gradiv. Mentorju poskušamo podatke prikazati jasno in zgoščeno na način, ki mu omogoča hitro poiskati razloge za uspeh ali neuspeh njegovih učencev.

V Sloveniji je med najbolj znanimi sistemi za e-izobraževanje eCampus, ki omogoča vnos učnih gradiv, posredovanje gradiv uporabnikom, ocenjevanje uporabnikov, pregledovanje opravljenih nalog itd. Ta prispevek je nastal na osnovi analize sistema eCampus in ugotavljanja potreb uporabnikov po njegovi nadgradnji.

V nadaljevanju najprej opišemo sisteme za e-izobraževanje in mere uspešnosti v njih. Nato definiramo nove mere uspešnosti učenca, mentorja in skupine učencev. Prispevek zaključimo z navedbo prednosti in slabosti predlaganih mer.

2. SISTEMI ZA E-IZOBRAŽEVANJE

Že v šestdesetih letih prejšnjega stoletja so na Univerzi v Illinoisu eksperimentirali z uporabo računalnikov v namene izobraževanja. Razvijali so sistem PLATO [12], ki je podal osnove za orodja, kot so spletni forumi, oglasne deske, spletna pošta, hitra sporočila in igre več igralcev. Vsa ta orodja uporabljajo tudi sodobni sistemi za e-izobraževanje. Nekateri samo dopolnjujejo klasično izobraževanje in omogočajo dostop do literature in dodatnih nalog ter komuniciranje preko elektronske pošte in spletnih forumov, drugi pa poleg tega omogočajo popolno izvajanje izobraževanja preko spleta, od tod tudi ime sistemi za upravljanje z učenjem oz. sistemi za upravljanje e-izobraževanja (ang. Learning Management System, LMS).

Obstajajo komercialne in odprtokodne izvedbe sistemov za e-izobraževanje. Nekatere najbolj znane v svetovnem merilu so Moodle [9], Canvas [3], Blackboard [2] in Desire2Learn [4], v Sloveniji pa eCampus [6], ki ga je razvilo podjetje B2, in E-CHO [5], ki ga nudi Laboratorij za telekomunikacije Fakultete za elektrotehniko Univerze v Ljubljani.

Način e-izobraževanja je zelo drugačen od klasičnega, zato je temu primerno treba prilagoditi izvajanje predmetov oz. tečajev. Splošno prepričanje je, da zaradi neosebnega stika med učiteljem in učencem ni mogoče usmerjati in nadzorovati učenja, kot je to možno pri klasičnem pouku. Toda pri interakciji učenca s sistemom za e-učenje nastane ogromno podatkov (obiskana gradiva, čas namenjen učenju, pravilni in nepravilni odgovori v testih, vprašanja učencev postavljena na forumih, razprave na forumih), ki odražajo značilnosti in učne navade učenca. Z analizo teh podatkov bi lahko dokaj točno ugotovili, kako učenec napreduje pri študiju, kje ima težave, kako je motiviran itd. Težava pa nastane, ker vnaprej ne vemo, kateri dejavniki vplivajo na učenčevo uspešnost.

Uporabniki običajno želijo zgoščen in informativen prikaz preteklih aktivnosti in trenutnega stanja. To lahko dosežemo z uporabo ustreznih mer, na osnovi katerih bi lahko primerjali

učence med seboj. Te mere bi nato vizualizirali tako, da bi omogočili vpogled v povezave med dejavniki učenja ter primerjavo uspešnosti uporabnikov.

3. PREGLED MER USPEŠNOSTI

Sistemi za e-izobraževanje med drugim tudi beležijo vse aktivnosti prijavljenega uporabnika. Zato tako komercialni kot odprtokodni sistemi ponujajo izpise, ki podajajo informacije o številu prijav v sistem, času učenja v sistemu, številu in vsebini obiskanih strani itd. [10]. Sistemi običajno vsebujejo tudi orodja za preverjanje znanja. Orodje Assistments [7] zbira podatke o času reševanja nalog in pravilnosti odgovorov, beleži, ali je učenec uporabljal pomoč (namige), ter katere osnovne pojme in koncepte je naloga preverjala. Uporabniku lahko prikaže, katere koncepte je učenec že osvojil in pri katerih se mora bolj potruditi. Podani so izračuni deležev pravilno rešenih nalog za vsako preverjanje znanja posebej in njihove povprečne vrednosti po vseh obiskovanih predmetih.

Sistemi za e-izobraževanje, kot je npr. Desire2Learn, posebej definirajo uspešnost učenca pri preverjanju znanja, pisanju poročil in seminarskih nalog ter stopnjo udeleženosti pri razpravah na forumih. Te mere že omogočajo vpogled v stanje učenčevega znanja, če pa imamo na voljo še povprečne rezultate ostalih učencev, lahko učence tudi primerjamo med seboj in jih razvrstimo po uspešnosti. V drugih sistemih, kot je npr. Desire2Learn, se izračuna splošna uspešnost učenca kot povprečje različnih aktivnosti: števila prijav v sistem, uspešnosti reševanja testov itd., vendar enačbe niso podane. V [1] je navedena mera, ki poskuša izračunati napredek učenca pri osvajanju novega pojma glede na deleže pravilnih odgovorov pri sprotnem preverjanju znanja. V istem članku predstavljajo tudi mero uspešnosti učitelja, odvisno od napredka učencev.

Poleg mer uspešnosti in napredka učencev v literaturi zasledimo tudi mere kakovosti gradiv, dostopnih v sistemih za e-izobraževanje. V [11] definirajo kakovost gradiva v odvisnosti od števila spletnih strani, na katerih je gradivo predstavljeno, števila ogledov strani ter števila interakcij s sistemom za e-izobraževanje.

Zelo pomembno za uporabnika je tudi, kako so vsi ti podatki prikazani. Sistem Moodle npr. beleži vse aktivnosti in zbira velike količine podatkov, nima pa vgrajenih orodij, ki bi te podatke prikazovala na uporabniku prijazen način. Za vizualizacijo podatkov iz Moodla so razvili orodje GISMO [8].Obe orodji omogočata pregled nad aktivnostmi učenca, kot so prijave v sistem, ogledovanje strani, reševanje testov, oddaja seminarskih nalog ipd. Sistemi za e-izobraževanje, kot so Desire2Learn, Blackboard, Canvas in eCampus, poskušajo s tabelami, stolpčnimi diagrami, z barvnimi signali in s škatlami z brki (ang. box plot, grafičen prikaz statističnih značilnosti skupin številskih vrednosti) čimbolj zgoščeno prikazati stopnjo aktivnosti in znanja učencev.

Pri pregledu uporabljenih mer uspešnosti nismo našli takih, ki bi upoštevale zahtevano stopnjo znanja (npr. učenec opravi izpit, če na preverjanju doseže vsaj 80 % možnih točk), niti takih, ki bi omogočale primerjavo uspešnosti učencev, ki so opravljali različna preverjanja znanja. Tudi metode vizualizacije, ki bi omogočala podrobnejšo analizo značilnosti posameznega učenca, nismo zasledili. Uporabniki sistema eCampus so izrazili tudi željo po meri kakovosti gradiv. Predloge omenjenih mer predstavljamo v naslednjem razdelku.

4. PREDLAGANE MERE USPEŠNOSTI

Sistemi za e-izobraževanje nimajo težav z beleženjem velikih količin podatkov o tem, kako uporabniki uporabljajo sistem ter kako dobro se učijo. Težje je pridobljene podatke obdelati in jih prestaviti uporabniku na način, ki ga uporabnik razume in lahko uporabi pri odločanju o nadaljnjih aktivnostih. Če je to učenec, običajno želi vedeti, kako uspešen je v primerjavi z ostalimi učenci, avtor gradiva želi informacijo o tem, kako kakovostno je gradivo, ki ga je pripravil, mentor želi pregled nad uspešnostjo svojih učencev in možnost ugotavljanja razlogov za uspeh ali neuspeh, vodja skupine učencev pa želi pregled nad kompetencami učencev.

4.1. Mere uspešnosti učenca

Osnovna mera, s katero bomo definirali tudi ostale, je mera uspešnosti učenca pri gradivu

$$i(u,g) = \frac{o(u,g) - Z(g)}{SD\left(o(g)\right)},$$

kjer u označuje učenca, g gradivo, $o(u,g)$ delež doseženih točk učenca u pri preverjanju znanja po gradivu g, $Z(g)$ zahtevani delež doseženih točk, da je gradivo g priznano kot opravljeno, $SD\left(o(g)\right)$ pa vzorčni standardni odklon deleža doseženih točk, ki ga za množico učencev $U(g)$, ki opravlja gradivo g, izračunamo kot

$$SD\left(o(g)\right) = \sqrt{\frac{1}{|U(g)|-1}\sum_{u\in U(g)}\left(o(u,g) - A\left(o(g)\right)\right)^2},$$

kjer je $A\left(o(g)\right)$ povprečen delež doseženih točk, ki so jih učenci dosegli pri gradivu g in se za množico učencev $U(g)$ izračuna kot

$$A\left(o(g)\right) = \frac{1}{|U(g)|}\sum_{u\in U(g)} o(u,g).$$

Tako definirana mera vrne pozitivne vrednosti za učence, ki so uspešno opravili preverjanje znanja po izbranem gradivu. Z normalizacijo s standardnim odklonom želimo standardizirati rezultate preverjanj znanja.

Če imamo podane mere uspešnosti za vsako gradivo, pri katerem je učenec udeležen, lahko izračunamo mero uspešnosti učenca $IU(u)$. Najenostavnejši način je kar izračun povprečja mere uspešnosti po gradivih

$$IU(u) = \frac{1}{|G(u)|}\sum_{g\in G(u)} i(u,g),$$

kjer je $G(u)$ množica gradiv, pri katerih je učenec u udeležen. Mera uspešnosti učenca z enim številom opiše, kako uspešen je učenec. Koristna informacija za učenca je tudi, kako se njegovi rezultati primerjajo z ostalimi udeleženci izobraževanja.

Pogosto nas zanima tudi, koliko je učenec napredoval. To lahko ugotovimo s primerjavo rezultatov predtesta $o_p(u,g)$ in končnega testa $o_k(u,g)$ učenca u pri gradivu g. Mero napredka izračunamo kot

$$IN(u,g) = \frac{o_k(u,g) - o_p(u,g)}{100\% - o_p(u,g)}.$$

Z mero napredka poskušamo predstaviti, kako dobro je učenec izkoristil gradivo in pridobil novo znanje. S povprečjem vseh mer napredka pri gradivih, ki jih je učenec zaključil, podamo mero splošnega napredka učenca

$$ISN(u) = \frac{1}{|G(u)|} \sum_{g \in G(u)} IN(u,g),$$

kjer je $G(u)$ množica gradiv, pri katerih je učenec u udeležen.

4.2. Mere uspešnosti mentorja

Uspešnost mentorja lahko merimo z uspešnostjo učencev. Ustrezno mero lahko definiramo kot povprečje mer uspešnosti vseh učencev u, katerim je pri gradivu g oseba m mentor, pri čemer množico parov (učenec, gradivo) označimo z $N(m)$,

$$IM_1(m) = \frac{\sum_{(u,g) \in N(m)} i(u,g)}{|N(m)|},$$

ali pa kot povprečje napredkov

$$IM_2(m) = \frac{\sum_{(u,g) \in N(m)} IN(u,g)}{|N(m)|}.$$

Mentor je oseba, ki mora najpodrobneje spremljati učenje učenca, ga pri tem spodbujati, opozarjati na napake in ga pohvaliti, ko mu gre dobro. Če je nekdo mentor velikemu številu učencev, potrebuje zelo veliko časa, da pregleda vse podatke o učencih, ki jih beleži sistem za e-izobraževanje. To delo lahko pohitrimo z zgoščenim prikazom vseh pomembnih značilnosti učenca hkrati. S pomočjo paralelnih koordinat lahko prikažemo več značilnosti, z dodanimi škatlami z brki pa učenca lahko primerjamo z ostalimi učenci. Slika 1 prikazuje primer uporabe te metode vizualizacije.

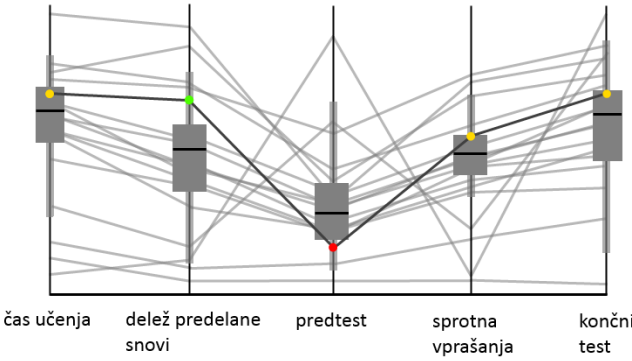
4.3. Mere uspešnosti avtorja gradiv

Uspešnost avtorja gradiv lahko ocenjujemo na osnovi uspešnosti ali napredka učencev, ki so obravnavali ta gradiva. Najprej izračunamo mero uspešnosti ali napredka pri gradivu z

$$IG_1(g) = \frac{1}{|U(g)|} \sum_{u \in U(g)} i(u,g)$$

ali

$$IG_2(g) = \frac{1}{|U(g)|} \sum_{u \in U(g)} IN(u,g).$$



Slika 1: Prikaz značilnosti učenca s paralelnimi koordinatami in dodanimi škatlami z brki

Nato lahko povprečje mer uspešnosti pri gradivih, ki jih je pripravil avtor a, privzamemo za mero uspešnosti avtorja

$$IA(a) = \frac{1}{|G(a)|} \sum_{g \in G(a)} IG_i(g),$$

kjer smo z IG_i označili mero uspešnosti ali napredka pri gradivu, z $G(a)$ pa množico gradiv, ki jih je pripravil avtor a.

Drug način ocenjevanja uspešnosti avtorja gradiv temelji na opazovanju časov učenja posamezne enote v gradivu. Enota je snov v gradivu, ki je predstavljena na eni učni strani sistema za e-izobraževanje. Po mnenju strokovnjakov je gradivo kakovostno sestavljeno, če se časi učenja posameznih enot v gradivu ne razlikujejo veliko. Mero, ki bi merila razlike v časih učenja, izračunamo s pomočjo standardnega odklona časov učenja posameznega učenca

$$T(u,g) = \sqrt{\frac{1}{|S(g)|-1} \sum_{s \in S(g)} \left(t(u,s) - \overline{t(u,g)}\right)^2},$$

kjer je u učenec, g gradivo, $S(g)$ množica učnih strani gradiva g, $t(u,s)$ čas učenja učenca u na učni strani s, $\overline{t(u,g)}$ pa povprečen čas učenja na učnih straneh, ki pripadajo gradivu g. Mera $T(u,g)$ torej meri turbulence v časih učenja učenca za posamezno gradivo. Zanima nas, kako velike so te turbulence za izbrano gradivo med vsemi učenci. To nam nakažeta povprečje (ali pa mediana) turbulenc

$$\overline{T(g)} = \frac{1}{|U(g)|} \sum_{u \in U(g)} T(u,g),$$

kjer je g gradivo, $U(g)$ pa množica učencev po gradivu g. Želimo, da so časi učenja čim bolj podobni, torej je manjša vrednost $\overline{T(g)}$ boljša od večje.

Seveda bi lahko opazovali še razlike v časih učenja vseh učencev, za katere je avtor pripravil gradiva

$$TU(a) = \frac{1}{|G(a)|} \sum_{g \in G(a)} \overline{T(g)},$$

kjer je a avtor in $G(a)$ množica gradiv, ki jih je pripravil avtor a. Mero $TU(a)$ poimenujmo mera enakomernosti učnih

strani. Ta podaja enakomernost zahtevnosti učnih strani, ki jih sestavlja izbrani avtor, in omogočala primerjavo z ostalimi avtorji.

4.4. Mere uspešnosti skupine

Pogosto nas zanima, kako uspešni so oz. kako napredujejo učenci iz točno določene skupine, npr. skupine zaposlenih v nekem podjetju ali skupine oseb istega spola, mogoče celo skupine oseb iz istega kraja itd. Z mero uspešnosti skupine učencev bi lahko odkrivali različne povezave med uspešnostjo in lastnostmi skupine. Definiramo jo lahko kar kot povprečje uspešnosti oseb iz izbrane skupine

$$IUS(s) = \frac{1}{|s|} \sum_{u \in s} IU(u),$$

kjer j s s skupina, u pa oseba iz te skupine. Namesto mere uspešnosti bi lahko uporabili mero splošnega napredka učenca in dobili mero napredka skupine

$$INS(s) = \frac{1}{|s|} \sum_{u \in s} ISN(u),$$

kjer je s skupina, $ISN(u)$ pa prej definirana mera splošnega napredka osebe u.

5. ZAKLJUČEK

V delu smo obravnavali nekaj novih načinov merjenja uspešnosti učencev, ki omogočajo primerjavo med skupinami učencev. Mere uspešnosti smo definirali tako, da se iz vrednosti hitro razbere, kako dober je učenec v primerjavi z ostalimi.

Predstavili smo tudi metodo vizualizacije s paralelnimi koordinatami in poudarili pomen prikazovanja različnih podatkov v zgoščenem prikazu za mentorje. Menimo, da bodo mentorji tako prihranili dosti časa in prišli do pravilnejših zaključkov o sposobnostih vsakega učenca. Predlagali smo tudi mero za merjenje kakovosti izdelave gradiv, ki avtorju posredno sporoča, kako zahtevna je podajana snov.

Zavedamo se, da predlagane mere ne morejo prikazati popolne slike stanja učenca in jim ne smemo slepo zaupati. Za vsako dobljeno numerično vrednost si moramo za pravilno ustvarjeno mnenje o sposobnostih učenca ogledati številne zapise, ki nastanejo ob interakciji učenca in sistema za e-učenje. Mere uspešnosti poskušajo te zapise in rezultate testov samo strniti v eno številsko vrednost, ki omogoča hitro primerjavo z ostalimi učenci.

Predlagane mere temeljijo na potrebah uporabnikov sistema za e-izobraževanje eCampus in pregledu že uporabljenih mer v literaturi. Za preizkus uporabnosti predlaganih mer v praksi bo potrebna njihova vgradnja v sistem eCampus. V prihodnje bomo z algoritmi podatkovnega rudarjenja tudi poskusili ločiti učence glede na način učenja. Tako bi lahko prilagodili učno izkušnjo za vsakega učenca posebej in mu priporočali aktivnosti, ki bodo pri njegovem stilu učenja najučinkovitejše.

ZAHVALA

To delo je nastalo v okviru projekta *Industrijska raziskava namenjena nadgradnji izobraževalnega sistema eCampus*, ki so ga na osnovi izbora na Javnem razpisu raziskovalni vavčer 2012 sofinancirali Republika Slovenija, Ministrstvo za izobraževanje, znanost in šport, Evropska unija, Evropski sklad za regionalni razvoj, in B2 d.o.o.

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Zbornik 16. mednarodne multikonference
INFORMACIJSKA DRUŽBA – IS 2013

Proceedings of the 16th International Multiconference
INFORMATION SOCIETY – IS 2013

Izkopavanje znanja in podatkovna skladišča (SiKDD 2013)

Data Mining and Data Warehouses (SiKDD 2013)

Uredila / Edited by

Dunja Mladenić, Marko Grobelnik

http://is.ijs.si

7. oktober 2013 / October 7th, 2013
Ljubljana, Slovenia

PREFACE

DATA MINING AND DATA WAREHOUSES (SiKDD 2013)

Data driven technologies have significantly progressed after mid 90's. The first phases were mainly focused on storing and efficiently accessing the data, resulted in the development of industry tools for managing large databases, related standards, supporting querying languages, etc. After the initial period, when the data storage was not a primary problem anymore, the development progressed towards analytical functionalities on how to extract added value from the data; i.e., databases started supporting not only transactions but also analytical processing of the data. At this point, data warehousing with On-Line-Analytical-Processing (OLAP) entered as a usual part of a company's information system portfolio, requiring from the user to set well defined questions about the aggregated views to the data. Data Mining is a technology developed after year 2000, offering automatic data analysis trying to obtain new discoveries from the existing data and enabling a user new insights in the data. In this respect, the Slovenian KDD conference (SiKDD) covers a broad area including Statistical Data Analysis, Data, Text and Multimedia Mining, Semantic Technologies, Link Detection and Link Analysis, Social Network Analysis, Data Warehouses.

Marko Grobelnik and Dunja Mladenić

PREDGOVOR

ODKRIVANJE ZNANJA IN PODATKOVNA SKLADIŠČA

Tehnologije, ki se ukvarjajo s podatki so v devetdesetih letih močno napredovale. Iz prve faze, kjer je šlo predvsem za shranjevanje podatkov in kako do njih učinkovito dostopati, se je razvila industrija za izdelavo orodij za delo s podatkovnimi bazami, prišlo je do standardizacije procesov, povpraševalnih jezikov itd. Ko shranjevanje podatkov ni bil več poseben problem, se je pojavila potreba po bolj urejenih podatkovnih bazah, ki bi služile ne le transakcijskem procesiranju ampak tudi analitskim vpogledom v podatke – pojavilo se je t.i. skladiščenje podatkov (data warehousing), ki je postalo standarden del informacijskih sistemov v podjetjih. Paradigma OLAP (On-Line-Analytical-Processing) zahteva od uporabnika, da še vedno sam postavlja sistemu vprašanja in dobiva nanje odgovore in na vizualen način preverja in išče izstopajoče situacije. Ker seveda to ni vedno mogoče, se je pojavila potreba po avtomatski analizi podatkov oz. z drugimi besedami to, da sistem sam pove, kaj bi utegnilo biti zanimivo za uporabnika – to prinašajo tehnike odkrivanja znanja (data mining), ki iz obstoječih podatkov skušajo pridobiti novo znanje in tako uporabniku nudijo novo razumevanje dogajanj zajetih v podatkih. Slovenska KDD konferenca pokriva vsebine, ki se ukvarjajo z analizo podatkov in odkrivanjem zakonitosti v podatkih: pristope, orodja, probleme in rešitve.

Marko Grobelnik in Dunja Mladenić

APPLYING NLP FOR BUILDING DOMAIN ONTOLOGY: FASHION COLLECTION

Inna Novalija, Gregor Leban
Artificial Intelligence Laboratory
Jozef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
Tel: +386 1 4773144; fax: +386 1 4251038
e-mail: inna.koval@ijs.si

ABSTRACT

This paper presents an approach to developing a fashion domain ontology based on inputs from fashion experts and natural language processing (NLP) methods. While many of software solutions for fashion industry are concentrated on the design, manufacturing and trading applications, semantic technologies are just starting to interact with fashion domain. Domain ontologies allow capturing, sharing, analyzing and reusing the important information from the defined field.

1 INTRODUCTION

Ontologies are considered one of the pillars of Semantic Web and Semantic Technologies [1]. Gruber [2] defined Ontology as an explicit specification of a conceptualization consisting of the following main components: concepts, relations, functions, axioms and instances. Furthermore, ontologies enable effective domain knowledge representation, knowledge sharing and knowledge reuse [3]. Usage of ontologies allows to effectively discover patterns, by searching not only within the terms occurring in the query, but also within their semantically related concepts.

One example of large common-sense ontology is the Cyc Knowledge Base [4], which has been being developed for more than 20 years (more than 900 human years of effort) and is used as a knowledge source in the Cyc Artificial Intelligence system. It already aggregates more than 15.000 predicates, 300.000 concepts and 3.500.000 assertions.

Domain ontology are built upon knowledge from a particular domain.

While there are many semantic tools in some domains, such as biomedical, software engineering domains, other domains are just starting to interact with semantic technologies in general and ontologies in particular.

For instance, BioPortal [5] is web portal developed by the National Center for Biomedical Ontology (NCBO) [6], which provides access to number of resources (ontologies, terminologies, mappings), tools (ontology recommender, ontology annotator) and web services in biomedical domain. BioPortal users obtain a possibility of knowledge sharing and reuse in different knowledge representation formats, such as Web Ontology Language (OWL) and Open Biological and Biomedical Ontologies (OBO). BioPortal contains around 260 ontologies [5] from different groups. Unlike biomedical resources, in fashion domain there are no available semantic tools and formalized knowledge materials.

In this paper we present a methodology for development of the domain ontology in fashion domain.

As stated by Pearson [7], fashion is often at the forefront of technology usage. With technology development quickly accelerating, the fashion industry sees the convergence of nanotechnology, biotechnology, information technology and cognitive technologies.

The aim of this work is, with an assistance of sematic technologies, to create supportive mechanisms and tools, contributing to the improvement of information analysis and sharing processes both on the production and consumption sides of fashion industry.

The development of fashion ontology is meant to

- provide advanced search functionalities for fashion related content
- track what is going on in the fashion world
- show fashion entities related to each other.

The paper is structured as follows: Section 2 contains the related work on ontology learning; Section 3 describes the methodology for domain ontology development; Section 3 provides the insights into the created fashion ontology resources; finally, Section 4 concludes the paper.

2 RELATED WORK

Automatic or semi-automatic ontology learning based on text mining usually starts with corpus definition, collection and preprocessing [8]. Many ontology learning approaches are based on the expertise of domain experts, who validate concepts and relationships discovered from text. Grobelnik and Mladenic [9] express the opinion that the process of ontology learning from text is closely connected to domain understanding and data understanding.

Natural language processing within ontology development problem has been covered by a number of researchers[10, 11].

Suchanek et al. [12] created a SOFIE system for ontology learning and population based on natural language document parsing and logical reasoning for disambiguation.

OntoGen [13] by Fortuna et al. is a system for topic ontology construction, which uses the vector-space model for document representation and operates based on a cosine similarity between textual documents.
A number of ontology extension and population methods based on lexico-syntactic patterns for ontology learning include Text2Onto [14] and SPRAT [15].
In comparison to the related work, the approach presented in this paper is heavily based on domain experts inputs required for fashion concepts extraction. The suggested methodology applies natural language processing and dependcy analysis for relation extraction.

3 APPROACH TO DOMAIN ONTOLOGY DEVELOPMENT

In this paper we propose an approach to creating domain specific ontology, based on user provided concept seeds for a particular domain. The approach consists of the phases described below:

1. **Collection and definition** of concept seeds.
2. **Mapping** seeds to **Wikipedia** and extending the ontology with relevant related concepts.
3. **Definition of relationships** between concepts.
4. Ontology **refinement**.

In the **first phase** the experts define a number of concepts and entitites for the particular domain.

Table 1: *Fashion Seeds*.

Seeds by Classes	Number of Entities
Designer	650
Model	448
Clothing term	59
Trend	41
Season	76
Celebrity	383

In case of fashion domain, which was explored in this research, a team of fashion experts provided a list of fashion related concepts and entitites of several types: Designer, Model, Clothing term, Trend, Season, Celebrity.
Table 1 contains a fashion seeds statistics for each entity type.
Table 2 provides examples of seeds provided by fashion expers for each entity type.

Table 2: *Examples of Fashion Seeds.*

Class	Example
Designer	Alexander McQueen
Model	Ava Smith
Clothing term	Hoodie
Trend	Safari
Season	Fall 2011 Womenswear
Celebrity	Penélope Cruz

The **next phase** of our approach constitutes mapping concept seeds to Wikipedia articles, obtaining more information about ontology concepts and new potentially related concepts. Mapping to Wikipedia is an automatic process, where concept seeds are compared to Wikipedia article titles.
Linking to Wikipedia provides us not only with textual description of a particular concept, but also allows obtaining structured information, such as Yago, Freebase and DBpedia inputs.

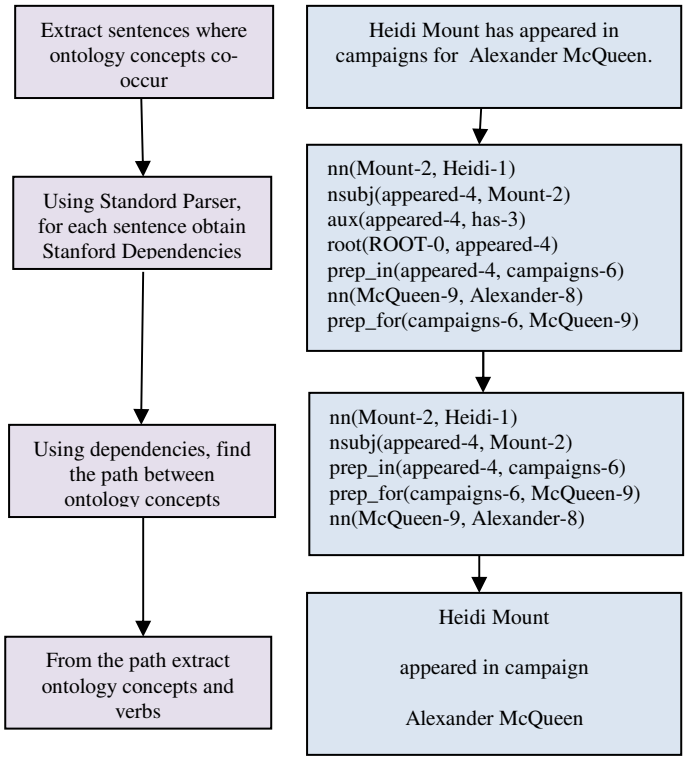


Figure 1: *Example of relation extraction.*

The definition of a term usually can be found in the initial paragraph of Wikipedia article about this term. At the same time, in the first paragraph Wikipedia often provides links to the related terms, which can be explored as potential ontology concepts.

Definition of the relations is an important step of ontology building, since relations allow expanding the usage of our ontology.
While we can determine a general relation "linksTo" already from the Wikipedia links, more specific domain relations can be discovered with natural language processing (NLP) techniques.
For instance, there is a statement about model Heidi Mount:

> "Heidi Mount has appeared in campaigns for Alexander McQueen."

This statement contains a number of ontology concepts: Heidi Mount (*Model*), Alexander McQueen (*Designer*). Using NLP we can also identify a potential ontology relation: *Model appearedInCampaign Designer*:

- Heidi Mount,appeared in,Alexander McQueen

We suggest the following method for ontology relations detection based on Stanford parser [16] and Stanford Part-Of-Speech (POS) tagger [17] (see Figure 1). The suggested approach to relation extraction is based on analysis of dependencies between words in the sentence. The path between concepts is obtained through dependencies and correspondent verbs are extracted from the path.
More examples of relationships in fashion domains include:

- Model walkedInCampaign Designer
- Model modeledInCampaign Designer
- Designer created ClothingTern
- Celebrity appearedInCloth Designer etc.

In order to group synonymic relationships WordNet [18] is used to obtain verb synsets.

Ontology **refinement** follows the ontology learning and population process. At this stage it is important to keep only fashion appropriate concepts in the fashion ontology. Ontology refinement can be performed using a pool of websites related to fashion and checking if concepts from our ontology are mentioned at fashion websites. All non-frequent and non-relevant concepts are removed from fashion ontology.

4 FASHION ONTOLOGY

The current version of the generated ontology contains around 15.000 concepts and is published in the Resource Description Framework (RDF) format. In Example 1 we show the representation for fashion ontology entity "Heather Marks".

Example 2 demonstrates the representation of fashion entity "Revlon".

Example 1: RDF Representation for Fashion Entity "Heather Marks"

```
<rdf:Description rdf:about="http://ailab.ijs.si/fashion/resource/35481">
 <rdfs:label>Heather Marks</rdfs:label>
 <rdf:type rdf:resource="http://ailab.ijs.si/fashion/upperclass/Model"/>
 <rdf:type rdf:resource="http://dbpedia.org/ontology/Person"/>
 <rdf:type rdf:resource="http://dbpedia.org/ontology/Model"/>
 <rdf:type rdf:resource="http://dbpedia.org/class/yago/LivingPeople"/>
 <rdf:type rdf:resource="http://dbpedia.org/class/yago/CanadianFemaleModels"/>
 <rdf:type
 rdf:resource="http://dbpedia.org/class/yago/PeopleFromGreenwichVillage,NewYork"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/5538"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/49678"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/35002"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/14130"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/11294"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/1906"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/18121"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/35481"/>
</rdf:Description>
```

Example 2: RDF Representation for Fashion Entity "Revlon"

```
<rdf:Description rdf:about="http://ailab.ijs.si/fashion/resource/5538">
 <rdfs:label>Revlon</rdfs:label>
 <rdf:type rdf:resource="http://dbpedia.org/ontology/Company"/>
 <rdf:type rdf:resource="http://dbpedia.org/ontology/Organisation"/>
 <rdf:type
rdf:resource="http://dbpedia.org/class/yago/CompaniesEstablishedIn1932"/>
 <rdf:type
rdf:resource="http://dbpedia.org/class/yago/CompaniesBasedInNewYorkCit
y"/>
 <rdfs:comment>Revlon is an American cosmetics, skin care, fragrance, and
personal care company founded in 1932.</rdfs:comment>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/37731"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/48778"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/49826"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/11461"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/10692"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/13835"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/18127"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/639"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/35481"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/41994"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/49147"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/24085"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/4119"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/21751"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/5538"/>
 <ailab:linksTo rdf:resource="http://ailab.ijs.si/fashion/resource/31080"/>
</rdf:Description>
```

As it is visible from the examples that "Heather Marks" is an entity of type Model. In addition, we have obtained a number of types from DBpedia and Yago: Person, CanadianFemaleModels, PeopleFromGreenwichVillageNewYork. "Revlon" is a Company, Organisation, CompanyBasedInNewYorkCity, CompanyEstablishedIn1932. In addition, it is possible to see that "Heather Marks" is connected to "Revlon".

5 CONCLUSION AND FUTURE WORK

In this paper we presented an approach to developing a fashion domain ontology based on domain experts input and natural language processing methods. Fashion domain ontology allows capturing, sharing, analyzing and reusing the important information from the field of fashion.
The future work will include the improvements of relation extraction and ontology refinement methods, as well as creating semantically grounded applications in fashion domain.

Acknowledgments

This work was supported by the Slovenian Research Agency, the IST Programme of the EC under PASCAL2 (IST-NoE-216886).

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CALL CENTRE KNOWLEDGE ACQUISITION AND DECISION SUPPORT PROTOTYPE

Zala Herga, Luka Bradeško
Artificial Intelligence Laboratory
Jožef Stefan Institute
Jamova cesta 39, 1000 Ljubljana, Slovenia
e-mail: zala.herga@ijs.si, luka.bradesko@ijs.si

ABSTRACT

The purpose of this paper is to present the approach to knowledge acquisition and computer reasoning support in a call center environment. The common problem in such environments (especially in technical call centers) is that the call operators are usually just the interface to the experts inside the company. They often lack the detailed technical knowledge in the field of study, especially when they are newcomers who just started with their job. For this reason we developed the expert system (ES) that is able to obtain needed expertise from technical staff and it is able to assist less technically versed operators to provide feedback to customers and acquire the knowledge needed to fix the particular customer problem. The prototype implementation of the ES was built for the national roadside assistance call center which is focused on car fault diagnosis.

1 INTRODUCTION

Fault diagnosis in technical fields has received a lot of attention over the last years. To solve these problems, various Artificial Intelligence techniques were used, which can to some extent successfully simulate processes that are similar to those that human brain performs when making a decision. As one of those techniques, Expert systems (ES) are commonly used in this domain. They perform reasoning over representations of human knowledge and solve problems using heuristic knowledge rather than precisely formulated relationships, in forms that reflect more accurately the nature of most human knowledge [4].

The idea behind ES is to collect knowledge from human experts and store it on computer. When users need an advice the computer can make inferences and find a solution. The solution is introduced to the user and when required, an explanation is provided. In a rule-based ES expertise is collected and then stored in a knowledge base in the form of rules. The inference engine then uses these rules to come to appropriate conclusion. The knowledge-based ES (KBS) are human-centered and usually have four main components: knowledge base (KB), an inference ngine, a knowledge engineering tool and a user interface. [4]

The ES we present in this paper is an inference engine and knowledge-based system that uses ontology driven natural language (NL) dialogs as a communication basis between domain experts, knowledge engineers and call operators. One of the improvements over the standard ES approaches is that the system is using the same expert knowledge inside KB for the NL dialog production. In its first experimental version it is also able to learn and acquire previously nonexistent concepts from its users. For example new engine faults, new type of transmission failure symptoms, etc.

2 RELATED WORK

Suryadi and Nurzal [1] had introduced a decision model for car fault diagnosis. Their ES is composed of an inference engine, knowledge base, data base, system-user interaction and adaptive component. Because there is a small number of outputs with many possible inputs backward chaining is used in the inference engine. Adaptive component is able to acquire additional knowledge base rules within the system-user interaction module.

A car failure detection ES was proposed by Al-Taani [3]. The user communicates with the system through the natural language user interface, which is represented as a menu that displays Yes-no questions to the user. Both English and Arabic languages were implemented. It has an “Explanation facility” part, which can explain the reasoning of the decision to the user. The CLIPS expert system language is used to store knowledge collected by mechanics, books and car websites. Knowledge is represented in rules. The inference engine decides which rules are satisfied by facts stored in the working memory, executes the rule and proposes proper solution. Forward chaining is used due to the data-driven nature of the domain and because of convenience using CLIPS. Good results during the test stage indicated a practical and useful ES approach. Further work is needed to improve it by adding sufficient domain knowledge, though.

In research paper [2] Car Failure and Malfunction Diagnosis Assistance System is presented with the aim to provide quick and precise expert guidance to car fault diagnosis. It is composed of three main parts: the knowledge acquisition module, GUI and the reasoning module. The reasoning module consists of Reasoning Specification part, which assist the inference engine in translating the logical results into meaningful text, the User Advisor, which assists the user how to handle the given problem and the Inference engine which is of forward chaining type. Rule-based approach is used as this is a good candidate to the problems that can be represented in decision tree form. Prototype of the system was successfully implemented and validated. However, further improvement to the system domain knowledge specifications is required to enhance domain knowledge representation.

3 RESEARCH OBJECTIVES

Nowadays, when a car breaks down it is very common to call a road service provider for help. But the customer service representatives (CSR) are very likely to lack of technical knowledge which means that they would not obtain all the relevant information. This results in assistance providers sending towing vehicles not only when necessary but also when the malfunction could be solved on the spot. However, towing vehicles consume much more gasoline than smaller vehicles. So, in order to reduce consumption, effectiveness in finding the car fault and appropriate response of the road assistance company has to be increased.

Thus, in this research interactions between a certain car part malfunction and severity of car fault are explored.

The main objective is to enable our ES to effectively obtain the most relevant information and based on this newly acquired knowledge find a solution for the road service provider. In the case of a minor malfunction this means that the ES has to exactly define the malfunction so that the mechanics can resolve it on spot. Otherwise, towing vehicle is required.

To achieve that, an appropriate knowledge representation and knowledge acquisition rules have to be designed, supported by the statistical analysis of the malfunctions reported to the call center.

4 IMPLEMENTATION

4.1 Architecture

The ES represented in this paper consists of four main parts: knowledge base, user interface, inference engine (IE) and knowledge acquisition (KA) module. It uses the Cyc AI Environment for three of those parts: the knowledge base (Cyc KB), IE and parts of the KA module, as shown in Figure 1.

In the knowledge base, the domain expertise is stored in the form of logical assertions and rules between them. The initial expertise is obtained by a knowledge engineering module which is currently not the part of the final application presented to the user. Furthermore, the KA module enables adding new knowledge to KB via the natural language interface on the fly as the side effect of using the ES. Cyc KB attempts to assemble a comprehensive ontology and knowledge base of everyday common sense knowledge, with the goal of enabling AI applications to perform human-like reasoning. It basically contains all the concepts, expertise and historical data that is available in the ES. Cyc KB is divided into many “contexts” (or “micro theories”) in which assertions that share a common set of assumptions are

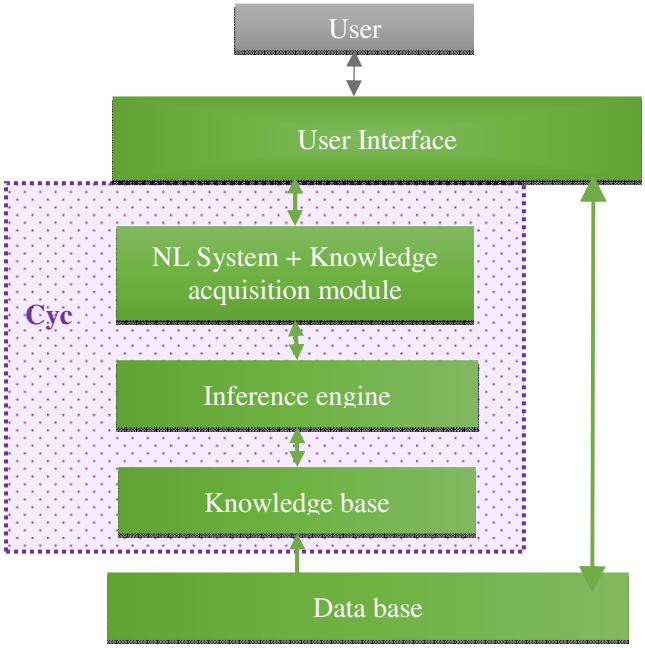


Figure 1: *System's architecture.*

collected. Using contexts makes inference a lot faster by directing it on a relevant set of theories.

User communication is over the list of natural language questions and responses. The language is converted into logic and vice versa in the KA module. Cyc offers a sophisticated natural language (NL) understanding. The lexicon, which is the main component of Cyc NL system, contains information about English words. Each word is represented as a Cyc concept. The system also provides natural language generation from its internal logic language (CycL) knowledge representation. This is achieved by templates that are specific enough to represent the mapping from logic precisely. They use predicates and functions that describe linguistic characteristics of a certain word or sentence. Since the NL Generator is a part of Cyc KB, the user himself can directly create new concepts and assertions in the KB about the specific domain. [5][6]

Here is an example of NL Generation template:

```
In Mt: EnglishParaphraseMt.
f: (genTemplate hasID
(ConcatenatePhrasesFn
   (ParaphraseFn-Np :ARG1)
   (HeadVerbForInitialSubjectFn Have-TheWord)
   (WordFormFn-Constrained nonPlural-Generic ID-
   TheWord)
   (ParaphraseFn-Np :ARG2))).
```

Cyc inference engine does the forward inference over the known facts to produce conclusions and goal-driven backward inference as well when the system is being queried. In forward type of chaining the engine goes through all the rules in knowledge base and triggers those, in which the obtained facts meet the conditions, producing new facts, or assertions which trigger KA module to ask a question or provide a suggestion. The IE is able to produce new questions for the user, relying on the previously acquired knowledge. Cyc can also add assertions independently if new knowledge triggers rules that lead to new conclusions. New assertions can then provoke further rule implementation. However, these assertions are removed from the KB if the data that they depend on become unavailable.

4.2 Functionality of the ES

The system is intended to be used in roadside assistance call centers. It can be utilized by an experienced or non-experienced CSRs. It is designed in a way that it leads the user through the conversation and obtains relevant information in as few questions as possible. The system provides a comprehensive application that can be used in call centers but the focus is on car fault diagnosis Based on the newly acquired knowledge, about a certain issue, the system reasons and tries to ask for additional information until it identifies the car fault reason.
All the collected data is stored in a database, available for further exploration and enlarging the knowledge.

4.3 Ontology

An automobile consists of many parts that can be unified in few main components. These components interact with each other and this makes it a tremendously sophisticated unit. Because of that a car fault diagnosis is a complicated process. For that reason a rule-based approach that can be represented in a complex decision tree is used in our ES.
In the following paragraph a simple CycL example rule used in the reasoning process is presented.

Direction: Forward.
f: (implies
(and
(malfunctionTypeAffectsSit ?SIT RoadVehicle VehicleIgnitionMalfunction)
(situationBeforeEvent ?SIT ConsumerElectronicDevice Device-On)
(stateOfDeviceTypeInSituation ?SIT ChargingSystemIndicatorLight Device-On))
(and
(stuffNeeded ?SIT JumperCables)
(stuffNeeded ?SIT RoadsideAssistanceCar)).

The condition part consists of tree sentences. If the road vehicle is experiencing an ignition malfunction and there was a consumer device turned on before the malfunction arose and the charging system indicator light is turned on then the assistance provider can solve the problem on spot and all the equipment they need are jumper cables.

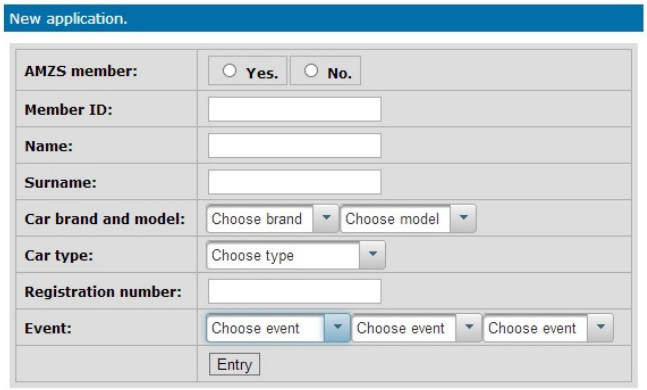


Figure 3: *System's main page.*

4.4 Prototype

When user (CSR) runs the program the main page displays, as shown in Figure 3.
There are a few lines dedicated to collecting client's information and at the end a drop-down menu opens from which the user can choose what the malfunction event is about. In this first level the event is divided into few basic

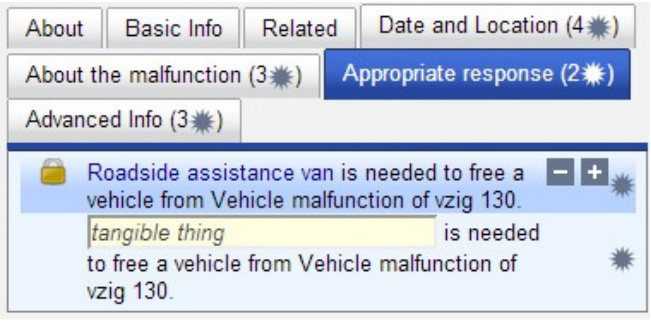


Figure 2: *Firstly proposed solution.*

sub events: ignition malfunction, engine malfunction, chassis malfunction, tire malfunction, transmission malfunction, electricity malfunction, lock malfunction and, if none of this is the case, an option "other" is available. When the user chooses one of these options two more drop-down menus open. They both contain some possible sub events according to the event chosen in the previous step. The user can leave these fields empty if the real event does not correspond to any of the offered possibilities.
When the "Entry" button is chosen all the data is stored in both, database and knowledge base and user is redirected on next page. There a KA window opens showing the facts that are already known and asking further questions, which are chosen correspondingly to the previous answers. All of it is separated into few thematically chosen tabs, which are controlled by knowledge base and inference engine as well.
The following paragraphs are an example of a dialogue that may occur. Let's say that in the main page the user had chosen that the client has problem with igniting the car and further, an electricity consumer was on before that problem occurred.
Based on these two facts Cyc can only tell, according to the rules, in "Appropriate response" tab that a roadside assistance van is required, as shown in Figure 2. Under that there is another very similar sentence starting with a yellow box in which the user can manually assert if anything else is required. "Tangible thing" inside the box is a condition to what that required thing can be. For instance, "sadness" cannot be inserted in that sentence since it is not a specialization of Partially tangible in Cyc's KB. Screwdriver, on the other hand, satisfies the condition.

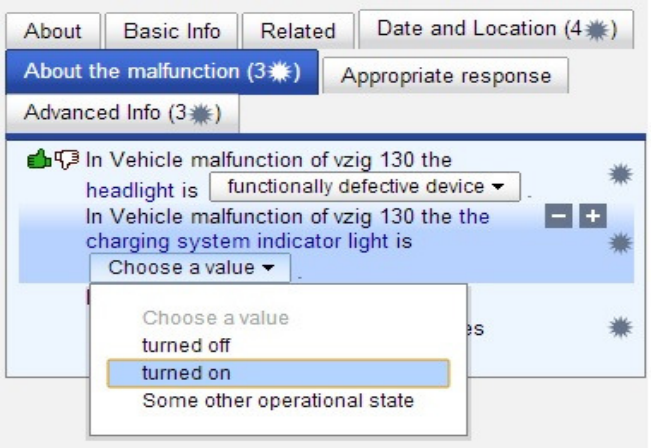


Figure 4: *Knowledge acquisition.*

In Figure 4 we can see the "About the malfunction" tab from the same step. The system asks whether the headlights are malfunctioning – they are, and whether the charging system indicator light is on – it is.

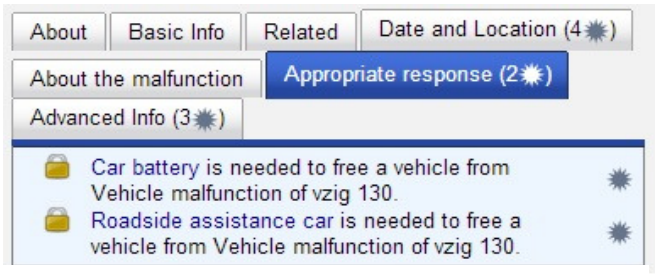


Figure 5: *The lastly proposed solution.*

Our ES processes newly obtained knowledge and provides a new solution, as shown in Figure 5. Now the service can send a car mechanics expert and resolve the problem on the spot, instead of a more expensive option – sending a much bigger vehicle that has a possibility of towing the vehicle into a workshop. Since the final solution was found, no further questions are asked.

5 CONCLUSIONS

In this paper an ES for car failure diagnosis was presented. The system consists of four main components and was implemented using Cyc AI Environment. The proposed system can be used to assist technically inexperienced operators in a roadside assistance call center to obtain the relevant information and diagnose the car fault. During the test phase the system provided appropriate solutions according to the rules. That implies that the final system will be functional and helpful.

However, the information about location of event has to be integrated in the system, since it has a lot of influence on decision making. Also, the logical rules which assist the fault diagnosis process have to be expanded so that the diagnosis can be more exact. The future plan is to extend the KA part to be able to elicit these rules from experts as well. Furthermore, knowledge based on statistical analysis has to be integrated on the fly, so that not only will the system provide solutions for cars in general but it will also recognize and take into account characteristics of individual car brand and models, without encoding this knowledge by hand.

Additionally, an extra branch of the knowledge acquisition module will be implemented. In case the system does not recognize the car fault, the system will obtain the information about it after the event. Meaning, when an expert identifies the fault, feedback is provided and the system learns it. Similarly, feedback should be provided by an expert in case that the system's car fault diagnosis was wrong.

Acknowledgement

This work was supported by the Slovenian Research Agency and the ICT Programme of the EC under MobiS (FP7-318452).

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SEMI-AUTOMATIC RULE CONSTRUCTION FOR SEMANTIC LINKING OF RELATION ARGUMENTS

Janez Starc, Dunja Mladenić
Artificial Intelligence Laboratory
Jožef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
{janez.starc, dunja.mladenic}@ijs.si

ABSTRACT

In this paper, we propose an iterative semi-automatic approach for linking textual arguments of relations to their semantic form using rules. Textual arguments are completely decomposed – every word is considered. They are composed back into semantic form using functions, which bring additional semantic information. The process starts with an initial set of seed rules, which can be obtained automatically. In each iteration, the user constructs new rules using the recommendations, which are calculated based on the frequency statistics of unlinked textual arguments. Our approach was tested on extraction of roles that people have in organizations. The results show that only 31 human crafted rules are needed to link more than 3400 additional arguments. We also show that combining rules have positive effects. The number of linked arguments grows super-linearly with respect to the number of patterns.

1 INTRODUCTION

Lately, methods for relation extraction from text have had a considerable amount of success. Relatively high percision, recall and F1 scores, and very little human intervention are usually their properties. On the other hand, many of them leave the arguments in textual form [1], without automatically linking them to a semantic knowledge base, such as Freebase, DBpedia, OpenCyc. In this way, the extracted knowledge is less actionable and less automated reasoning can be done on it.

For example, suppose some relation extraction method extracted the following relation (isa "blue plastic spoon" KitchenItem) and this is the only relation about "blue plastic spoon". The relation is not wrong, however, more information could be extracted. For example, the observed argument is a spoon, made out of plastic.

(isa "blue plastic spoon" Spoon)
(mainMaterial "blue plastic spoon" Plastic)
(prevailingColor "blue plastic spoon" BlueColor)

The observed entity can also be expressed with one expression, containing the same information as in the three relations above.

(ColorFn (MaterialFn Spoon Plastic) BlueColor)

ColorFn and *MaterialFn* are functions. *MaterialFn* accepts a tangible object and a material as arguments. The result of the function is a new entity. In our case, this is a spoon made out of plastic. This kind of knowledge representation is very suitable for recursive information extraction, where arguments can be further split into sub-arguments. Many functions can be found in Cyc [1].

Noun phrases are usually arguments that are to be linked. However, this is not always the case. For example, in the sentence: *"Stocks will tumble" John told reporters…* it is possible to further extract John's statement.

Rule definition

When extracting relations and establishing connection to a semantic knowledge base, semantic forms are assigned to textual arguments by applying *rules*. A semantic form is composed of functions, predicates and entities from a particular knowledge base. These terms are combined in such a way that they express the meaning of the textual argument. Rules are composed of a lexical part and a semantic part. The lexical part consists of fixed words and empty slots. When the lexical part is applied to the text, empty slots become filled with words and become lexical arguments. The semantic part consists of terms from the knowledge base and empty slots, which become filled with the semantic form of the corresponding lexical argument.

Rules that do not have arguments are *entity rules*. For example,

"Barack Obama" → id39813

In this rule, the name of the US president is assigned an id from a particular knowledge base.

Pattern rules have at least one argument. For instance,

"blue" [object] -> (ColorFn [object] BlueColor)

is the pattern rule that is used in the previous example.

Related work

Our problem has similarities with *entity linking* [2]. The goal of entity linking is to link noun phrases to entities in a large database. However, many noun phrases do not have a corresponding entity in the knowledge base, and some are not even entities. The problem of determining the type of such entities is studied in [3]. In our case, the type of the argument is known from the beginning, similar like in

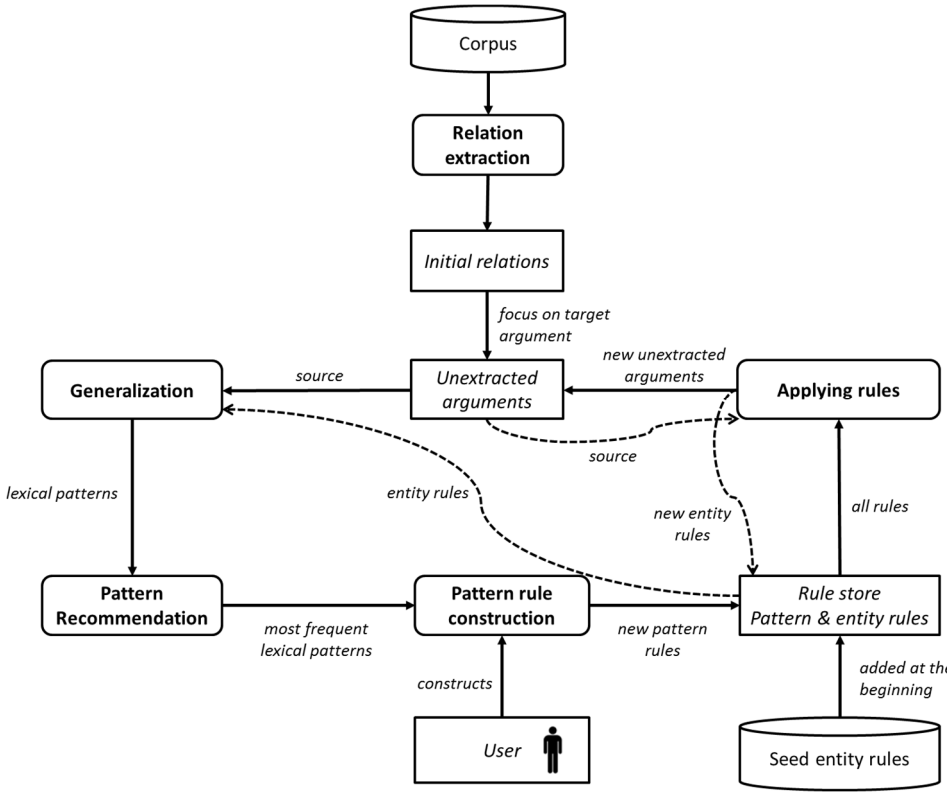


Figure 1: *Architecture of the system*

targeted disambiguation problem, which was examined by [4]. Our goal is not only to discover if the argument belongs to the target type, but also providing additional information by decomposing it.

In the following sections, we first present our approach to link arguments (Section 2). We evaluated our approach on a relation that expresses roles of people in organizations. The experimental setting and results are presented in Section 3. The discussion follows in the final section (Section 4).

2 APPROACH

This section describes the proposed approach. The architecture of the system is presented in **Error! Reference source not found.**. The input to the system consists of (1) a corpus containing several text documents relevant for the rules we would like to construct and (2) seed entity rules providing the starting point for extraction. Seed entity rules should be taken from the target knowledge base. Notice that a human user is also needed to finalize the construction of pattern rules based on the recommendations provided by the system. The result of our approach are rules, which provide links for the selected textual arguments. Selected arguments represent one position in the relation. For instance, we would to link *role* arguments from *roleInOrganization* relations.

*(roleInOrganization person organization **role**)*

Relation extraction

A relation extraction method must be chosen to extract the relations of the selected type from the corpus. This method can be very simple, e.g., a set of hand-crafted patterns or more sophisticated like semi-supervised method from [5]. The selected arguments are placed on the unlinked argument list before the iterative procedure, which is presented in the following section.

Iterative procedure

Each iteration starts with *generalization* of unlinked arguments into lexical patterns. Some lexical patterns are presented to the user as *recommendations*. The user is encouraged to use them as lexical parts in the *pattern rule construction*. Newly created pattern rules are added to the rule store. In the next step, both pattern and entity rules are *applied* on unlinked arguments, which results in new unlinked arguments and entity rules. This is the last step of the iteration and it is explained in details below.

In the first iteration, the user skips his turn and the seed entity rules are added to the empty rule store. Therefore, the first application of rules is done without pattern rules.

For the rest of this section, we will present each step shown in **Error! Reference source not found.** in more details.

Generalization

Generalization is used to group similar arguments into *lexical patterns*. In process of generalization, parts (substrings) of arguments are replaced by their types. For instance:

"vice president" is replaced by [Role],
"London" is replaced by [Location],
"October 2012" is replaced by [Date].

The first example shows the generalization of substrings that are generalized to the type of the observed argument. If a part of an argument matches the lexical part of any entity rule, then it is generalized. The bottom two examples show generalization of other entities. Using named-entity resolution, locations, organizations, people and dates are generalized. Numbers are generalized using part-of-speech tagger. In case, that two overlapping substrings are candidates for generalization, longer substring is generalized. If two overlapping candidates are equal length, the one that starts first is generalized.

Pattern recommendation

The user, who constructs pattern rules, can use the recommended lexical patterns to construct rules that will provide many correct links. Lexical patterns obtained in the generalization step, which do not contain any target type generalizations, are discarded. The remaining lexical patterns are sorted according to their frequencies and only the most frequent lexical patterns are presented to the user. The frequency of the lexical pattern is the number of unlinked arguments that matches it. Different lexical patterns will appear on the top of the list in different iterations. Lexical patterns that have been used in pattern rules will automatically disappear from the list in the succeeding iteration. Other patterns will have at least the frequency they had in the preceding iteration.

Rule construction

For the selected lexical patterns, the user constructs their semantic parts using the terms from the knowledge base or creates new ones. The newly created pattern rules are added to the rule store. Different orders of rules can produce different results. Entity rules are placed before pattern rules. The order of pattern rules is defined by the user.

Applying rules

In this step, the rules from the rule store are applied on each unlinked argument. The algorithm for applying rules on an argument, *ApplyRules,* is presented on **Error! Reference source not found.**. The result of the algorithm is the semantic form of the argument. Completely linked arguments have no empty slots in their semantic form. They are removed from the list of unlinked arguments and moved to the rule store in a form of an entity rule. In this rule, the argument presents the lexical part, and the result of the algorithm presents the semantic part. If the argument is partially linked, which means that some rules did apply, but not all parts are linked, then the unlinked parts are added to the unlinked arguments. In the latter case, where none of the rules apply, the argument is left in the unlinked argument list.

Algorithm 1 ApplyRules

Input: argument Arg, rule store RS, new argument list $NewArgs$
Output: semantic form SF

```
SF ← empty
while RS has more rules and SF = empty do
    rule R = next rule from RS
    if R.semanticPattern matches Arg then
        SF ← R.semanticPattern
        SubArgs = sub arguments from matching
        for each argument Arg′ ∈ SubArgs do
            SubSF ← ApplyRules(Arg′, RS, NewArgs)
            if SubSF = empty then
                add Arg′ to NewArgs
            else
                insert SubSF into SF
            end if
        end for
    end if
end while
```

3 EVALUATION

We evaluated our approach on the *roleInOrganization* relation, which states the role of a person in an organization. For example,

(roleInOrganization 'Peter Murphy' 'The Walt Disney Co.' 'former strategic officer')

We tried to link the last argument of the relation, the role. To extract the initial relations from the corpus, the following pattern was used

[person],[role] of [organization]

The words between the comma and 'of' are taken as the role argument. Although we used only one pattern, there were more than 110.000 matches in a corpus of 1.3 million English news articles.

We prepared the seed entity rules using Freebase data. We have chosen a list of types, including job title, leadership role, academic post title, whose instances are roles. Each instance has one property '*name*' and some of them also have property '*also known as*'. For each instance, at least one entity rule was constructed. The properties mentioned above represent the lexical part of the rule and the id of the instance presents the semantic part.

The user was presented with 30 most frequent lexical patterns on each iteration. The user repeated the process until no useful lexical patterns with frequency above ten were present on the recommendation list.

Results

There were five iterations, in which the user created 31 pattern rules. A selection of constructed rules is presented in **Error! Reference source not found.**. After the rule construction procedure, rules were applied on initial arguments. Without pattern rules there

Lexical part	*Semantic part*	*Applied on # arguments*
the [role]	[role]	2798
[role] and [role]	(and [role] [role])	2085
former [role]	(FormerFn [role])	229
who was [role]	(FormerFn [role])	148
assistant [role]	(AssistantFn [role])	26

Table 1: *A selection of pattern rules from the experiment. Empty slots are denoted with [pos].*

were 10.819 completely linked arguments. If pattern rules are added, than additional 3.428 arguments were completely linked, and 5.123 are partially linked.

To measure the precision and recall, one evaluator evaluated 300 random arguments together with their semantic form. If the argument is completely linked, then it counts as retrieved. If the semantic form represents the right meaning of the retrieved argument, then it is a true positive. The experiment achieved 100% precision and 84% recall.

In many cases, more than one pattern rule must be applied to completely extract an argument. If one rule is missing, then the argument cannot be completely linked. Therefore, rules do not perform well by themselves. Having lots of rules should be beneficial, because they complement each other.

We made an experiment, where we took the arguments and rules constructed in the experiment. We split the experiment into two cases. In the first case, the pattern rules are combined and in the second case they are applied alone. For each number *k* from one to the number of pattern rules, we randomly selected *k* pattern rules and count how many arguments they completely link. In the first case, the rules are applied together. In the second case, each rule is applied separately and the counts are added up. In both cases, arguments that are completely linked without any pattern rule, only with seed entity rules, are not counted. This procedure is repeated several times and the average for each number *k* is calculated. The results are presented on **Error! Reference source not found.**. The trend for the uncombined case is linear. For the combined case the trend is super-linear. If the *k* is maximum (31) then the combined method extracts 24 percent more arguments than uncombined method. The motivation for selecting k rules at random out of all rules was to show that rules have added value if they are combined, and not to measure the growth of linked arguments with every new rule user constructs.

4 DISCUSSION

Our approach does not focus on extraction of relations, but exhaustively extracts information from their arguments. The approach is semi-automatic, thus it needs human intervention. However, our experiment shows that with only 31 human made rules, the number of completely linked arguments increases by 32%. Furthermore, many of these have semantic forms of better quality, because they are composed of functions.

The experiment was done only on one relation - *roleInOrganization*. However, this approach could be used on any relation. It works better if target arguments have many common words, if they can be decomposed with functions, and if enough seed entity rules are provided.

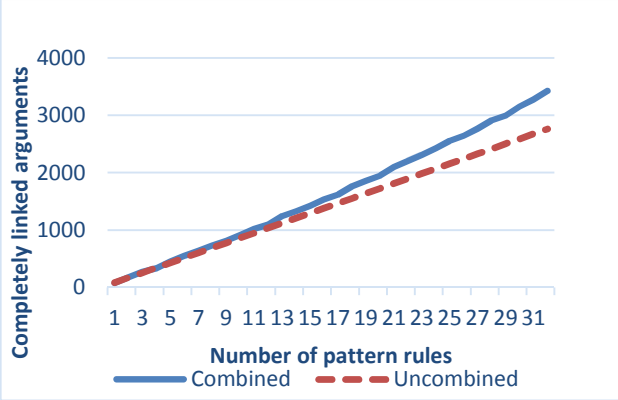


Figure 3 *Comparison of combined and uncombined approach*

Acknowledgements

This work was supported by Slovenian Research Agency and the ICT Programme of the EC under XLike (ICT-STREP-288342).

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PERSONALIZED QUERY AUTO-COMPLETION FOR NEWS SEARCH

Lorand Dali[1], Blaž Fortuna[2], Jan Rupnik[2]
[1]Jožef Stefan International Postgraduate School
[2]Artificial Intelligence Laboratory - Jožef Stefan Institute
[1,2]Jamova cesta 39, 1000 Ljubljana, Slovenia
Tel: +386 1 4773419; fax: +386 1 4251038
e-mail: lorand.dali@ijs.si, blaz.fortuna@ijs.si, jan.rupnik@ijs.si

ABSTRACT

In this paper we study the problem of guessing what search query the user intends to type into a search engine based on the first few characters of the query, also known as prefix based query auto-completion. We train and evaluate two personalized auto-completion models on search logs from an online news portal. The personalization comes from using demographic and location information specific to the user. Our experiments show that we can guess the query the user intended to type and rank it among the top three suggestions over 75% of the time. Moreover, the methods described can decrease the number of keystrokes by about 40%, thus saving the user a lot of typing.

1 INTRODUCTION

Search has certainly become one of the most frequently used computer applications. Keyword search got established as the standard way to do search on the internet. Although keyword search may have its disadvantages, it is appealing to a wide variety of users because it is a very fast and easy to use form of search. One feature which further contributes to the usability of search engines, and which most of the search engines nowadays have, is query auto-completion. Query auto-completion consists of the search engine trying to guess what query the user intends to type before the user finishes typing the query. Most often query auto-completion is prefix based, which means that while the user types the beginning of the query, like for instance 'mo', the search engine suggests possible continuations like '**mo**rning', '**mo**ther', '**mo**nastery', '**mo**on', etc. The main goal of query auto-completion is to save time so that the user does not have to type the full query but can choose from the suggestion instead. Such a timesaving feature is always convenient, but it is a must-have especially on mobile devices where the keyboards are often small, slow and awkward to use, and typing a query can take a lot of effort [1]. With the large increase in usage of mobile devices, auto-completion becomes more and more important and has turned into a necessity, rather than a mere convenience.

Because the main goal of query auto-completion is to save time, it has to satisfy two important requirements. First, the search engine should try to guess what the user wants to type after just a few characters in order to save the user as much typing as possible. Secondly, the suggested queries should be sorted such that the query the user most likely intended to type is at the top of the list. This is to prevent the user losing the time which he gained in typing, to search through the list of suggestions. A user study on mobile search [2] shows that query auto-completion is very appreciated by the users who select a correct suggestion about 90% of the time. This user study also shows that query suggestion increases the cognitive load of a user which results in a 30% increase of time needed to type the query. This means that the number of keystrokes saved due to auto-completion has to be high enough to make the tradeoff worthwhile.

The most straightforward way to satisfy the requirements of query auto-completion is to suggest past queries which begin with the given prefix, and sort them by popularity. In this paper we explore ways of improving on this simple idea. We focus our attention on news search and will try to accomplish better query auto-completion by tailoring the ranking of the suggestions to the specific user who is typing the query. In order to personalize the query completion, we shall take into account several features of the user such as age, gender, job, income, location, etc. It is easy to imagine that users with different attributes, in different contexts will prefer different queries. As an example form our news search data let's take a look at the most preferred queries of a user from France (*michael jackson*, *french*, *paris*, *kenken*, *swine flu*, *paul krugman*, *sarkozy*) versus the preferred queries of a user form the US (*crossword*, *warren buffet*, *sudoku*, *buffett*, *maureen dowd*, *michael jackson*). Additionally to preferring quite different queries, the users from France would also need different suggestions for query completion. For example if a French user starts a query with the letter 's' then he should be suggested *swine flu* and s*arkozy* first, while if the user is from the US then *sudoku* should be suggested. This difference makes sense as the importance which location has in search has been studied [3]. How important information about location is for query auto-completion specifically, is shown in [4]. Additionally we also look at other demographic features and use them to do better query auto-completion. News search lends itself to such experimentation because as opposed to web search, users are often logged in to the news website when doing search and so more personal information can be leveraged.

2 RELATED WORK

Quite a few papers [5][6][7][8][9][10][11][12][13] have been written on mining query logs for automatic query suggestion, also called query recommendation. Given a query of a user, query recommendation consists of suggesting related or alternate queries. In this case the suggestion is made after the user has finished typing the query, and the suggestions are not necessarily morphologically related to the query. Several approaches taking into account the previous queries of the user have been tried. Association rule mining is proposed in [5]. In [6] query-flow graphs are proposed, and in [7] an optimization framework using query-flow graphs is evaluated. Information contained in query sessions is leveraged in [8] and [9] by using query co-occurrence, and in [10], where the similarity between two queries is influenced by how many queries appear chronologically between them in the query history of the user. The queries and search results clicked after the queries are represented as a bipartite graph in [11] and [12]. In [12] a random walk model for query similarity is proposed. In [13], to do clustering of queries into topics, queries are represented by a term-weight vector taking into account not only the query terms but also terms from the documents which were clicked. All related papers mentioned so far focus on query recommendation. The query recommendation problem is slightly different from the problem we tackle because our approach completes the query before the user has finished typing it. Much less research has been done on prefix based query auto-completion. Although the most popular web search engines use auto-completion, there is no detailed description on which models they use and how they work. CONQUER [14] is a context aware prefix-based query suggestion system which uses time of day and location as contextual features for personalizing the query completion. The behavior of users when using auto-completion in mobile search is studied in [2]. In [4], a series of experiments done, studying query auto-completion in the mobile search case. These experiments look at how often a correct query completion can be suggested and how many keystrokes that saves the user on average. The experiments also evaluate the impact of features such as hour, day and location.

Our contribution is a personalized query auto-completion based on user-specific demographic features. As far as we know, an evaluation of the influence of demographic features for query auto-completion or query recommendation was not done previously.

3 DESCRIPTION OF THE DATA

The data we use to experiment with personalized query completion consists of search logs from an online news portal for the period 18th of August – 30th of August 2009. After filtering out some of the entries the data amounts to 380000 searches. The users who perform the searches are also tracked and uniquely identified. From a log entry we can determine what query was asked, which user did the search, and at what time did the search happen.

There are around 250000 unique users in the dataset, and about each of them we have some additional demographic information: gender, age, job, industry, income and the location (city and country) from which the user made the search. We divide the age into ranges: under 21, 21-30, 21-40, 41-50, 51-60 and over 60. The age is quite uniformly distributed, with slightly more younger users. Similarly, the yearly income is also given in ranges. A user can have one of several different types of jobs in one of several different industries. For the location we chose to take into account only the countries and cities which appear at least one thousand times in the logs. If a user has a location which is rarer than this, then the location is considered to be unknown.

The users are of two types, those who have an account on the website and those who do not. For the users who have an account we know all the demographic data which the user has filled out in a form when registering to the site. For the other users we can extract only the location from the IP address, and demographic data is unavailable. Over one third of the users, more exactly 112000, are registered users. Hence the demographic data has many missing values.

The analyzed data contains about 80000 unique queries. There are a few very frequent queries, and a long tail of very rare queries. This power-law distribution is plotted in Figure 1 on a log-log scale. The number of words in a query is usually small. The most queries, 40.78% of them, have two words, 33.44 % are made of one word and 13.79% have three words. Thus almost 90% of the queries are three words or shorter.

In conclusion, for a given search from the log we have the following information:

- The query
- Time when the query was made (hour)
- Information about the user who made the query (gender, age, job, industry, income, city, country)

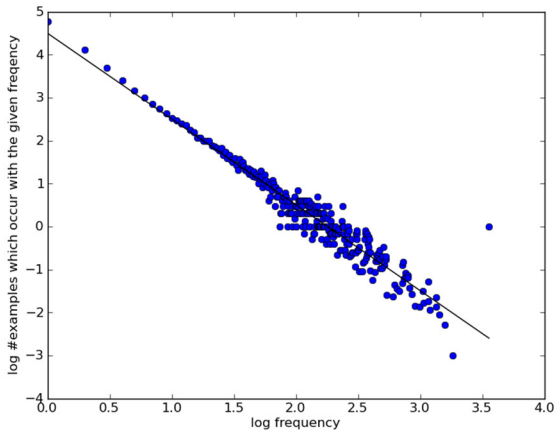


Figure 1: *Power law distribution of the query frequencies plotted on a log-log scale.*

4 QUERY AUTO-COMPLETION

Query auto-completion takes as input a prefix $x$of a query and a set of features of the user $\{F_1, F_2, \cdots F_N\}$ and suggests queries which start with the prefix x and are likely to be

asked by a user with the given features. Suggestions can be only queries which were asked by some user in the past. First we get the set of candidate queries Q which consists of the queries which start with x, and then for each query $q \in Q$ we compute its score by estimating the probability

$$p(q|F_1, F_2, \cdots F_N)$$

The query with the highest score will be suggested as the first option for auto-completion, and so on. Due to sparseness and missing values we cannot directly compute the joint conditional probability to obtain the score. Instead, we shall approximate the score by taking the product of the probabilities:

$$score(q) = p(q) \cdot p(q|F_1) \cdot p(q|F_2) \cdot \ldots \cdot p(q|F_N)$$

The factor $p(q)$, which is the frequency of the query q in the past, penalizes the score if q is rare and boosts it if q is frequent. We do this in order to get a very popular query among the suggestions even if it does not fit the user very well. Intuitively, the score for a query is high if the query is popular by itself and also popular among the queries asked by users who have features in common with this user.

4.1 Baseline Ranking of Query Suggestions

As the baseline query auto-completion we rank the candidate queries according to frequency only. So the first suggestion for a prefix will be the most popular query which begins with that prefix. The baseline is not personalized as it does not take into account any of the user's features.

5 EXPERIMENTS

This section describes several experiments used to evaluate the performance of personalized automatic query completion in general, to identify the best features and subsets of features and to estimate how useful the auto-completion is for the user. In order to be consistent, all the experiments use the same training data and the measurements are made with the same testing examples. The training data consists of the chronologically first 300000 entries in the log. The test examples are selected from the later entries such that they contain no missing values for any of the features. This is because to evaluate a model which takes into account all features we need the values for those features to be present. Although models which take into account only a subset of features may have missing values for the other features we decided to keep the testing data the same to enable a more reliable comparison of the results. We have chosen about 2200 such testing points.

The general idea of the experiments is the following. Given a testing example for which we know the query and the features of the user we take a prefix of the test query and try to suggest queries from the training data. We measure how often the actual query will be found and how high it will be ranked in the list of suggestions. We also look into how long a prefix is required to get good results and which features play a greater role in making correct query completions. The following subsections address each of these problems in detail.

5.1 Measuring Ranking Performance

In order to measure the performance of query auto-completion we look at which rank the correct query has in the list of query suggestions. The correct query is the query from the test example, and we try to guess it from prefixes of length 1, 2, 3 and 4. We evaluate separately for registered and unregistered users. For unregistered users we know: city, country and the time of day when the query was made. For registered users we know additional features like: age, gender, industry, job and income.

The columns R1, R2, R3 show in percentages how often the suggested auto-completion which is correct is on the first place, on the second place and on the third place. The column TOP3 shows how often the correct suggestion makes it into the top three in the suggestion list. The Prefix column shows what length a prefix was used to guess the query. The first column shows which feature set has been used. Knowing this, we can read for instance that the probability product model puts the correct query as the first suggestion 44% of the time when given a prefix of length three and the full feature set.

When comparing to the baseline, it looks like personalized auto-completion is most useful when the prefix is short. As the length of the prefix increases it gets easier to guess the correct query, and the margin by which the baseline is beaten decreases. In some cases the baseline even wins in these situations. Another observation is that our method tends to put the correct query as the first suggestion more often when compared to the baseline. The improvement which the extra features available for registered users give is consistent but not very big. Knowing these extra features improves the performance by 1-2%.

5.2 Dominant Features

In this section we discuss which features are the most important in predicting the correct query completion. In

Table 1: *Auto-completion Evaluation.*

		RANK OF SUGGESTION (%)			
FEATURES	**Prefix**	**R1**	**R2**	**R3**	**TOP3**
UNREG.	**1**	11.50	5.08	2.47	19.06
	2	23.44	10.12	5.39	38.96
	3	43.96	13.53	7.56	65.05
	4	56.87	14.59	5.30	76.78
REGISTERED	**1**	12.07	6.01	2.16	20.25
	2	25.56	9.86	4.90	40.33
	3	44.44	13.79	6.54	64.79
	4	57.71	13.44	4.86	76.02
BASELINE	**1**	9.06	6.19	2.34	17.60
	2	23.07	9.81	5.92	38.83
	3	42.94	14.55	6.59	64.05
	4	57.49	13.48	6.19	77.17

order to do that we define the concept of dominant feature as being the feature F_i for which the probability $p(q|Fi)$ is highest. For each test example we keep just a short prefix from the query and try to guess the rest using personalized query auto-completion. If the correct suggestion is in the top three suggestions then the dominant feature of this ranking is remembered. At the end we have for each feature the number of times it has been the dominant feature. The piechart in Figure 2 shows the distribution obtained using a prefix of 2 and the probability merging auto-completion model. It seems that the city has a slight edge over the other features accounting for about a quarter of the correct suggestions in the top three. Next are industry, job and age which are roughly equal and are the dominant features between 15% and 20% of the time each. Frequency performs poorly compared to the other features. This means that very rarely the correct auto-completion appears in the top three suggestions because of query frequency, and other features play a much greater role.

5.3 Keystrokes Saved

Because the goal of query auto-completion is to save time by guessing the query before the user has completely typed it, the natural question to ask is how much time the proposed approach actually saves for the users. Therefore we counted how many keystrokes our method saved. For each query from the test set we first give the first letter as prefix and run auto-completion. If the actual query gets suggested in the top three suggestions then we assume that the user very likely notices it, chooses it and stops typing, so we have saved the user the length of the query minus one keystrokes.

If the actual query is not one of the top three suggestions, then we assume that the user continues typing and we run auto-completion with prefix of the first two letters, maybe now the correct query makes it into the top three and gets chosen. We go so forth increasing the length of the prefix up to length 4. If for a prefix of length 4 the auto-completion still does not suggest the correct query in the top three suggestions, then we assume that the auto-completion has failed, and we have not saved any keystrokes on this particular query.

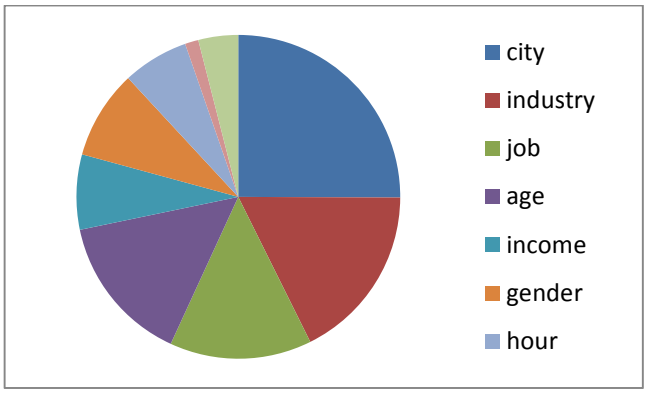


Figure 2: *Relative importance of Demographic Features.*

It turns out that our approach can save on average 5.7 keystrokes per query. Considering that a query in our dataset has on average 13.9 characters it looks like we can reduce the average number of keystrokes used to search to 8.2. This is a huge timesaver if the user uses a mobile device, especially if he has a multitap keyboard.

5.4 Query Suggestion

Automatic query recommendation is a problem very similar to query auto-completion. The difference is that based on the current query and past queries the user gets suggestions of queries which are not necessarily morphologically related to the current query. Although query recommendation is not the focus of our paper, we have to notice that the auto-completion approach which we propose could be applied to the personalized query recommendation scenario as well. We could obtain related queries by dropping the constraint that the suggested query has to start with the prefix. As an example consider a male user, in his thirties, from New York who issued the query *crossword*. Our approach would suggest him the following related queries: *kenken*, *crossword puzzle*, *today's crossword*, *sudoku*, *crosswords*, *puzzle*, *modern love*, *daily crossword*, etc. It is clear that the suggested queries are highly relevant. Most of them are alternative searches for crossword, some are queries for other puzzles and games, and the query *modern love* is not related to puzzles, but it is very specific for the given age group. Please note that the user would miss many of these related queries if the suggestions were based of prefixes only. In the future we plan to investigate this kind of query recommendation and possible combinations of it with prefix based auto-completion.

6 CONCLUSIONS

In conclusion, we have proposed and evaluated prefix-based personalized query auto-completion for news search. The context for personalization comes from user-specific demographic data, and the time of day when the query was made. The results are very promising. We can suggest the correct completion for over 75% of the queries, and we can decrease the number of characters the user needs to type by over 40%. Our work is among the few research works done on prefix-based query auto-completion, and as far as we know it is the only one which uses demographic data for personalized query completion. In the future we plan to focus more on the information which can be obtained from previous queries, and we shall try to combine some ideas from the field of query recommendation into our work.

Acknowledgements

This work was supported by the Slovenian Research Agency amd the ICT Programme of the EC under XLike (ICT-STREP-288342)

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Parameter Estimation for the Latent Dirichlet Allocation

Jaka Špeh, Andrej Muhič, Jan Rupnik
Artificial Intelligence Laboratory
Jožef Stefan Institute
Jamova cesta 39, 1000 Ljubljana, Slovenia
e-mail: {jaka.speh, andrej.muhic, jan.rupnik}@ijs.si

ABSTRACT

We review three algorithms for parameter estimation of the Latent Dirichlet Allocation model: batch variational Bayesian inference, online variational Bayesian inference and inference using collapsed Gibbs sampling. We experimentally compare their time complexity and performance. We find that the online variational Bayesian inference converges faster than the other two inference techniques, with comparable quality of the results.

1 INTRODUCTION

Probabilistic graphical models such as Latent Dirichlet Allocation (LDA) allow us to describe textual documents as a distribution over topics, where the topics are represented as distributions over words. Given a collection of documents, the task of LDA parameter estimation is to find the most likely per-document topic distributions and the most likely topic distributions. The task is based on computing the LDA posterior distribution, which is known to be intractable, but can be tackled by using approximate inference methods.

Modern approximate posterior inference algorithms fall into two categories: sampling approaches and optimization approaches. The sampling approaches are usually based on Markov Chain Monte Carlo (MCMC) sampling. The conceptual idea of these methods is to generate independent samples from the posterior and then reason about the documents and topics. The second category of approaches are the optimization approaches, usually based on variational inference, also called the Variational Bayesian (VB) methods. These methods optimize the closeness (based on the Kullback-Leibler divergence) of the posterior to a simplified parametric distribution.

In this paper, we compare one MCMC and two VB algorithms for approximating the posterior distribution. In the subsequent sections we formally introduce the LDA model and review the inference algorithms. We study the performance of algorithms and make comparisons between them. We use articles from Wikipedia to infer and evaluate the models. We show that Online Variational Bayesian inference is the fastest algorithm. However the accuracy is lower than in the other two, but the results are still good enough for practical use.

2 LDA MODEL

Latent Dirichlet Allocation [1] is a Bayesian probabilistic graphical model, which is regularly used in topic modeling. It assumes M documents are built in the following fashion. First, a collection of K topics (distributions over words) are drawn from a Dirichlet distribution, $\varphi_k \sim \text{Dirichlet}(\beta)$. Then for m-th document, we:

1. Choose a topic distribution $\theta_m \sim \text{Dirichlet}(\alpha)$.
2. For each word $w_{m,n}$ in m-th document:
   i. choose a topic of the word $z_{m,n} \sim \text{Multinomial}(\theta_m)$,
   ii. choose a word $w_{m,n} \sim \text{Multinomial}(\varphi_{z_{m,n}})$.

LDA can be graphically represented using plate notation (Figure 1).

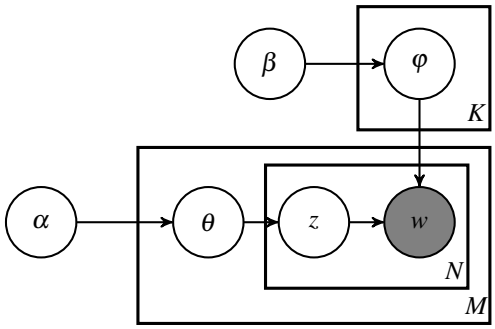


FIGURE 1. Plate notation of LDA.

The total probability of the LDA model is:

$$p(\mathbf{w},\mathbf{z},\theta,\varphi \mid \alpha,\beta) = \prod_{k=1}^{K} p(\varphi_k|\beta) \prod_{m=1}^{M} \left(p(\theta_m|\alpha) \prod_{n=1}^{N_m} p(z_{m,n}|\theta_m) p(w_{m,n}|\varphi_{z_{m,n}}) \right).$$

We can analyze a corpus of documents by computing the posterior distribution of the hidden variables $(\mathbf{z},\theta,\varphi)$ given a document $(\mathbf{w})$. This posterior reveals the latent structure

in the corpus that can be used for prediction or data exploration. Unfortunately, this distribution cannot be computed directly [1], and is usually approximated using Markov Chain Monte Carlo (MCMC) methods or variational inference.

3 ALGORITHMS

In the following subsections, we will derive one MCMC algorithm and two variational Bayes algorithms for the approximation of the posterior inference.

3.1 Collapsed Gibbs sampling

In the collapsed Gibbs sampling we first integrate θ and φ out.

$$p(\mathbf{z}, \mathbf{w} \mid \alpha, \beta) = \int_{\theta} \int_{\varphi} p(\mathbf{z}, \mathbf{w}, \theta, \varphi \mid \alpha, \beta)\, d\theta\, d\varphi.$$

The goal of collapsed Gibbs sampling here is to approximate the distribution $p(\mathbf{z} \mid \mathbf{w}, \alpha, \beta)$. The conditional probability $p(\mathbf{w} \mid \alpha, \beta)$ does not depend on $\mathbf{z}$, therefore Gibbs sampling equations can be derived from $p(\mathbf{z}, \mathbf{w} \mid \alpha, \beta)$ directly. Specifically, we are interested in the following conditional probability:

$$p(z_{m,n} \mid \mathbf{z}_{\neg(m,n)}, \mathbf{w}, \alpha, \beta),$$

where $\mathbf{z}_{\neg(m,n)}$ denotes all z-s but $z_{m,n}$. And furthermore we assume that the omitted word is the vth word in the vocabulary of size V. Note that for collapsed Gibbs sampling we need only to sample a value for $z_{m,n}$ according to the above probability. Thus we only need the probability mass function up to scalar multiplication. Moreover we simplify the model by taking $\alpha_k = \alpha,\ \beta_k = \beta$ for all k. The distribution can be simplified [4, page 22] as:

$$p(z_{m,n} = k \mid \mathbf{z}_{\neg(m,n)}, \mathbf{w}, \alpha, \beta) \propto \frac{n^{(v)}_{k,\neg(m,n)} + \beta}{\sum_{t=1}^{V} (n^{(t)}_{k,\neg(m,n)} + \beta)} \, (n^{(k)}_{m,\neg(m,n)} + \alpha), \tag{1}$$

where $n^{(v)}_k$ refers to the number of times that term v has been observed with topic k, $n^{(k)}_m$ refers to the number of times that topic k has been observed with a word of document m, and $n^{(\cdot)}_{\cdot,\neg(m,n)}$ indicate that the n-th token in m-th document is excluded from the corresponding $n^{(v)}_k$ or $n^{(k)}_m$.

The topics and document topic mixtures can be obtained by [4, page 23]:

$$\varphi_{k,v} = \frac{n^{(v)}_k + \beta}{\sum_{t=1}^{V} (n^{(t)}_k + \beta)}, \quad \theta_{m,k} = \frac{n^{(k)}_m + \alpha}{\sum_{k=1}^{K} (n^{(k)}_m + \alpha)}.$$

In collapsed Gibbs sampling algorithm, we need to remember values of three variables: $z_{m,n}$, $n^{(k)}_m$, and $n^{(v)}_k$, and some sums of these variables for efficiency. The algorithm first initializes $\mathbf{z}$ and computes $n^{(k)}_m$, $n^{(v)}_k$ according to the initialized values. Then in each iteration, the algorithm makes a pass over all the words in all the documents, samples values of $z_{m,n}$ according to Equation (1), and recomputes $n^{(k)}_m$ and $n^{(v)}_k$. Then one has to decide when the Markov chain has converged and which initial samples to discard ("burn in" process).

3.2 Variational Bayesian inference

This algorithm was proposed in the original LDA paper [1]. In Variational Bayesian inference (VB) the true posterior is approximated by a simpler distribution $q(\mathbf{z}, \theta, \phi)$, which is indexed by a set of free parameters [6]. The simplified distribution is illustrated using plate notation in Figure 2. We choose a fully factorized distribution q of the form:

$$\begin{aligned} q(z_{m,n} = k) &= \psi_{m,n,k}, \\ q(\theta_m) &= \text{Dirichlet}(\theta_m \mid \gamma_m), \\ q(\varphi_k) &= \text{Dirichlet}(\varphi_k \mid \lambda_k). \end{aligned}$$

The posterior is parameterized by ψ, γ and λ. We refer to λ as corpus topics and γ as documents topics.

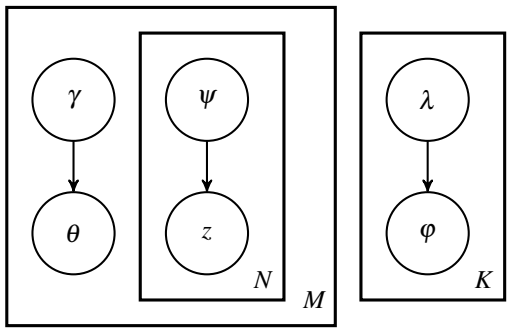


FIGURE 2. Plate notation of parameterized distribution q.

The parameters are optimized to maximize the Evidence Lower Bound (ELBO):

$$\begin{aligned} \log p(\mathbf{w} \mid \alpha, \beta) &\geq \mathscr{L}(\mathbf{w}, \psi, \gamma, \lambda) \\ &= \mathbb{E}_q[\log p(\mathbf{w}, \mathbf{z}, \theta, \varphi \mid \alpha, \beta)] - \mathbb{E}_q[\log q(\mathbf{z}, \theta, \varphi)]. \end{aligned} \tag{2}$$

Maximizing the ELBO is equivalent to minimizing the Kullback-Leibler divergence between $q(\mathbf{z}, \theta, \varphi)$ and the posterior $p(\mathbf{z}, \theta, \varphi \mid \mathbf{w}, \alpha, \beta)$.

ELBO $\mathscr{L}$ can be optimized using coordinate ascent over the variational parameters (detailed derivation in [1, 2]):

$$\psi_{m,v,k} \propto \exp\left\{\mathbb{E}_q[\log \theta_{m,k}] + \mathbb{E}_q[\log \varphi_{k,v}]\right\}, \tag{3}$$

$$\gamma_{m,k} = \alpha + \sum_{v=1}^{V} n_{m,v} \psi_{m,v,k}, \tag{4}$$

$$\lambda_{k,v} = \beta + \sum_{m=1}^{M} n_{m,v} \psi_{m,v,k}, \tag{5}$$

where $n_{m,v}$ is the number of terms v in document m. The expectations are

$$\mathbb{E}_q[\log \theta_{m,k}] = \Psi(\gamma_{m,k}) - \Psi\left(\sum_{\widetilde{k}=1}^{K} \gamma_{m,\widetilde{k}}\right),$$
$$\mathbb{E}_q[\log \varphi_{k,v}] = \Psi(\lambda_{k,v}) - \Psi\left(\sum_{\widetilde{v}=1}^{V} \lambda_{k,\widetilde{v}}\right),$$

where Ψ denotes the digamma function (the first derivative of the logarithm of the gamma function).

The updates of the variational parameters are guaranteed to converge to a stationary point of the ELBO. We can make some parallels with Expectation-Maximization (EM) algorithm [3]. Iterative updates of γ and ψ until convergence, holding λ fixed, can be seen as the "E"-step, and updates of λ, given γ and ψ, can be seen as the "M"-step.

The VB inference algorithm first initializes λ randomly. Then for each documents it does the "E"-step: initializes γ randomly and then until γ converges does the coordinate ascent using Equations (3) and (4). After γ converges, the algorithm performs the "M"-step: sets λ using Equation (4). Each combination "E" and "M"-step improves ELBO. VB inference finishes after relative improvement of $\mathscr{L}$ is less than a pre-prescribed limit or after we reach maximum number of iterations. We define an iteration as "E" + "M"-step. After the algorithm converges, the parameters γ represent document topics and λ represents corpus topics.

3.3 Online Variational Bayesian inference

The previously described algorithm has constant memory requirements. It requires a full pass through the entire corpus on each iteration. Therefore, it is not naturally suited to the online setting. We now present a variant of the algorithm that is more suitable in this case.

The first step is to factorize the ELBO (Equation (2)) into:

$$\begin{aligned}\mathscr{L}(\mathbf{w}, \psi, \gamma, \lambda) = \\ \sum_{m=1}^{M} \{\mathbb{E}_q[\log p(\mathbf{w}_m \mid \theta_m, \mathbf{z}_m, \varphi)] + \mathbb{E}_q[\log p(\mathbf{z}_m \mid \theta_m)] \\ - \mathbb{E}_q[\log q(\mathbf{z}_m)] + \mathbb{E}_q[\log p(\theta_m \mid \alpha)] - \mathbb{E}_q[\log q(\theta_m)] \\ + (\mathbb{E}_q[\log p(\varphi \mid \beta)] - \mathbb{E}_q[\log q(\varphi)])/M\}.\end{aligned}$$

Note that we bring the per corpus topics terms into the summation over documents, and divide them by the number of documents M. This allows us to look at the maximization of the ELBO according to the parameters ψ and γ for each document individually. Therefore, we first maximize ELBO according to the ψ and γ as in the batch algorithm with λ fixed. Then fix ψ and γ and maximize the ELBO over λ, as we will now describe. Let $\gamma(w_m, \lambda)$ and $\psi(w_m, \lambda)$ be the values of γ_m and ψ_m produced by the "E"-step. Our goal is to find λ that maximizes

$$\mathscr{L}(\mathbf{w}, \lambda) = \sum_{m=1}^{M} \ell_m(\mathbf{w_m}, \gamma(\mathbf{w_m}, \lambda), \psi(\mathbf{w_m}, \lambda), \lambda),$$

where $\ell_m(\mathbf{w_m}, \gamma(\mathbf{w_m}, \lambda), \psi(\mathbf{w_m}, \lambda), \lambda)$ is the m-th document's contribution to ELBO.

Then we compute $\widetilde{\lambda}$, the setting of λ that would be optimal with given ψ if our entire corpus consisted of a single document w_m repeated M times:

$$\widetilde{\lambda}_{k,v} = \beta + M n_{m,v} \psi_{m,v,k}.$$

Here M is the number of available documents, the size of the corpus. Then we update λ using a convex combination of its previous value and $\widetilde{\lambda}$: $\lambda = (1-\rho_m)\lambda + \rho_m \widetilde{\lambda}$, where the weight is defined as $\rho_m := (\tau_0 + m)^{-\kappa}$. The parameters κ and τ_0 have the following interpretation: $\tau_0 \geq 0$ slows down the early iterations of the algorithm and $\kappa \in (0.5, 1]$ controls the rate at which old values $\widetilde{\lambda}$ are forgotten. This choice of parameters is essential to ensure convergence, see [5, Subsection 2.3].

To sum up, the algorithm first initializes λ randomly. Then, given a document, it performs the "E"-step as in Variational Bayesian inference. Next it updates λ as discussed above. Finally it moves on to the new document and repeats the process. The algorithm terminates after all documents have been processed. Online Variational Bayesian inference (Online VB) was proposed by Hofffman, Blei and Bach in [5].

4 EXPERIMENTS

We ran several experiments to evaluate algorithms of the LDA model. Our purpose was to compare the time complexity and performance of previously described algorithms. For training and testing corpora we used Wikipedia.

Effectiveness was measured by using perplexity on held-out data, which is defined as

$$\text{perplexity}(\mathbf{w}_{\text{test}}, \lambda) = \exp\left\{-\frac{\sum_{m=1}^{M} \log p(\mathbf{w_m} \mid \lambda)}{\sum_{m=1}^{M} N_m}\right\},$$

where N_m denotes number of words in m-th document. Since we cannot directly compute $\log p(\mathbf{w_m} \mid \lambda)$, we use ELBO as approximation:

$$\begin{aligned}&\text{perplexity}(\mathbf{w}_{\text{test}}, \lambda) \\ &\leq \exp\{-\textstyle\sum_{m=1}^{M} (\mathbb{E}_q[\log p(\mathbf{w_m}, \mathbf{z_m}, \theta_m \mid \varphi)] \\ &\quad - E_q[\log q(\mathbf{z_m}, \theta_m \mid \varphi)])/\textstyle\sum_{m=1}^{M} N_m\}.\end{aligned}$$

We tested three algorithms and ran experiments with varying sizes of training sets: 10,000, 20,000, ..., 80,000. Later we evaluated perplexity on 100 held-out documents. Size of vocabulary was approximately 150,000 words.

In all experiments components of α and β were set to 0.01 and the number of topics K was set to 100. Collapsed Gibbs sampling exhibited problems with convergence of the model parameters: the relative change in $\mathbf{z}$ variable

was never dropped bellow 20% in 1000 iterations. In VB inference, the "E"-step and the "M"-step converge if relative change in γ is under 0.001 and relative improvement of the ELBO is under 0.001, respectively. In the Online VB, the convergence of "E" step is determined the same way is in the batch VB inference. Batchsize was 100 documents, τ_0 was 1024 and κ was equal to 0.7 as proposed in [5].

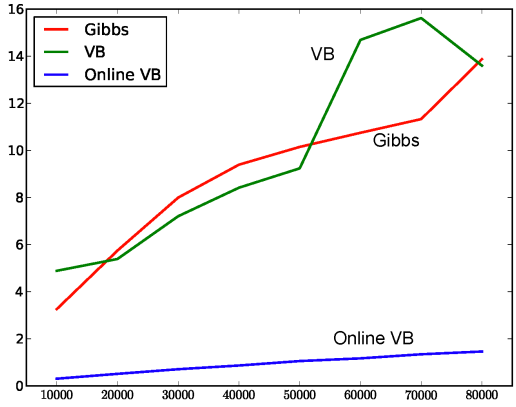


FIGURE 3. Time used by the algorithms (in hours) given the number of the documents.

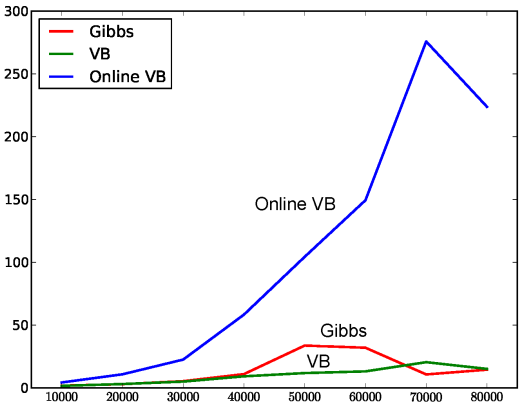


FIGURE 4. Perplexity on held-out documents as a function of number of documents analyzed.

The fastest algorithm is Online VB (see Figure 3), batch VB has a higher time complexity, while Gibbs sampling algorithm did not fully converge.

We would like to compare our results to [5]. So we choose the perplexity on held-out data as the model fit. When measuring the perplexity on held-out data (lower perplexity corresponds to a "better" model) we observed two things: the perplexity slightly increased as the training set size increased in case of batch VB and collapsed Gibbs sampling, while it dramatically increased for the Online VB method (see Figure 4). The results are unexpected: increasing the training set size from 10,000 to 98,000 for the batch VB (Figure 2 in [5]) decreased the perplexity, whereas an increase was observed in our experiments. The behaviour of online VB is drastically different than the one reported in [5]. Note however, that we only computed an upper bound on the perplexity, since computing it exactly is not tractable. This means that the particular method of evaluation gives us very little information on the performance of Online VB. The quality of the topics learned by Online VB was estimated as good based on visual inspection, which could be evidence of the perplexity bound being loose or some instability in computation. The other reason for the different behaviour of the perplexity bound when comparing our work and [5] might lie in the big difference between the vocabulary sizes: 150,000 in our study vs 4,253. Our future goal is to gain a further insight into this issue.

Based on the experiments, the authors recommend using the online VB algorithm for large corpora with large sizes of vocabularies, since scalability becomes an important factor.

5 ACKNOWLEDGMENT

The authors gratefully acknowledge that the funding for this work was provided by the project XLIKE (ICT-257790-STREP).

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DISCOVERING POPULAR EVENTS FROM TWEETS

Călin Railean, Alexandra Moraru
Artificial Intelligence Department
Jožef Stefan Institute
Jamova cesta 39, 1000 Ljubljana, Slovenia
e-mail: calinraileanfirst@yahoo.com, alexandra.moraru@ijs.si

ABSTRACT

Social events happening in a city can influence and affect a large number of the citizens, directly or indirectly involved. Having a metric to measure the popularity of such events can help in estimating the resources needed for handling them, improving facilities such as public transportation or traffic estimations. This paper reports on the problem of association of Tweet messages to social events in order to discover the popularity of an event. We propose and evaluate a method that computes an association coefficient for an event-tweet pair and discuss the results obtained.

1. INTRODUCTION

The open data movement[1] has gained popularity in the last years from more and more platforms providing their data through open application programming interfaces (APIs) or from other initiatives such of open-data government or linked open data. These sources of data give data mining researchers an increasing number of problems to discover and solve. The challenges now come not from getting the data for testing hypotheses, but from finding the appropriate technologies that can handle such large volumes of data.

Social media channels are recognized as highly interactive platforms that report on all kinds of events happening around the world at any moment in time. As a micro-blogging service, Twitter generates constantly a large number of short messages that give the pulse of the communities involved in using it. Research performed on Twitter messages (i.e. tweets) has been a very popular topic in the last years, with applications ranging from sentiment analysis, to opinion mining and from topic model summarization to event extraction [1][2]. The application we are proposing is that of discovering social events popularity from tweets, where social events refer to concerts, festivals, sport events, conferences, etc. Knowing the popularity of an event can help in improving the organization of the infrastructure in the area of the event's location (i.e. scheduling of public transportation, detour paths for traffic decongesting, etc.) in case of high popularity, as well as in alerting the event's organizers for the need of better promotion of the event, in case of low popularity. We start our experiments from the simple hypothesis that the larger the number of tweets associated to an event, the more popular the event is. Therefore the problem reduces to identifying the tweets associated with an event. We propose and implement a method that determines wheatear a tweet is associated to an event and we analyze the performance of the method proposed.

Given the streaming nature of twitter data we considered appropriate to perform our experiments following the Complex Event Processing (CEP) principles. CEP is emerging as a new paradigm for continuous processing of streaming data in order to detect relevant information and provide support for timely reactions. The main role of a CEP engine is to detect the occurrence of event patterns on the incoming streaming data [3]. We implemented our application using a CEP platform that provides classic operators for real time processing of streaming data.

The rest of the paper is organized as follows. Section 2 describes in more detail the problem addressed and introduces the event processing concepts and methods used. Section 3 presents the results of our experiments and the evaluation of the method proposed, while section 4 briefly discusses some of the related work. Finally we conclude the paper.

2. CORRELATION OF SOCIAL EVENTS AND TWEETS

The problem that we address in this paper is to determine the popularity of social events (i.e. music concerts) based on their presence in social media (i.e. tweets). We propose an algorithm that computes the degree of association between events and tweets. Furthermore, we consider that the popularity of an event directly depends on the number of tweets associated.

2.1. Dataset Description

The dataset used for experimentation consists of a set of social events and a set of micro-blogs. The social event set has been collected from an online platform[2] reporting on entertainment events happening in various locations, from sports and concerts to family fun and nightlife. The micro-blogs set refers to tweets collected from the public stream of Twitter[3]. The dataset refers to London city during the time interval from March 6th to April 11th 2013 and comprises10033 social events and over 4 million tweets.

[1] http://en.wikipedia.org/wiki/Open_data

[2] http://eventful.com/

[3] http://twitter.com/

The social events are separated in categories: art, music, conference, attractions, food etc. Each event has 59 fields, from which we were interested in: event title, start and stop time of event, type of event, location, performers name and their "short bio" description. The missing data for some of the events is the stop time, which we determine as the median event duration for each category.

Tweets have 90 fields that include, along with the tweet text, information such as: hash tags, time of posting tweet and geographical coordinates.

2.2. Event Processing with NEsper

NEsper is the .NET version of Esper [4] that shares the same syntax; therefore, throughout the rest of the paper we will refer to it as Esper. The Esper system provides the functionalities of an Event Stream Processing (ESP) system, as well as those of a Complex Event Processing (CEP) system. The interaction with Esper is supported by the Event Processing Language (EPL) that defines the main operators for expressing queries that are run by the engine. It is designed for a high-volume of data where one cannot store all information in database and process it in real time by using classical database queries. It is used in several areas such as finance, fraud detection, medicine where decisions need to be made as fast as possible.

The principle of the Esper system is that it allows registering queries in the engine and creates a listener class that will be called if the incoming event matches one of the inserted queries. The query can contain timeline windows, filtering, aggregation and sorting operators. Another functionality of the Esper system is to generate a new stream as combinations between two or more input streams. The EPL statement used in our applications is the following:

```
select * from pattern [every Event ->
every Tweet(Event.Stop_Time-
Tweet.Time>0)]
```

which is similar to an inner-join statement from classical database management systems, where the join condition is represented by the time constraint. In order to obtain only the combinations that overlap over time, we use a pattern-based event stream structure, on which we specify the time constraints we want to impose. Therefore, the event stream generated will contain only the event-tweet pairs for which the timestamp for the tweet is between that start and stop time of the event or two hours before the event (the start time of the event is altered with two hours before the initial start time). For each event-tweet pair we call a method that calculates the degree of association between a tweet and a social event. To determine the degree of association, we use an *association coefficient* (AC) defined by the next formula:

$$AC = 0.5 * P + 0.25 * W + 0.125 * L + 0.125 * B,$$

where P = 1 if tweet text contains the event's performer name, W is calculated by number of words matching between the tweet's text and the event's title divided by the total number of words in the event's title, L = 1 if location name is found in tweet's text and B = 1 if the tweet's text contains short-bio description of the performer. The weights of these parameters are set based on a common sense understanding of their meaning.

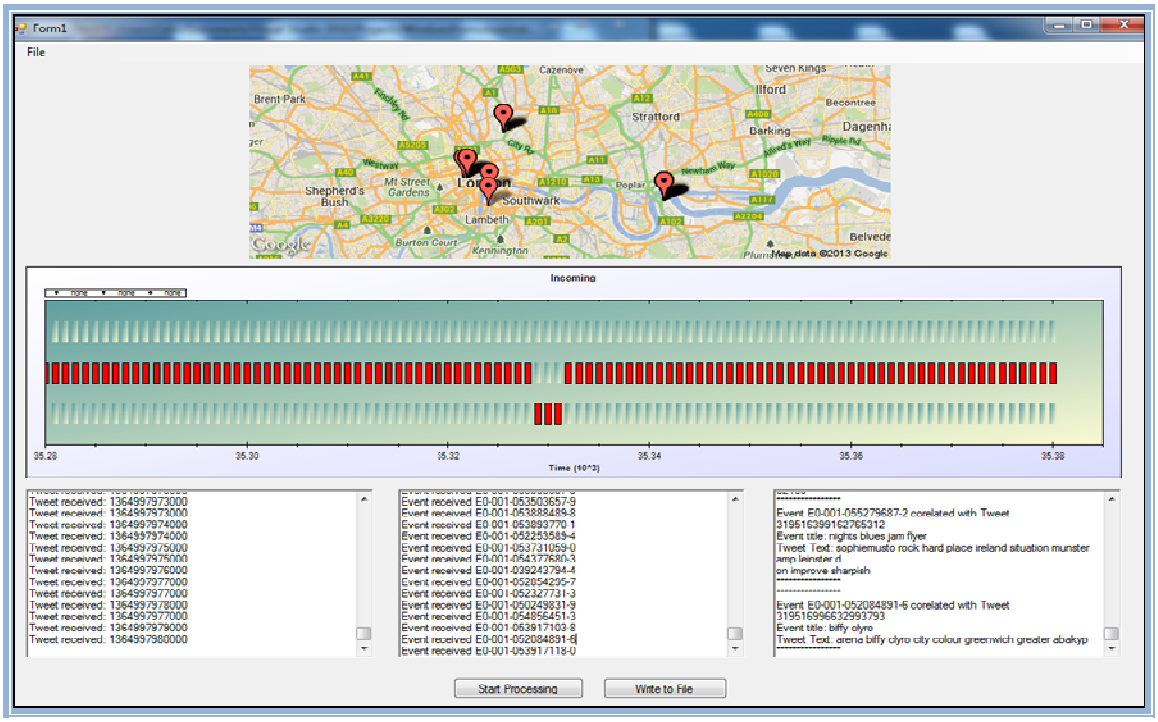


Figure 1: *GUI of the application developed for running experiments.*

.

In addition, in the preprocessing steps we used a stop-word list for eliminating words such as: “this”, “and”, “that” from the event’s title and tweet’s text.

As an illustrative example, let us consider the event with the title “*Halestorm*”. The performer’s name is included in the title and the associated tweet is: “*I'm at @eballroomcamden for Halestorm, In This Moment and Sacred Mother Tongue*”. As the word “*Halestorm*” from the tweet is found in the event title and in the performer’s name, we assign an AC value of 0.75 (0.25 points for W and 0.5 for P).

For a better visualization of how the application processing flows, we created a graphical user interface (GUI) that shows us in real time all steps of data processing (Figure 1): locations of events, events and tweets received and some information about them. The application also registers all correlated events and tweets and gives the option to save the results at any time.

3. RESULTS

The results of the processing performed with the Esper system comprise 15455 tweets correlated with 572 music events having the AC higher than 0.25 (with an average of 27 tweets per event). From these, 5600 tweets were associated in the 2 hours interval before the event start time and the rest during the events. Figure 2 illustrates the influence of AC over the average number of tweets associated with an event, so if the AC threshold increases, the number of tweets per event decrease Specific examples of event-tweet associations can be found in Table 1. We can observe that the association with event title “Union” is incorrect because the tweet refers to union council and not Union music band. Similarly, two more examples are incorrect because the event titles have commonly used

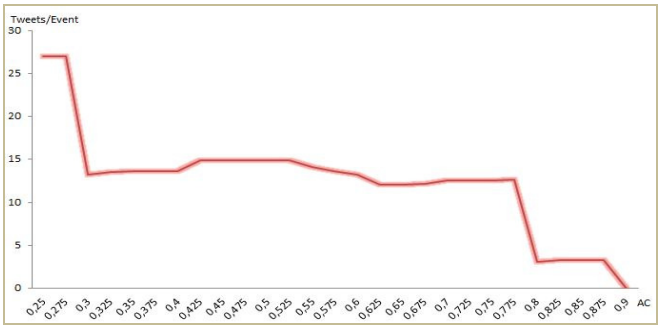


Figure 2 : *Tweets-Events ratio for different values of AC.*

words and they are mistakenly associated with the tweet. However, the other examples show correct associations, indicating that the coefficient defined can yield positive results. Moreover, it can be observed that the highest values of AC are obtained by the events that have the name of the artist in their title. In order to analyze the performance of AC we manually evaluated a sample of event-tweet association, as it is explained in the next section.

3.1. Evaluation and Discussion

A low value of AC is understood as a low degree of association between the tweet and the event analyzed. In order to analyze the performance of AC we have manually evaluated a random set of associations of events and tweets. We first set a threshold value for AC to 0.25 and then we randomly selected 100 associations of events and tweets where AC was higher than 0.25. Two human annotators have analyzed the tweet and the event title and evaluated them as correct or incorrect. The inter-annotator agreement has been calculated in order to illustrate the utility of the annotator’s results. The inter-annotator agreement, or Cohen’s kappa coefficient, is described by the next equation [5]:

$$k = \frac{\Pr(a) - \Pr(e)}{1 - \Pr(e)},$$

Table 1: *Example of event-tweet associations.*

Event Title	Tweet	AC	Event Popularity
Olly Murs	I'm at O2 Arena - @the_o2 for Olly Murs, Tich and Loveable Rogues (Greenwich, Greater London) w/ 8 others http://t.co/lDTRyUTCpb	0.75	23
Halestorm	I'm at @eballroomcamden for Halestorm, In This Moment and Sacred Mother Tongue	0.75	9
Beyonce	#NowWatching @Beyonce #LifeisButADream	0.75	9
The Script	O2 arena the script http://t.co/nItxTURl88	0.75	54
Bastille	Seeing \"Bastille\". I am cool and with it. (@ O2 Shepherd's Bush Empire - @o2sbe w/ 7 others) http://t.co/BweCOsv4s5	0.75	106
Thursday Night	"#bigreunion concert on a Thursday night. Loving it!	0.25	98
Union	tweeting union council agenda avidly from @UKMStudentLive"	0.25	16
Over The Moon	Because of this, ive lost my faith in humanity! I'm done, *disappears to moon*	0.25	21
Everything on Red! -Columbia-Sabre Tooth Monk–Metropolis-Dogdaze	No red card will ever too that	0.535	118

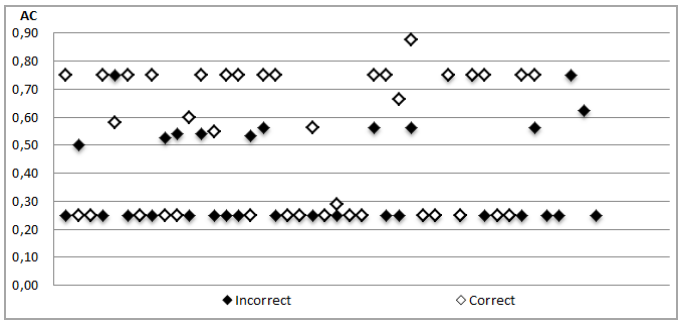


Figure 3: *Values of AC for the associations of tweets and events evaluated.*

where Pr(*a*) is the relative observed agreement among annotator, and Pr(*e*) is the hypothetical probability of chance agreement. We obtained a Cohen's kappa coefficient equal to 0.661 for the two annotators, which can be considered as a "substantial" level of agreement [5].

The next step was to analyze the annotated associations, considering only those for which the annotators gave the same score. The analysis revealed that the average value of AC for the correct associations is higher than the average value of AC for the incorrect ones: 0.52 and 0.36, indicating that the AC defined is a fair metric for association. Further analysis of the performance of AC is done in Figure 3 and Figure 4. Figure 3 shows that the values of AC for correct associations are generally higher that the values of AC for incorrect ones.

Next, we have analyzed the precision of correct associations, calculated as the ratio between the number of correct associations and the total number of associations. As, expected, the precision of tweet event associations increases with the increase of AC, and a more detailed relation between AC and precision can be observed in Figure 4. Although the recall performance would have been an interesting measure to analyze, it was considered too expensive to be done manually. A larger dataset fully annotated would be more appropriated for such an analysis.

4. RELATED WORK

A large amount of research on Twitter messages has been performed and reported in literature and a full comparison of the work presented with other work is out of the scope of this paper. However, we would like to mention the work reported in [1] where a system for processing tweets in real time is introduced. The applications tackled refer to sentiments analysis and detection of term frequencies in real time. Although our method is not comparable in terms of complexity with the methods proposed in [1], the similarity can be found on the stream processing concept. Another similar problem is reported in [2], where the problem addressed is that of linking tweets with news articles. The authors propose a graph based latent variable model for enriching the short text of tweets in order to create a larger context for it. Finally, in [6], another study over open data sources for London city presents the results of possible associations between social events, weather data and traffic.

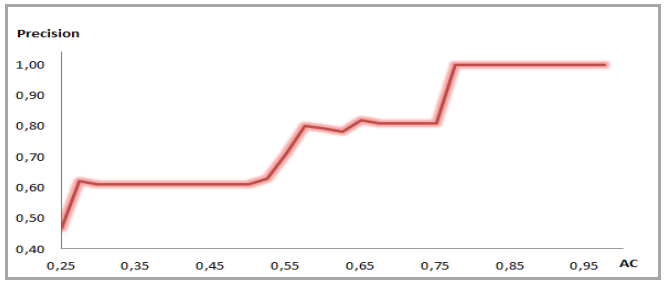


Figure 4: *Precision performance for different values of AC.*

5. CONCLUSIONS

We have proposed and evaluated a method for discovering the popularity of social events happening in the city of London, based on tweets. The results show that the method proposed yields a positive outcome and is a valid solution for the problem addressed. The number of false positive associations of events and tweets can be decreased by setting a higher threshold for the AC coefficient. Further improvements of the method may be brought by including geo-location parameters in the AC equation, as well as by improving the preprocessing of data in terms of extension of the stop-word list or by including natural language processing techniques.

Acknowledgements

This work was supported by the Slovenian Research Agency and the ICT Programme of the EC under PlanetData (ICT-NoE-257641).

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USAGE OF THE KALMAN FILTER FOR DATA CLEANING OF SENSOR DATA

Klemen Kenda, Jasna Škrbec, Maja Škrjanc
Artificial Intelligence Laboratory
Jožef Stefan Institute
Jamova cesta 39, 1000 Ljubljana, Slovenia
Tel: +386 1 4773528; fax: +386 1 4773851
e-mail: klemen.kenda@ijs.si

ABSTRACT

This paper presents a methodology for data cleaning of sensor data using the Kalman filter. The Kalman filter is an on-line algorithm and as such is ideal for usage on the sensor data streams. The Kalman filter learns parameters of a user-specified underlying model which models the phenomena the sensor is measuring. Usage of the Kalman filter is proposed to predict the expected values of the measuring process in the near future and to detect the anomalies in the data stream. Furthermore the Kalman filter prediction can be used to replace missing or invalid values in the data stream. Algorithm only requires sensor measurements as an input, which makes it ideal to be placed as near to the resource tier in the N-tier architecture as possible.

1 INTRODUCTION

A sensor measurement today is cheap. One single sensor can produce thousands of measurements per day, per hour or even per minute. However, such measurements have often proven to be unreliable (not being delivered), a subject to environmental or system noise or even invalid, which quite often happens due to network failures or software errors along the process pipeline.

Due to the high volume of sensor measurements data cleaning should be performed in a computationally efficient way.

In this paper we propose the usage of the Kalman filter [2] to assist the data cleaning process. We propose to use prediction part of the Kalman filter for filling in the missing values in the sensor data stream. We propose to take advantage of prediction also with the detection of invalid sensor measurements. It is possible to perform a simple anomaly detection, based on comparison of new measurements and predictions and then according to the previously learned thresholds decide whether the new measurement is valid or not.

For the learning of thresholds we propose a semi-supervised method, where the user follows the evaluation of sensor measurements on a sample dataset and decides whether a measurement is an outlier or not.

Section 2 presents basics of the Kalman filter, relevant for understanding its role in the data cleaning process, which is described in Section 3. In Section 4 we propose the placement of data cleaning component within the N-tier architecture. We proceed with a presentation of prototype results on a sample sensor dataset where we also discuss a question and solution for the instability of the method. We finish with conclusion and ideas for the future work.

2 THE KALMAN FILTER

The Kalman filter is a method for solving the discrete-data linear problem. The filter consists of a set of mathematical equations that can estimate the underlying (hidden) state of a process in a way that the mean of the squared error is minimized. The filter supports estimation of past, present and even future states [5].

Underlying process to be modeled is a Gauss-Markov process (see Figure 1). This means that any subsequent state is only dependent on the previous state of the system. Figure depicts observations (in our case sensor measurements) x_j and underlying hidden states θ_j (vectors of a real value of the measured phenomena and its first and second temporal derivative). The arrows in the figure depict the Gaussian processes and point from underlying state θ_j to the next state θ_{j+1} (transitional equation) and also from the underlying state θ_j to the observable state of the system x_j (observational equation).

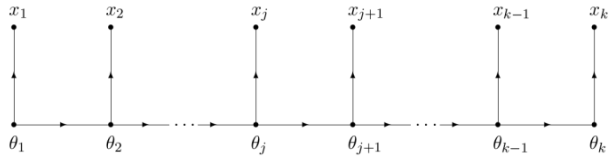


Figure 1: *Diagram of the Gauss-Markov process.*

The result of solving such a problem is a set of equations that include prediction and correction phase depicted in Figure 2. Comprehensive explanation and derivation of the filter equations can be found in the literature [3][4].

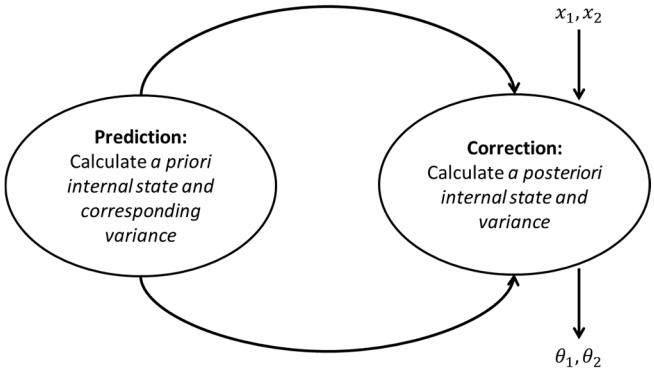


Figure 2: *Kalman filter schema – prediction and correction phase.*

The Kalman filter loop consists of two phases. Correction and prediction phase. The correction phase takes a measurement (x_j) and corrects the prediction (or the initial state) of the system. The correction phase also updates the underlying model parameters of the filter, which makes the filter adaptive. This means that the model is changing according to the measurements in an on-line manner. The prediction phase relies on the model-nature of the algorithm and is therefore able to project the current underlying state of the system into the future.

To illustrate the prediction phase of the Kalman filter only one equation from the whole set needs to be understood – the transitional equation below.

$$\theta_{k+1}^{-} = \Phi_k \theta_k$$

The new *a priori* state (prediction) θ_{k+1}^{-} is obtained by simply multiplying the transitional matrix Φ_k with the *a posteriori* state vector (previous correction). In our case, each row in the transitional matrix describes how each element of the state vector is transformed.

3 DATA CLEANING

Data cleaning is the first step to a proper preparation of input data stream for the research. The process of data cleaning detects and corrects data, which is corrupt, inaccurate, incorrect, incomplete, irrelevant, duplicated or missing. The data is corrected with a replacement or modification. The input of valid and correct data is very important for modeling, detection and prediction methods. Data cleaning includes data transformation, elimination of duplicated values, detection of missing data, statistical methods, error correction and detection of lost information.

Data obtained from sensors can contain many errors, which may happen at the sensor level (the power supply is cut off, a sensors environment changes, mechanical failure, or a sensor measures imprecisely) or during the transfer of the measurement to the data acquisition system (a network problem, errors in gathering software or device, communication with a sensor is lost) [1].

In the process, decisions need to be made how to handle missing values, how big will be threshold and how data cleaning will be achieved with a live data stream. All these decisions have to be based on a profound analysis and knowledge of the raw data.

3.1 Kalman Filter for Data Cleaning of Sensor Data

In our experience, the characteristics of the sensor data are as follows:

- streaming (on-line)
- high frequency (i.e. sensor readings are much more frequent than big changes of the property they are measuring)
- measured property is continuous and is changing smoothly (no big sudden jumps are expected with most of the properties; exceptions should be handled in the phase of semi-supervised initialization of the data cleaning filter)
- there are either only vague or too complex models for modeling the physical phenomena being measured

Considering the features above, we conclude that Kalman filtering is a suitable method for detecting outliers in sensor data. With its prediction features, one can also be able to replace the incorrect or missing data in the sensor data stream.

We propose a second-degree model (also suggested in [5]) that takes into account first and second order temporal derivatives of the measured properties. The equalities in Figure 3 define the state vector and the model to be used with a Kalman filter for data cleaning. A denotes the physical phenomena the sensor is measuring, and t the time. The state vector θ_k is 3-dimensional and includes the actual value of the physical phenomena in the first component, its first temporal derivative in the second component and its second temporal derivative in the third component.

$$\theta_k = (A, dA/dt, d^2A/dt^2)$$

$$\Phi_k = \begin{pmatrix} 1 & \Delta t & \frac{1}{2}\Delta t^2 \\ 0 & 1 & \Delta t \\ 0 & 0 & 1 \end{pmatrix}$$

Figure 3: *The state vector and the transitional matrix in a dynamic linear model.*

The concept of usage is straightforward. We exploit the prediction phase of the Kalman filter to predict the value of the measured phenomena for the timestamp of the measurement. Based on the comparison of the prediction with the actual value, the system decides whether the new measurement is correct or if it should be classified as an outlier. The difference between prediction and measurement is interpreted in terms of variance.

Figure 4 shows two examples for assessing whether a new measurement is an outlier or not. The principle can be generalized to any method using the prediction, not only Kalman filtering. In the first case prediction lies within the defined gap and in the second case the measurement lies outside the gap and is therefore discarded. The gap could be learned with a semi-supervised method, where the user would assist the algorythm by manually annotating the *good* measurements and outliers in the training set. The set

defines a hard border for the gap: every measurement that falls outside the gap is considered as an outlier to the algorythm.

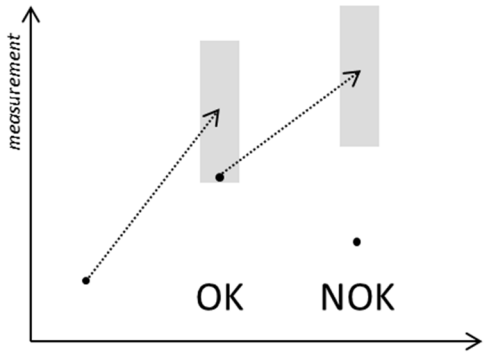


Figure 4: *Evaluation of new measurements with Kalman filter prediction and learned threshold.*

Stochastic invalid or missing values can be replaced with prediction values of the Kalman filter. These errors occur at random and usually represent single, isolated events. The second class of invalid/missing values represents those which are a consequence of a system failure (device or network), last longer and can not be compensated.

4 ARCHITECTURE

Many sensor network systems architecture is based on the N-Tier scheme. We propose to keep the data cleaning as close to the resource tier as possible. This enables all the upper layers to use cleaned data. Kalman filtering approach that we propose is relatively independent. It only needs sensor measurements to function properly and can be therefore implemented even at the sensor itself. However, we propose implementation just above the Data Access Tier (see Figure 5), which enables uniform access to all the data sources and optimizes the implementation.

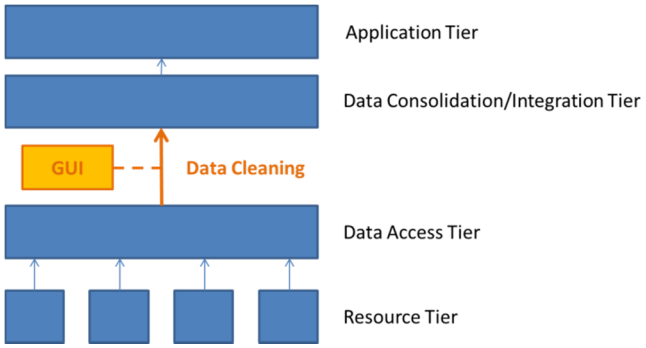


Figure 5: *Position of data cleaning within the system architecture.*

It needs to be pointed out that with such an approach we lose the possibility of data fusion aiding the data cleaning methods (e.g. using spatially or semantically correlated sensors).

The data cleaning process is semi-supervised, which in the context of on-line data streams means that the supervised part should be executed off-line. Supervised process includes data analysis and fine-tuning of parameters. Fine-tuning of parameters is done via a dedicated data cleaning GUI, where the expert user is able to supervise the process of data cleaning. After this process is finished, data cleaning can run automatically.

5 EVALUATION ON THE USE-CASE

The proposed methodology has been implemented in an early prototype for Data Cleaning in the NRG4Cast project. Experiments have been performed on the outside temperature dataset with one sensor reading per 15 minutes. The dataset included measurements from July to August 2013 with occasional stochastic failures in the form of 0.0˚C readings.

Figure 6 shows basic principle of the algorithm. The Kalman filter in its prediction phase returns two relevant values: prediction for the value of the temperature and its variance. After semi-supervised stage, an expert user has determined proper upper and lower bound interval, which was 5σ (only observing the first dimension of state vector).

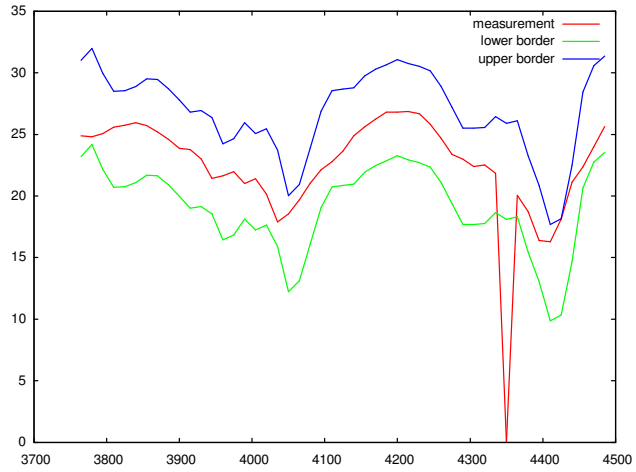


Figure 6: *Identifying an outlier with the Kalman filter.*

Figure shows the upper and lower boundary calculated from prediction and its variance and the actual measurements. Where a measurement lies outside the band delimited by the lower and upper boundary an outlier is detected.

With a good choice of model parameters, we have been able to achieve the results that included all the true positives and none of the false negatives. However, errors in the dataset have been specific and easily identifiable in the summer time (with high temperatures). The most difficult problem for the algorithm was a sudden change in temperature – as expected.

The Kalman filter is not a complex algorithm, but it can be difficult to adjust all the required initial conditions and parameters, which demand either an expert user or a statistical method to adjust them. With optimal tuning of the parameters very good results can be achieved.

6.1 Instability

The principle had proven to be unstable and the Kalman filter prediction had diverged in some cases. If the filter encounters a false negative it relies on the prediction model, which can then move the lower/upper boundary so that no measurement ever again fits the criteria (see Figure 7).

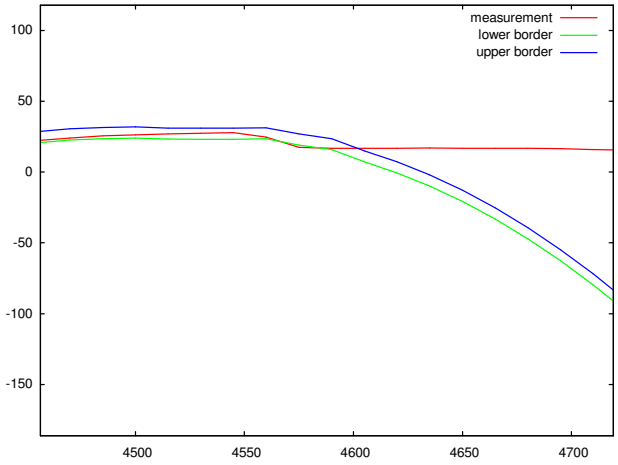


Figure 7: *Instability of the algorithm when detecting a false negative.*

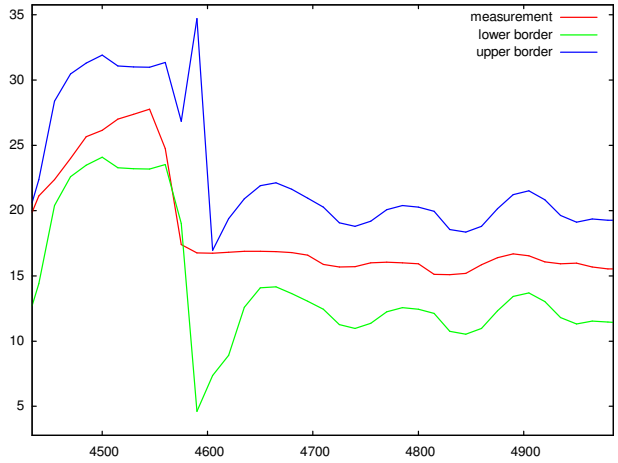


Figure 8: *Instability workaround.*

A possible workaround includes an artificial increase of *a posteriori* variance (see band enlargement after false negative in the Figure 8). Theoretically, changing variance is mathematically incorrect, but in practice it has proven to be efficient. Besides, variance in the case of slowly changing values of sensor data soon converges to the vicinity of the correct values. Further research on the proposed approach is needed.

6 CONCLUSION AND FUTURE WORK

We have proposed a methodology for data cleaning of the sensor data that requires no complex data processing. It relies solely on sensor measurements and initialization data. The use of this approach is possible already at the data source, but we propose to use it just above the Data Tier in the N-Tier system architecture, which still enables upper layers (Integration and Application Tier) to work with clean data. There is however a trade-off between complexity and efficiency, which has not been examined.

We have tested some basic linear models with the Kalman filter equations and proposed to use a general second-degree model with sensor measurements. Kalman filtering results (its prediction and corresponding variance) have been proposed to be used for detection of outliers in the data stream. Method has been successfully tested on an environmental dataset.

As the experiments revealed an instability of the approach we have successfully addressed the issue with a modification of the algorithm.

Many interesting ideas have been identified for the future work. A very big problem when using the Kalman filter is initialization of the filter. One needs to optimize the behavior of the filter to a large number of parameters (approx. 20 for a 3-dimensional model). It would be interesting to investigate an optimization with gradient descent or other efficient methods (Levenberg-Marquardt), where the measure to minimize would be the χ^2 measure.

Another idea would include a more explicit definition of the instability workaround with increasing *a posteriori* variance.

An algorithm should be used, which reduces number of initial parameters (initial variance and internal state) [6] and which would replace the classical Kalman filter.

Acknowledgements

This work was supported by the Slovenian Research Agency, by the Ministry of Education, Science and Sport within the Competence Center Open Communications Platform and the ICT Programme of the EC under PlanetData (ICT-NoE-257641), ENVISION (IST-2009-249120) and NRG4Cast (ICT-EeB- 600074).

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EVENT PROCESSING IN ASSET MANAGEMENT

Maja Škrjanc[1], Klemen Kenda[1], Gašper Pintarič[2]
Artificial Intelligence Laboratory, Jožef Stefan Institute[1]
Špica International d.o.o.[2]
Jamova cesta 39, 1000 Ljubljana, Slovenia
Tel: +386 1 4773528; fax: +386 1 4773851
e-mail: maja.skrjanc@ijs.si

ABSTRACT

This paper presents the conceptual architecture of the system for optimization of maintenance of assets that are equipped with adequate sensors. Beside the conceptual architecture we also present our implementation in the telecommunications use case, where we developed a system that helps optimizing technician response time and reduces effort needed for resolving problems with maintaining the mobile telephony base stations.

1 INTRODUCTION

Maintenance of remote assets is a task that can be significantly optimized, when the correct data about the state of the asset can be provided. This means that the assets have to be equipped with appropriate sensors to measure the state of the system, relevant external data needs to be provided and a pipeline for the streaming sensor data needs to be in place. With these prerequisites fulfilled, a system can be developed to support event detection and fast and efficient response time by technicians in case of failures or other alarms.

The market for applications of Complex Event Processing (CEP) is estimated to grow enormously across various industry verticals like banking and healthcare in the next 5 years. By using CEP technology, organizations can monitor and predict compliance risks in advance, ensure smoothness of business processes and remove inconsistencies [8]. Therefore, some of the software providers such as TIBCO, Oracle, IBM and many others are already providing CEP technologies in their software product portfolio. These solutions however come in packages that require demanding calibration and final implementation process. These types of solutions also do not support bottom up approach, which is crucial for a learning organization.

In the paper we describe the conceptual architecture for Asset Management (ASM) system and present a partial implementation that has been carried out in a use case in the KC OpComm project. The implementation uses a bottom up approach, since it supports learning process in the organization. It also enables external data usage and provides event triggers in a human readable form.

In section 2 we discuss the conceptual architecture, where the central part handling also event processing is taken by a dedicated stream processing engine, which we discuss in section 3. Section 4 is dedicated to event processing, where two main tasks are rule discovery and event detection. In section 5 we present our implementation of the system and conclude in section 6.

2 CONCEPTUAL ARCHITECTURE

Conceptual architecture of the system is depicted in Figure 1. It consists of analytical platform, which is essentially a stream processing engine, which includes event detection engine (ED) and analytical capabilities to aid an expert user to discover, test and refine rule definitions for events. When rule conditions are fulfilled, an alarm is triggered. Alarm consists of an asset ID, priority and a basic description. Basic description can also be generated with a natural language module.

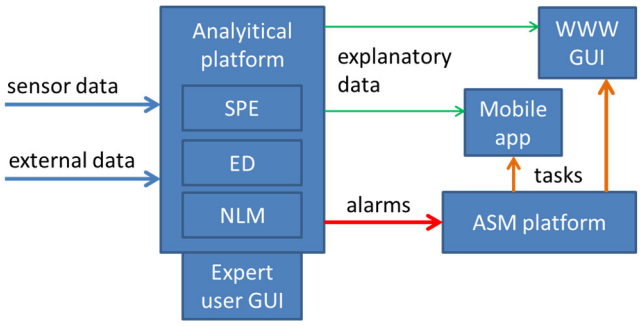


Figure 1: *Proposed conceptual architecture for event processing in asset management use case. SPE represents Stream Processing Engine, ED Event Detection and NLM Natural Language Module.*

Alarms are sent to the ASM platform. ASM platform is able to enrich alarm information with additional data, such as recent measurements or measurement aggregates from the relevant sensors or external data sources or with the detailed

information about the rule that triggered the alarm. This additional information could be describing weather conditions or electrical properties of relevant electronic devices. The information about the underlying causes of an alarm are important for further steps in the alarm resolution process. All the described information is used to create appropriate response actions.

These response actions include assignment of tasks to the responsible personell, task scheduling and other administrative actions. End user, who is typically a technician in charge of an intervention at the asset, is notified of the alarm via instant messaging (typically via SMS) and can then further investigate the issue either via a dedicated mobile app or a WWW graphical user interface.

For instance, one of the triggers could be device malfunction. In this case the maintenance personell would recieve the work order and could then execute the repair in the shortest possible time. Arrows in the left side of the figure represent incoming sensor and external data. There are two types of outputs from the analytical platform: outgoing alarms, detected by Event Processing engine and explanatory data that is retrieved, by personell in charge of the repair. Alarms are received by ASM platform, which automatically or through a system supervisor generates a work order to handle the alarm and assigns it to the technician in the field.

3 HANDLING THE SENSOR DATA STREAM

Analytical platform is a solution for streaming data processing. It can be implemented in three different ways as identified in [3]: as a traditional database management system (DBMS), as a rule engine or as a dedicated stream processing engine. For a traditional event processing engine a rule engine implementation would be the most natural solution. With the asset management scenario there is, however, a demand to access also historic data or different aggregates of the sensor measurements, either to obtain additional knowledge of the alarm or to define, discover or refine a rule as an expert user. The latter requirements suit best an SQL DBMS solution. However, the need for low latency response, fast rule evaluation and access to raw data and aggregates, make the dedicated stream processing engine option the most appropriate.

We propose to use a data layer schema as explained in [1] with an addition of two stores (tables) as depicted in Figure 2. Basic unit of the schema is a sensor measurement, which is taken by a sensor. Sensor is a device that is usually a part of a bigger electronic device that we call a node. A node carries additional meta-data about the measurement, which is for example geographical location or coexistent sensors. Every sensor also has a type defined. Type of a sensor joins a sensor measurement with the data about the measured phenomena, units of measurements, information about the used hardware, frequency of measurements and others.

Data layer consists of two additional independent stores, which are: a store with a rule definition database and a store with events. Events can be either human detected – observed (and can be used to learn the models for detecting alarms) or system detected.

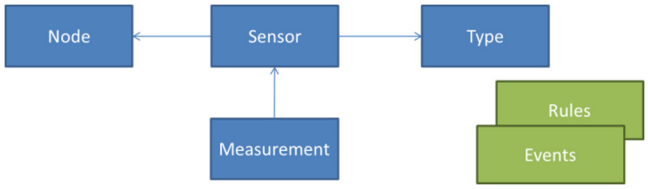


Figure 2: *Proposed data layer schema.*

4 EVENT PROCESSING

Event processing consists of three phases. Firstly, one needs to discover the rules or build classification models to detect events. Secondly, the system has to evaluate these rules on the current state of the system and lastly, an appropriate action should be taken according to the triggered alarm.

There are various possible scenarios for discovery of the rules:

1. Expert user has sufficient knowledge of the system and is able to create a rule without any support.
2. Expert user knows about a certain type of events that are happening and is using a graphical user interface to analyse the sensor and external data, different aggregates to get an idea about the behaviour of the system prior to the event. Expert user is able to test his hypothesis, evaluate its results and refine it if needed. Also a rule suggestion method would be useful in this scenario (e. g. a method that would be able to detect relevant sensors for an event or a series of events and create a rule, based on the constraints on the values of the sensor measurements at the time of events).
3. Expert user provides a list of events of a certain type and the system tries to build a model, based on the timestamp of events and corresponding sensor data.

A simple and effective GUI should be available for creating the rules.

System should be able to evaluate high number of rules on a huge amount of data in a reasonable timespan. Effective indexing and pre-processing of sensor measurement would be needed therefore.

Event detection, where rules are provided by an expert user, can only return true or false, therefore priority of the event (case that the rule is fulfilled) should be entered by the expert user. In the case of event prediction based on a model, a classification algorithm is able to return probability of the event happening based on the learning process. Expert user should define a probability threshold for triggering such an event; probability can be used also as a priority parameter, which should be determined by an expert user.

Exports of rules and data could have additional value for usage with other event processing/data mining systems. Relevant standards for exporting rules are RuleML and Datalog.

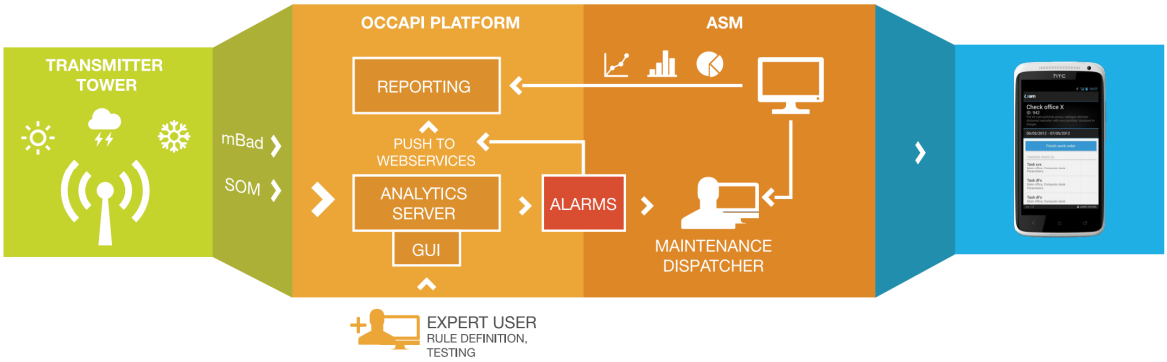


Figure 3: *Architecture of the ASM OpComm solution.*

5 IMPLEMENTATION

In this paper we are presenting an implementation of proposed conceptual architecture for event processing in asset management in Figure 1. Part of the functionality, described in previous sections has been implemented in the ASM scenario within the OpComm competence centre project.

The aim of the ASM scenario is to optimize maintenance tasks on mobile telephony base stations for a telecommunications company. Base stations have been equipped with different sensor nodes, measuring environmental data like temperature, humidity or pressure inside and outside the base station. A sensor system has also been implemented that is able to obtain the data about the electronic devices within the base station and send it to the analytical platform.

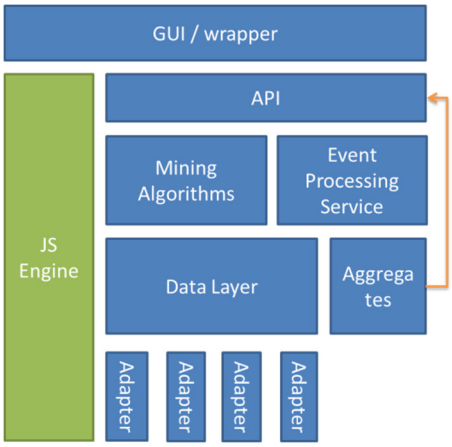


Figure 4: *EnStreaM architecture.*

Sensor sources are depicted in the left side of Figure 3. mBad is the data source about the state of electronic devices in the base stations and SOM (Smart Object Management) is responsible for the delivery of environmental data. Analytical platform consists of two interconnected components. The first component serves as a *reporting component* and is responsible for performing basic operations on the data stream and the delivery of results to the end user. *Advanced analytics* component consists of an implementation of a stream processing engine EnStreaM [7], which is based on the QMiner solution. Architecture of the EnStreaM is depicted in Figure 4.

QMiner platform provides core functionality in a set of in-house C++ libraries. A data layer schema as proposed in section 3 has been implemented. The platform already provides native support for a set of data mining algorithms and an API on top of it. Additionally, a naïve event processing engine (evaluating rules on a current state of the system after each measurement is received) has been implemented to handle event detection.

Event definitions consist of a rule, natural language event description template, priority index and an asset ID. When conditions for a rule are met, an alarm is triggered. Request is made to the ASM component, which starts a proper response procedure. Based on the asset ID a proper end user is notified with instructions, how to access detailed information about the alarm (history of measurements, etc.). A WWW GUI (see Figure 5) is available to the responsible technician, but also a mobile app (see Figure 6) [6] for even faster response and access to all the needed data from the terrain.

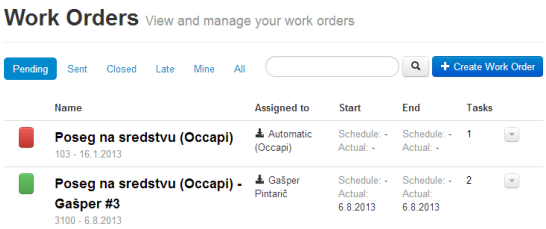


Figure 5: *Screenshot from ASM WWW client.*

5.1 Rules in the ASM use case

Telecommunication expert users have created a limited set of fairly simple rules. The justification for the usage of the simple rules the experts have given is that with a concrete simple rule there is no doubt about the source of the alarm. The end-users also pointed out the step-by-step approach.

First they need to integrate a module with analytical capabilities into the ASM solution and only in the second

phase they wanted to test more complex rules and include also predictive capabilities, such as event prediction.

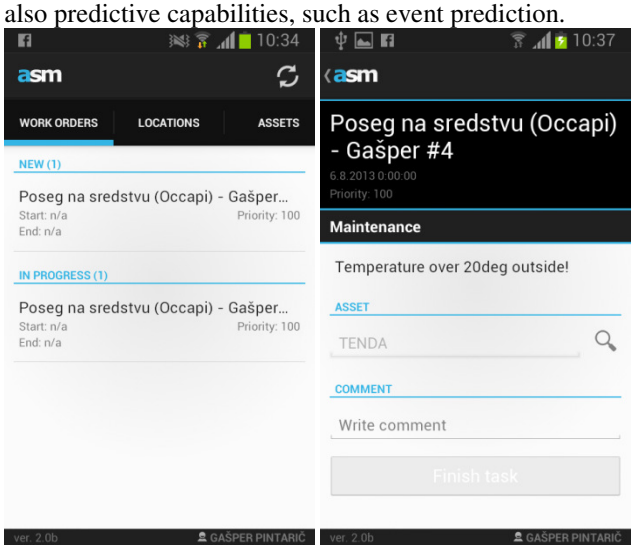


Figure 6: *Screenshots from mobile ASM client.*

Some illustrative examples of rules are listed below:

- if temperature inside the station is lower than 5°C or higher than 40°C
- if the temperature inside the emitting cell is lower than 5°C or higher than 35°C
- if the voltage on all 5V devices is lower than 4V or higher than 6V
- if the value on the WLTS device is not equal to 1186

Rules are added, edited or disabled through the expert user GUI depicted in Figure 7.

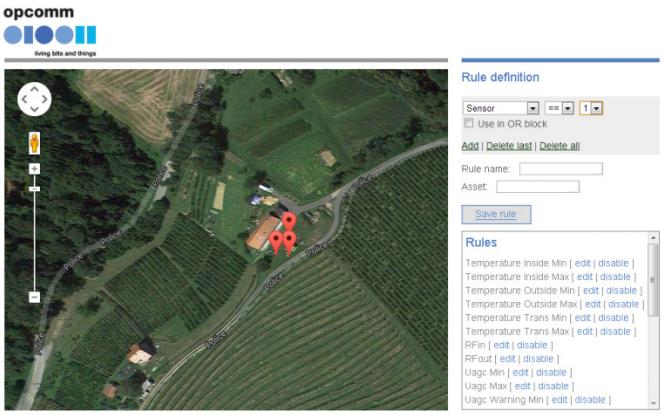


Figure 7: *Screenshot from expert user GUI.*

The expert user is able to visualize the geographical information of the sensor nodes, show measurements and their aggregates etc. The main functionality of the GUI is to assists the user to create rules through key/value pairs, which are then encoded in the rules.

Implemented rule language is based on JSON. An example of the rule is shown in Figure 8. Rule language consists of rule atoms based on a key/value pairs, where a value can be either equal, not equal, greater or smaller than the reference value.

```
{"Phenomena":"air_temperature", "Value":{"$gt":", 40.0"}}
```

Figure 8: *Example of an expert user rule, encoded in JSON.*

6 CONCLUSION

In this paper we propose the conceptual architecture for analytical module for stream processing in Asset management and present a concrete example of its implementation. The first results of testing, which are evaluated by end-user's feedback, showed promising results. The maintenance process is being more controlled and maintenance crew has all the needed information in their work orders, which appear on their mobile devices.

The proposed architecture is considered to be appropriate also for other business cases, since it enables data stream processing, complex event processing and also supports natural language, which is used in this case as one of the options for result interpretation. With the implementation we have demonstrated usability of the system for small/medium-sized companies.

Further work will include implementation of predictive capabilities, such as prediction of selected input streams, as well as simple and complex events.

Acknowledgements

This work was supported by the Slovenian Research Agency, by the Ministry of Education, Science and Sport within the Competence Center Open Communications Platform and the ICT Programme of the EC under PlanetData (ICT-NoE-257641), ENVISION (IST-2009-249120) and NRG4Cast (ICT-EeB- 600074).

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SENSOR-BASED SINGLE-USER ACTIVITY RECOGNITION

Blaž Kažič, Jan Rupnik
Artificial Intelligence Laboratory
Jožef Stefan Institute
Jamova cesta 39, 1000 Ljubljana, Slovenia
e-mail: blaz.kazic@gmail.com, jan.rupnik@ijs.si

ABSTRACT

The focus of this work is to explore the possibilities of recognizing three common user activities (sitting, walking and running) with accelerometer data from smartphones. Among five common machine learning algorithms, Naïve Bayes classifier proved to be the best choice. Classification accuracy of more than 90% was achieved when phone is carried in a pocket. It is shown that this method is appropriate and that the phone's orientation information is not needed. Finally, the classification of one day-long data set is presented.

1 INTRODUCTION

Over the previous decade, we have witnessed the significant rise of smartphone technology; the built-in sensors of such phones have also improved significantly. Because contemporary smartphones are highly programmable, their cheap and powerful sensors represent a variety of new research opportunities in the field of mobile context awareness. Data from the built-in sensors (e.g. gyroscope, accelerometer, digital compass, GPS, microphone and camera) have already led to the development of some interesting applications in the fields of healthcare [1], social networks [2], business and environmental monitoring [3] and transportation [4].

This article discusses the possibility of activity recognition of the smartphone user, with data obtained by the Apple iPhone's built-in accelerometer sensor. Knowing the users' activity could be useful information in profiling their preferences and behavior. This information may be used for offering personalized recommendations for points of interest, services or products (e.g., targeted advertising).

In this stage, recognizing three main user postural behaviors (sitting, walking and running) has been researched. Sitting also includes all standstill behaviors (like standing), and running also includes all behaviors that include sudden movements (jumping). Different activities are distinguished based on the data from the accelerometers' sensors, since accelerometer is one of the most common sensors and has already been used in many studies (even before they were commonly built into smartphones) [5]. Using only accelerometer data also has another advantage, as it is not particularly demanding on the battery, in comparison to other sensors (especially GPS). Power consumption can be a difficult obstacle in conducting research with smartphones, so energy efficient approaches must be considered [6].

2 METHODOLOGY

In this work, supervised machine learning is used for recognition of users' activity; therefore, labeled training data from accelerometer sensors had to be collected.

2.1 Application for Collecting Data

A brief survey of the two most popular application markets, Apple's *App Store* and Google's *Android Marketplace*, shows that many applications have already been developed to extract sensor data from the phone. Consequently, instead of developing new piece of software for the task an iPhone application called SensorLogger was used. This application records a phone's sensor data for a later review, or streams it to other devices via wireless networks as UDP broadcast packets.

2.2 Collecting Data

With the help of this application, a training set spanning five hours of user activity was collected by seven users. Data from the accelerometers was recorded at a sampling rate of 30 Hz. The data was then divided into nonintersecting 10 second intervals (windows). For each window, several features were computed. A set of features of one window represents one sample. In total, 1750 samples were collected, as summarized in Table 1.

Person	Sitting	Walking	Running
a	80	77	80
b	79	116	94
c	79	78	59
d	92	86	68
e	68	92	86
f	166	79	78
g	68	63	62
Sum	632	591	527

Table 1: *Training data set*

2.3 Orientation Problem

Most current smartphones have tri-axial (3d) accelerometers, i.e. sensors detecting acceleration in the x, y and z directions; sensor orientation depends on phone

orientation. While information for x, y and z accelerations can be extremely useful in the case of body worn sensors, where the orientation of a sensor is fixed [9], such regime of operation cannot be expected in our case. Since a phone is a portable device, it is obvious that its position varies from person to person. Figure 1 presents accelerometer data from two different persons who were performing the same activity (sitting). It is clear that the two sets of data differ significantly, which means that the two orientations are different.

One easy solution to the orientation problem is the use of magnitude of each (x, y, z) accelerometer signal. Figure 1 also shows that although the readings from x, y and z axes were significantly different, the magnitude signal was very similar, which indicates that such information may be used as a feature for classification. The magnitude in both cases is stationary in time at approximately $1 m/s^2$, which corresponds to the sensor measuring the force of gravity while being static.

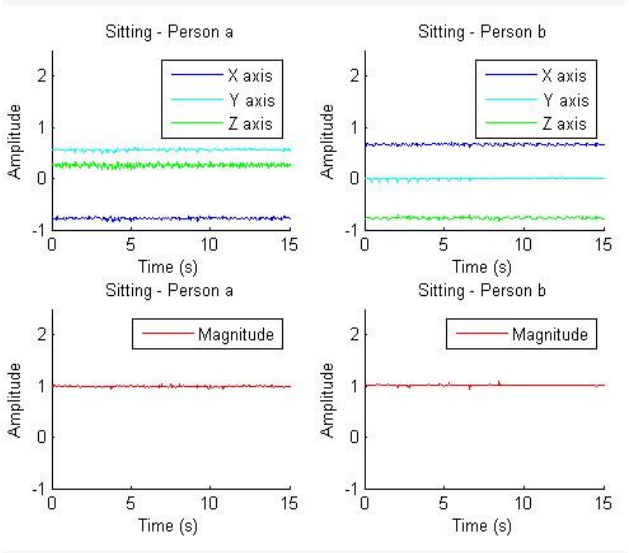


Figure 1: *Accelerometer data from two different persons performing same activity (sitting).*

2.4 Feature Extraction

During the research, many different features were considered. Some of them are common when processing accelerometer signals (e.g. mean and standard deviation). Others, such as dominant frequency [5], are calculated based on a signal preprocessed with a discrete Fourier transform (DFT).

However, using all available features as an input in a classifier is not always appropriate. If a feature does not provide any new information that would improve classification, it can be irrelevant, redundant or even distracting. To achieve the best classifications results, the number of features should be as low as possible, retaining only the most relevant ones [8].

To find the best set of features, the following three subsets were analyzed;

- **All Features:** mean, standard deviation, variance, median, root mean square, skewness, kurtosis, 25 percentile, 75 percentile, inter-quartile, mean crossing rate, dominant frequency, DFTs energy, spectral entropy, xy correlation, xz correlation, yz correlation.
- **Simplified Features:** mean, standard deviation, 75 percentile, dominant frequency, xy correlation
- **Mean & StdDev:** mean, standard deviation

The first set, *All Features*, contains features that have already been considered in some of the related literature on activity recognition research [9]. We omit the definitions of used features due to the lack of space and refer the reader to [9][5]. The second set, *Simplified Features*, includes some of the most popular features for activity recognition [5]. The third set contains only two features: mean and standard deviation. Different studies [7] show that only with these two features it is possible to classify user behavior to some degree of accuracy. The benefits of using only two features are energy efficiency and ease of computation, which make them highly appropriate for the use in systems with low computation power.

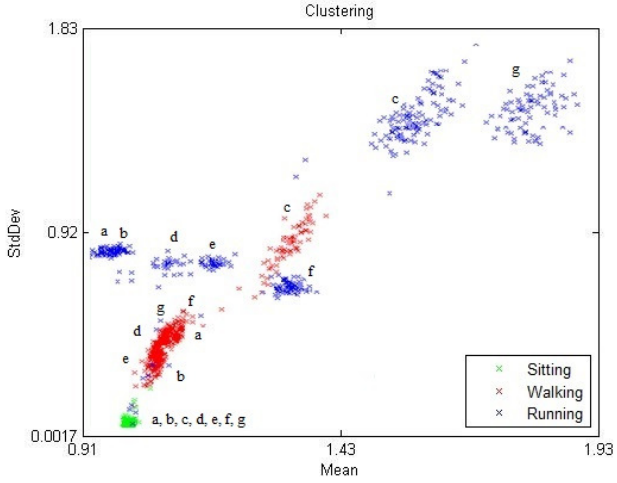


Figure 2: *Mean vs. Standard deviation clustering.*

Figure 2 shows clustering of activities from different users by using only Mean and Standard deviation as features. The boundary between sitting and movement (walking or running) is quite obvious, but less so between walking and running. This is mainly because the smartphones were worn differently and also because people walk and run differently. The clusters with larger variance and larger average force magnitude (top right region) correspond to the users (c and g) wearing the phone in more loose pockets, causing more phone movement. In contrast, users who wore phone more tightly to their body (a, b, d, e and f) caused less vibrations and less dispersed signals. While the walking and running are linearly separable for each user individually, they are no longer linearly separable for all users simultaneously.

A particularly useful feature to distinguish between walking and running is the dominant frequency. From Figure 3, it is clearly seen that the average dominant frequency of persons in the test group for walking is 2 Hz, and the average dominant frequency for running is 2.9 Hz. This is also very interesting information from which the approximate speed of the user could be calculated.

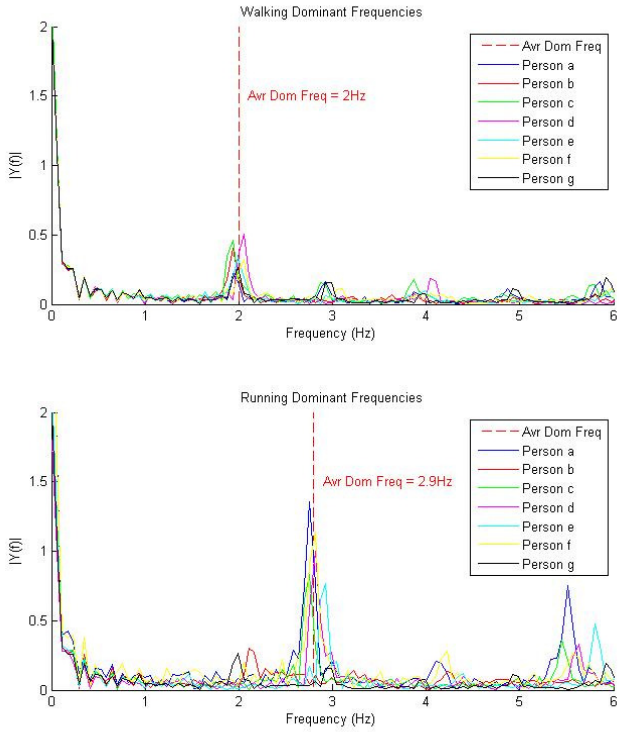


Figure 3: *Dominant frequency.*

2.5 Feature and Classifier Selection

For testing and evaluating different sets of features and different classifiers, a Weka toolkit [10] was used. Five common machine-learning algorithms (*Decision Tree (J.48), Naive Bayes (NB), k-Nearest Neighbor (IBK), Support Vector Machine (SMO)* and *Neural Network (Multilayer perceptron))* were used to test the accuracy of the activity detection of all three previously mentioned feature sets.

All classifiers for every person in the data set have been tested, in a way that the person that was being tested was excluded from the training data. The results in Figure 4 are the average results for all classifiers and all features sets.

It is seen that *Naïve Bayes* in combination with the *Simplified feature* set has the most correctly classified samples (93.2%). The second best results (88.2%) are of the *Decision Tree* classifier, which is a tremendously popular choice in activity recognition research [11]. It is also seen that the *Simplified Feature* set generally gives better results than *All Features* set, as it was expected and discussed in previous section. *Mean & StdDev* set also gave some quite acceptable results, but considering the fact that smartphones are constantly becoming more powerful, there is no need for this kind of simplification. Based on these observations, we focused the evaluation on the *Naïve Bayes classifier* based on *Simplified features*.

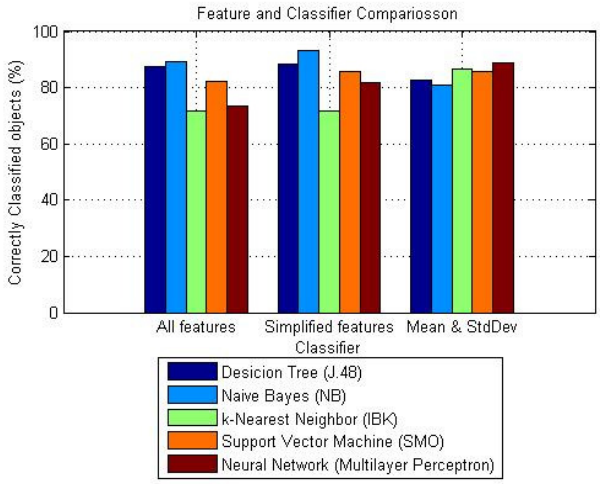


Figure 4: *Feature sets and Classifiers evaluation.*

2.6 Naïve Bayes Classifier

For classification with Naïve Bayes, data from every feature set first had to be discretized in to several parts, so that every piece contains approximately the same amount of data. Bayes Theorem with Laplacian smoothing is then used to calculate the likelihood of one sample belonging to each class (activity). The sample is classified into classes with the highest calculated probability.

Finally, the classifier was tested on the set of data that was not in the test group. From the confusion matrix in Table 2, it is seen that the classifier is working properly. With 96.3% correctly classified samples, the result is slightly better than in the previous test; this is due to data discretization.

Labeled activity	Recognized activity		
	Running	Walking	Sitting
Running	92	2	0
Walking	0	116	5
Sitting	0	4	75

Table 2: *Confusion matrix.*

3 RESULTS

The goal of this research was to recognize three common human physical activities (sitting, walking, running) with accelerometer data, regardless of the phones' orientation. In the previous section, it was shown that classification with Naïve Bayes classifier worked well with the labeled samples. In this section, data collected from one entire day is classified.

Twelve hours of data were collected on one working day by the author. The classifier was trained on a previously collected data set, which includes seven different persons (the data from the author was not part of the training set).

From Figure 5, the daily activity of the subject (the author) is clearly seen. It can be observed that there was some walking activity combined with sitting in the morning. At around 8am, the subject cycled to work, which usually takes half an hour. It can be seen that cycling is considered more similar to walking than running. Also it is evident that the subject's work involves sitting most of the time. Some walking activity is recognized during the lunch break around 1pm. At 5pm, the subject cycled back home, which is again recognized as walking. Later that day, the subject went for a short walk up the nearest hill. It is seen that during this trip walking is sometimes considered as running, which is understandable, since walking up or down a hill can cause more vibrations and shocks than a normal walk would, therefore classifier can recognize it as running.

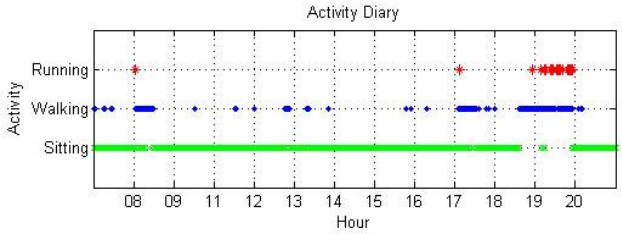


Figure 5: A*ctivity recognition during one day period.*

Since the data was recorded constantly throughout entire day, with 10-second long samples, this was extremely energy consuming. Therefore, the data were filtered as if a 10-second sample had been recorded only every 3 minutes. The results can be seen on Figure 6. It is seen that all activities during the day are still reasonably recognized, as they were on Figure 6. Walking up a hill between 18:30 and 20:00 is now even better classified, since many of the previously running classified samples are no longer in the data set.

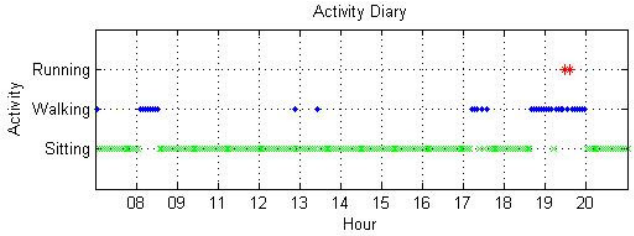


Figure 6: *Filtered activity recognition.*

4 CONCLUSION

In this paper, human activity recognition of a single user is presented. The research indicates that with Naïve Bayed classifier and orientation independent features, it is possible to distinguish user behavior into three common activities: sitting, walking and running. The results show that such an approach has the potential and it can be extended into several directions.

First, it would be interesting to test the system on a larger data set, spanning a weak or a month of user activity. Increasing the number of recognizable human activities, such as standing, cycling and driving, could be the next step. To maximize the classification accuracy for a larger set of recognizable human activities, combination with GPS data could be considered. Finally, the effect of varying the sampling frequency and the window size on the classification performance could be investigated.

Acknowledgement

The authors acknowledge the European Commission for its support and partial funding and the partners of the research project: FP7-318452 MobiS.

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(i)DiversiNews – A STREAM-BASED, ON-LINE SERVICE FOR DIVERSIFIED NEWS

Mitja Trampuš, Flavio Fuart, Jan Berčič, Delia Rusu, Luka Stopar, Tadej Štajner
Artificial Intelligence Laboratory
Jožef Stefan Institute
Jamova cesta 39, 1000 Ljubljana, Slovenia
Tel: ++ 386 1 477 3528; fax: +386 (01) 477 38 51
e-mail: {name.surname}@ijs.si

ABSTRACT

With the ever-increasing ease and speed of opinion exchange, the internet often displays the echo chamber effect. This is exacerbated by a free market: search engines and other data aggregators are monetarily incentivized to primarily show the most popular opinions. We propose a data aggregation, processing and retrieval system to combat this phenomenon in the domain of web news. We developed two applications (web, iOS) that allow users to explore news articles along several uncommon dimensions, diversifying them and discovering new aspects of a story. The iOS application works in real time, making for a novel alternative to classic news reader apps. Our user study shows a need for such diversity-aware approaches and judges our solution to be directly useful.

1 INTRODUCTION

The RENDER European project[1] aims at developing tools and services which enable the analysis of text in a Web-based environment from a diversified perspective. The focus is on two main sources of information diversity. Firstly, we are interested in analysing *information content diversity*, and identifying the main topics of the text, its geographical provenance, the opinions expressed in text, and aggregating this content in a short summary. Secondly, we want to observe *diversity in information usage*, and identify how different user groups such as domain experts, user communities or the general public are interacting with RENDER technology.

As a step towards reaching these goals, we propose a case study which is based on near real-time analysis of news. We developed a web application[2] and an iOS client that allow users to browse and summarize news from different perspectives. The individual news articles are grouped into several news clusters. Given a certain topic of interest, the tool provides a succinct summary of the most related news cluster, as well as the individual news articles that have been summarized, sorted by relevance. The user can further specify which perspective on the news should be emphasized: articles containing certain predominant keywords, articles that belong to a certain geographical region, or articles with a positive or negative outlook.

Related work. There are several applications which aim at representing information from different perspectives. *DisputeFinder* [1][2] is a browser extension that alerts the user when detecting that the information accessed is disputed by a trusted source. The tool highlights known disputed claims and presents a list of articles that support a different point of view. *Social Mention*[3] is a social media search and analysis platform which aggregates different user generated content, providing it as a single information stream. The platform provides sentiment (positive, negative, and neutral), top keywords, top users or hashtags related to the aggregated content. The *Global Twitter Heartbeat*[4] project performs real-time Twitter stream processing, taking into account 10% of the Twitter feed. The text of each tweet is analysed in order to assign its location. A heat map infographic displays the tweet location, intensity and tone. *Europe Media Monitor* [3] represents a number of news aggregation and analysis tools that track stories across time, languages and geographic locations. It also detects breaking news stories and hottest news topics. Topic-specific processing is used, for example, to monitor EU policy areas[5] and possible disease outbreaks[6][4].

The remainder of this paper showcases our applications and is structured as follows: in section 2, we describe the data collection and preprocessing shared by both applications. Section 3.1 describes *DiversiNews*, and section 3.2 describes how it was extended *iDiversiNews*, a mobile iOS application, to show near real-time news. Section 4 shows the results of a UI study.

[1] http://render-project.eu/
[2] http://aidemo.ijs.si/diversinews/
[3] http://www.socialmention.com
[4] http://www.sgi.com/go/twitter/
[5] http://emm.newsbrief.eu/
[6] http://medisys.newsbrief.eu

2 DATA COLLECTION AND PREPROCESSING

The data is collected using the JSI Newsfeed. The system's reference article [5] describes how the data sources, mainly RSS, are collected and crawled. It also details some of the preprocessing built into the newsfeed, notably cleartexting and language detection. However, for the purposes of (i)DiversiNews, news stages of preprocessing have been added that have not yet been documented.

Publisher geolocation. We try to associate each publisher/site with geographic coordinates. We crawl public listsings of news publishers to learn the city and country of origin. Failing that, we have developed a set of heuristics that query a WHOIS server with the publisher's hostname and extract the most likely country of origin. Hostnames with national TLDs are automatically assigned to that country. A publisher with a known country but unknown city is mapped to the geocenter of the country.

Stable enrichment. Articles are enriched using the Enrycher [6] service as pointed out in [5]. In the scope of (i)DiversiNews development, several critical stability bugs were fixed and a separate instance of Enrycher was installed for the needs of the project. It performs part of speech (POS) tagging, sentiment analysis, named entity extraction and resolution and DMOZ classification.

Sentiment analysis. The sentiment analysis module in Enrycher has been rewritten from scratch, largely motivated by (i)DiversiNews. A supervised method is now being used with significantly improved performance.

Article clustering. A stream clustering method has been developed by Janez Brank for clustering news articles into stories. It maintains the centroids (in the high-dimensional bag-of-words space) of several thousand clusters using a dynamic proximity search data structure. Each new article is assigned to the cluster with the nearest centroid. If the resulting cluster is large enough, it is periodically considered for splitting into two subclusters using bisecting k-means; the decision on whether to accept the split or not is based on a Bayesian information criterion). Individual articles' weight/contribution to the centroid is attenuated exponentially to prevent old stories from lingering in the system for too long. Overly old articles are discarded. Periodically, we examine pairs of similar clusters and consider merging them. A combination of cosine distance and Lughofer's ellipsoid-overlap criterion is used to determine whether to perform the merge. The service has a push API to keep subscribers updated about cluster membership changes.

We limit ourselves to English articles, although the only language-dependent component is sentiment analysis so expansion to other languages is feasible.

Architecturally, the enrichment is performed in the scope of Newsfeed. Its output is the starting point for DiversiNews and iDiversiNews. The former being designed for browsing through historical data and the latter serving real-time data, their respective caching mechanisms and backends are different, as are obviously the frontends.

3 USER INTERFACES

News data offers many aspects of diversity and no single application can present them all due to sheer information overload. We therefore had to choose only a few and did so based on several criteria: 1) how well defined the aspect is, 2) how good are the automated methods at extracting it and 3) our ability to propose an intuitive user interface for navigating the space of that aspect. In the end, we chose a) topic of focus, b) geography of publisher origin and c) sentiment.

We developed two applications that allow a user to navigate

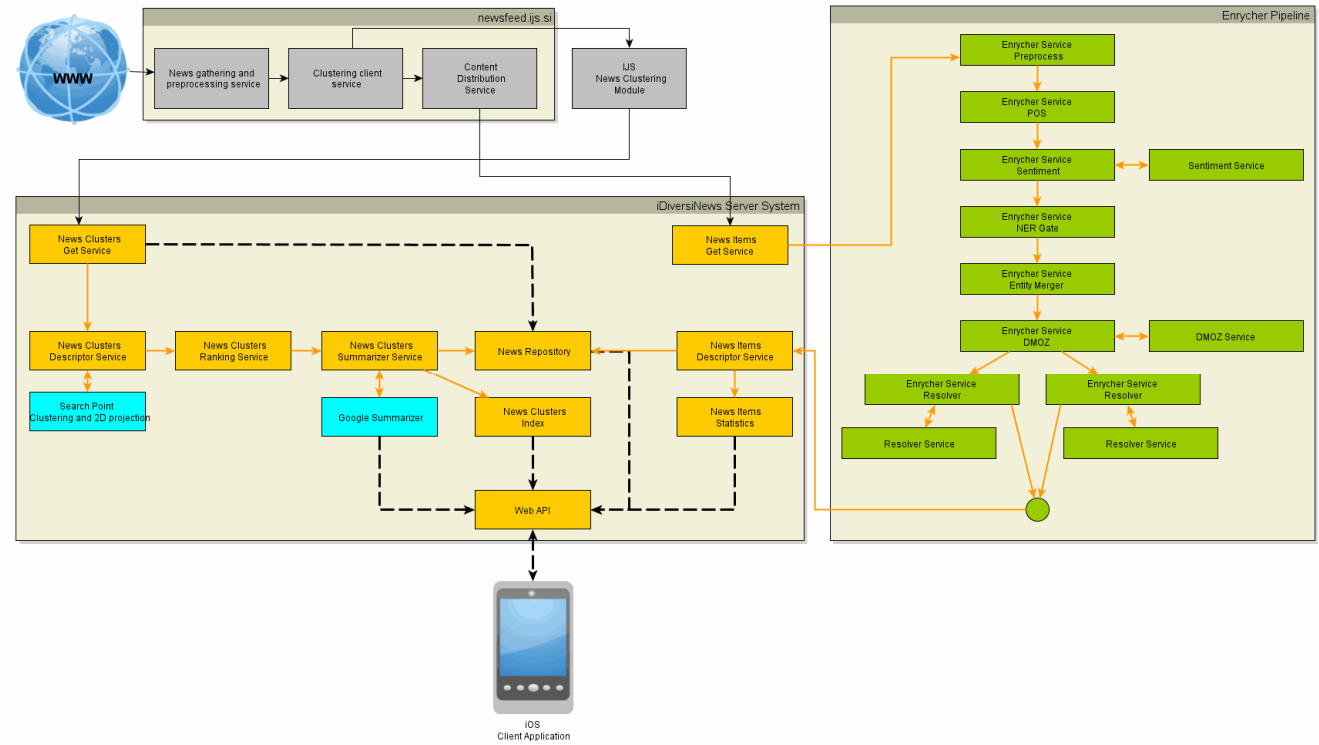


Figure 1: *iDiversiNews System Architecture, in part shared with DiversiNews.*

a cluster of articles along these three dimensions. For example, browsing a cluster of news about the British royal wedding, the user might express interest in articles a) focusing on Kate's headwear b) with a positive spin and c) coming from Japan; the user interface will react by displaying the relevant articles and their summary.

The most prominent part of both applications is the News Story Exploration Area where different views on a same story can be explored. Users select a position in a multi-dimensional story space: by selecting most descriptive keywords ("Search Point" area), pinpointing a particular geographic area (publisher location) and selecting news sentiment (a scale that goes from negative through neutral to positive). The selected viewpoint is then used to rank news articles by relevance. A summary is created from the top scoring articles. Figures 2 and 3 show a sample view of the user interface in DiversiNews and iDiversiNews, respectively.

3.1 DiversiNews (webapp)

This application allows browsing of static news data dumps in a web browser. The browser is a thin client; the other component of the application is a server that fetches data from the Newsfeed and then performs data storage, retrieval, ranking, summarization and result caching. Storage and retrieval are implemented using the QMiner in-memory database engine developed by Blaz Fortuna. Ranking, result caching (= retrieved, ranked articles and their summary) and client-server communication are implemented within the SearchPoint framework. Two summarization algorithms were implemented in the scope of RENDER and are available in the interface; the first [7] was developed by Google and is based on a probabilistic model, the second by JSI and is based on an iterative greedy approach operating in the space of subject-verb-object triplets, using WordNet as background knowledge to define distances between triplets.

Figure 2 shows the user interface. Diversity controls can be found on the right (top to bottom: topic, geography, sentiment); the ranked articles and the summary appear on the left. The entry field on top provides keyword-based search (for example, search for New York, then use diversity controls to discover articles about NY coming from different parts of the world with different focuses and sentiments). It is also possible to analyse all articles belonging to the same story cluster (not shown).

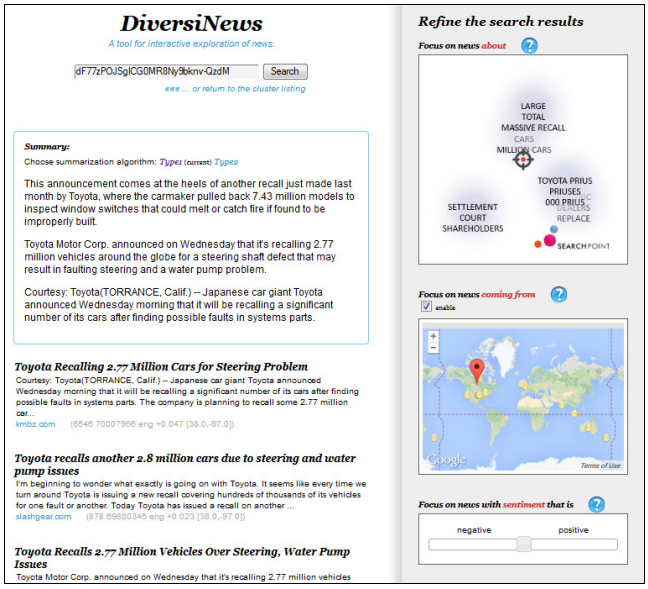


Figure 2: *DiversiNews main interface.*

3.2 iDiversiNews (iOS)

The iOS version allows near real-time browsing and analysis of news. Figure 1 gives an overview of the system architecture. The backbone of the server part are components implemented as web applications for the Apache Tomcat Java Servlet Container. Components are set up in a pipeline using Apache ActiveMQ, an open source messaging server.

Some functionalities, implemented in C++, have been exposed as (C++) web-services:

- SearchPont service – keyword extraction (k-means clustering) and projection of keywords and their relevance to a 2D plane.
- Google Summarizer integration.

In order to enhance user experience *iDiversiNews* server is to pre-processes as much data as possible before serving it to the client application. To achieve that purpose, data is downloaded (Figure 1, orange arrows) from *NewsFeed* and the *JSI Clustering Module* as soon as it is made available by those systems.

News Items are pushed through the Enrycher pipeline and stored in a repository.

News Clusters data is a list of cluster identifiers with corresponding news item identifiers. From this list an RSS-like structure is created by grouping news items from the repository. Those lists (clusters) are sent to the Descriptor service where all potentially useful metadata is extracted from single news articles, aggregated, calculated and added to the cluster itself. Metadata consists of the following: region, country, top tags, top categories, sentiment information, top entities mentioned, SearchPoint top keywords and their positions on the 2D plane, top image. News articles for each cluster are then ranked (Ranking Service) and a summary (Summarizer Service) is created according to that order. Each cluster is then indexed and saved to the repository.

At the end of the pipeline, a list of the biggest stories in the news is published through the Web API module and an aggregation of basic statistics is created. The client, in this case the iOS application, can request the latest list or make its own customized search. After selecting a cluster, all available metadata ("news story dimensions") is displayed and the user can then interact with the news story. User selection is sent back to the server (dashed arrows) where the cluster is re-ranked and a summary re-calculated.

Figure 3 shows the News Story Exploration Area. On the top an overview of the story is shown. Diversity controls

can be found on central part of the screen (geography, sentiment, topic); the summary and the ranked articles appear on the bottom.

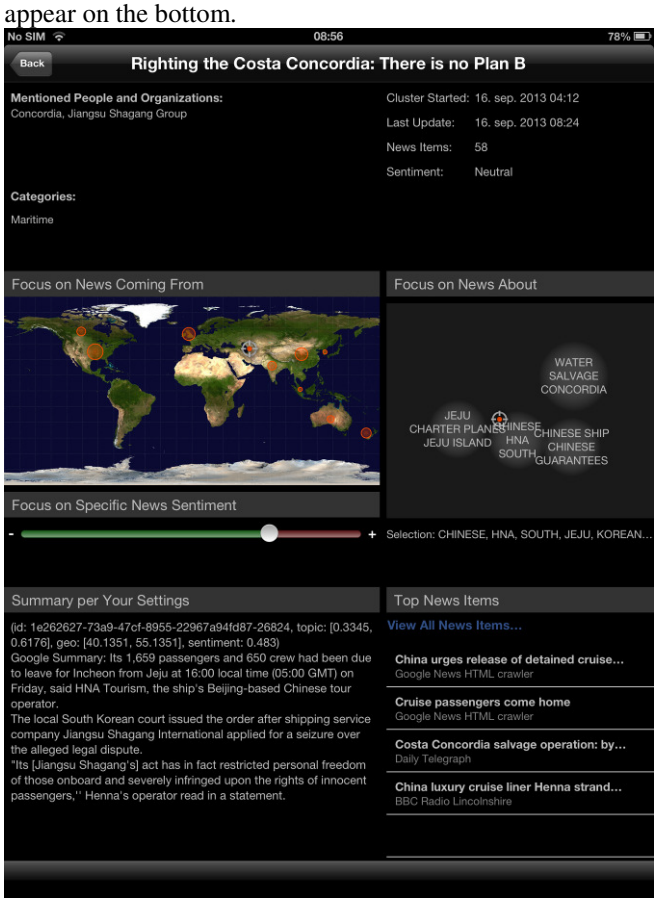


Figure 3: *iDiversiNews.*

4 EVALUATION

Together with the RENDER project partners we performed a two-step evaluation of the DiversiNews web application. As a first step, we wanted to quantify fluency, informativeness and the impact of controls (the choice of topic and sentiment) on the generated summary. Next, we performed a user study with two domain experts from the Slovenian News Agency and other 14 non-expert users.

Impact of controls on summary. The evaluation was performed with two expert annotators on a random selection of 20 news clusters. Approximately 30% of the summaries were found to be fluent and informative. Regarding sentiment, the annotators were asked to mark 2 out of 8 summaries which have the most positive and most negative connotation, respectively. Sometimes polarity is not easy to detect, showed by lower recall (approximately 60%) compared to precision (approximately 75%). Topic-relatedness proved to be especially difficult to evaluate because of limitations in the user interface design. The annotators were asked to mark 2 out of 8 summaries which are most central with respect to the selected topic. The summarizer achieved approximately 90% F1 score on topic relatedness.

User Study. The user study was conducted according to three dimensions: a static evaluation, an interactive evaluation and a perceived utility evaluation. The **static evaluation** aims at assessing how self-explanatory the DiversiNews interface is. The results show that the majority of subjects found the interface very clear and self-explanatory from the very first moments of usage, and correctly identified the function and the behaviour of all the components. In the **interactive evaluation** the users were actually working with the system. ~81% of the subjects was either very pleased or pleased with the response time of the interface. The **perceived utility evaluation** aims to understand the real potential of DiversiNews as a platform for diversity aware news browsing. The subjects found summaries to be effective in capturing and representing relevant information. Moreover, the application succeeds in modelling different dimensions of diversity.

5 CONCLUSION

In this paper we described two applications – web and iOS – part of the RENDER news analysis case study. The applications allow users to explore news articles along several uncommon dimensions, diversifying them and discovering new aspects of a news story. The iOS application works in real time, making for a novel alternative to classic news reader apps. The web application was evaluated bot quantitatively, form the point of view of the impact of controls on the generated summary, as well as within a user study with domain experts and general users, showing a need for such diversity-aware solutions.

Acknowledgements

The research leading to these results has received funding from the Slovenian Research Agency and the European Union's Seventh Framework Programme (FP7/2007-2013) RENDER project under grant agreement no.257790.

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USE OF POINT SYMMETRY BASED DISTANCE FOR GENE EXPRESSION DATA CLUSTERING

Sriparna Saha, Asif Ekbal, Neha Vinayak
Department of Computer Science and Engineering
Indian Institute of Technology Patna
Patna-800013 India
Tel: +91-8809559190; fax: +91-612-2277383
e-mail: {sriparna,asif}@iitp.ac.in

ABSTRACT

Introduction of microarray technology helps to study the expression profiles of thousands of genes across different experimental conditions or tissue samples simultaneously. Clustering techniques have been widely used for analyzing such microarray data, typical properties of which are its inherent uncertainty, noise and imprecision. In this paper we have developed some unsupervised approaches for clustering of tissue samples. In recent years some symmetry based clustering techniques have been developed. These clustering algorithms try to optimize total symmetry within a given partitioning. We have used these point symmetry based clustering techniques as the underlying unsupervised approach for gene expression data clustering. Here for grouping of different genes point symmetry based distance is used. The performance of the symmetry based clustering method is compared with that of several other clustering algorithms for some publicly available benchmark gene expression datasets. Biological significance tests have been conducted to analyze the biological relevance of the clustering solutions.

1 INTRODUCTION

Clustering [1,2,4] is an unsupervised classification technique. It has many applications in data mining, which helps to group objects, such that objects in the same group/cluster are similar to each other with respect to some criteria and objects in different clusters are different from each other with respect to the same criteria. Clustering [1,2,4] is performed based on an objective function which can be either minimized or maximized, depending on the algorithmic requirements. Many types of clustering algorithms have been developed, which can be broadly grouped as partitional, hierarchical and graph theoretic methods. Examples of these are K-means, single linkage and minimum spanning tree-based algorithms [2].

For partitioning a data set, at first some measure of similarity or proximity has to be defined based on which cluster assignments can be done. The measure of similarity is generally data dependent. In general, one of the fundamental features of shapes and objects is symmetry. This is considered to be important for enhancing the recognition of different objects [1]. As the concept of symmetry is common in the natural world, several researchers have utilized this property while clustering a data set. In the real world there are many objects which contain some form of symmetry; the human face, jellyfish, the human body, stars, etc. are some examples of symmetry. Symmetry mainly conveys balance and reflects perfection or beauty. As symmetry represents the well-defined concept of balance or "pattern self-similarity", it has been extensively used to describe many processes/objects in geometry and physics. Thus, we can assume that symmetry would be a desirable property of good clusters and that it should therefore be included as an objective for the clustering algorithm to pursue. Based on this concept, several different symmetry-based similarity measures/distances have been proposed in the literature [1].

A point symmetry based distance measure was proposed in [1] denoted as $d_{ps}(\mathbf{X},\mathbf{C})$, where **X** is the point and **C** is the centroid. The definition of d_{ps} is as follows: let a point be **X**. The symmetrical (reflected) point of **X** with respect to a particular centroid **C** is 2***C*****X**. Let us denote this by **X'**. Let the first and the second unique nearest neighbors of **X'** be at Euclidean distances of d1 and d2, respectively. Then $d_{ps}(\mathbf{X},\mathbf{C}) = \frac{(d1+d2)}{2} \times d_e(\mathbf{X},\mathbf{C})$, where $d_e(\mathbf{X},\mathbf{C})$ is the Euclidean distance between the point **X** and **C**.

The major characteristics of this distance is that in d_{ps}, two nearest neighbours are taken into consideration. So, the term $(d1 + d2)/2$ will never be equal to 0 and hence, the effect of the Euclidean distance d_e will always be taken into account. Also, considering only one nearest neighbour may be misleading in some cases, whereas on taking into account two nearest neighbours, if both d1 and d2 of a point **X** with respect to **C** are less, then the likelihood that **X** is symmetrical with respect to **C** increases.

Gene Expression Data Clustering -

Gene is the fundamental unit of storage of hereditary information in living beings [3][5]. Technically, it can be viewed as a distinct sequence of nucleotides forming part of a chromosome. Information from a gene is used in the synthesis of functional gene products like proteins and functional RNAs for non-protein coding genes. This process

of synthesis is called Gene Expression, by which genotype gives rise to phenotype.

This Gene Expression Data is generally very huge in size and to search for useful patterns within this data, genes have to be grouped into "clusters" on the basis of similar features. The Gene Expression data is in the form of a 2-Dimensional matrix of Gene Names and the corresponding expression levels for features exhibited by the genes.

Clustering of Gene Expression data has been done by various algorithms. Here we have analysed the performance of a symmetry based genetic clustering technique, GAPS, [1] with respect to Gene Expression data. We have also compared the performance of GAPS with respect to two popular clustering algorithms, e.g., GAK-means algorithm [4], average linkage clustering technique [2]. Results on five gene expression data sets including yeast sporulation, yeast cell cycle, rat CNS, human fibroblasts serum, Arabidopsis Thaliana [3] show the superior performance of the GAPS clustering technique. Clustering results are validated using an internal cluster validity index named Silhouette index [6]. Experimental results show the efficacy of GAPS over other well-known clustering algorithms in finding clusters of co-expressed genes efficiently. We have also carried out biological significance tests to check the biological relevance of the obtained clusters, i.e., consist of genes which belong to the same functional group. Results reveal that GAPS can be effectively used to identify co-expressed genes from gene expression data sets.

2. PROPOSED APPROACH OF GENE EXPRESSION DATA CLUSTERING

In this paper, we have applied the GAPS algorithm [1] on gene expression data, for the readily available datasets (Refer section 3) and analysed the performance of GAPS relative to other single objective clustering algorithms – GAK-Means [4] and Average Linkage [2]. The Biological Significance of GAPS has also been established, as compared to the above mentioned algorithms.

The GAPS algorithm uses a genetic algorithm based approach for clustering, when the value of K (No. of Clusters) is known. GAPS uses the above defined Point Symmetry distance measure d_{ps} [1] instead of the Euclidean distance to determine a clustering metric, M. The objective of the algorithm is to find the cluster centroids such that M is maximized.

The main steps of the GAPS algorithm are as follows:

String Representation and Population Initialization: Each chromosome in the population is represented by a string of K cluster centroids, which are initialized to K randomly chosen points from the dataset. Then after executing five iterations of K-means on each of the chromosomes, the cluster centroids are replaced by the result of K-means algorithm.

Fitness Computation:

If the total symmetricity (**(d1+d2/2)** is less than a given threshold value (which is set depending on the data set; here we have used 0.6 for all the data sets), assignment of points to different clusters are done based on the point symmetry distance, otherwise Euclidean distance measure is used for assignment. The cluster centroids are then updated to the mean points of the respective clusters. Subsequently, the clustering metric, M is calculated for each chromosome, as

M=0

For k = 1 to K do

For all data points **Xi**, i=1 to n and **Xi** ϵ kth cluster do

$$M = M + d_{ps}(\mathbf{Xi},\mathbf{Ck})$$

The fitness function fit is defined as fit = 1/M. The function will be maximised by using GA.

Selection: Roulette wheel selection has been implemented.

Crossover: Single point crossover has been used. The crossover probability μ_c of each chromosome is such that when the better of the two chromosomes to be crossed is itself quite poor, μ_c is increased and when it is a good solution, μ_c is decreased.

Mutation: Each chromosome undergoes mutation with a probability μ_m. Like μ_c, μ_m will also get lower values for high fitness solutions and higher values for low fitness solutions.

In GAPS the processes of fitness computation, crossover, mutation, selection are executed for a maximum number of generations. The best string seen upto the last generation provides the solution to the clustering problem. Elitism has been implemented at each generation by preserving the best string seen up to a generation in a location outside the population. Thus, on termination, this location contains the centers of the final clusters. According to these center combinations we have to assign cluster labels to each point using the point symmetry based distance.

3. DATA SETS USED

In this paper we have used five gene expression data sets. These pre-processed datasets have been downloaded from the site mentioned in [3] (http://anirbanmukhopadhyay.50webs.com/mogasvm.html). A short description of the data sets is provided in Table 1. The description of these data sets are already available in [3] but we have included those here for the sake of completeness.

a. Yeast Sporulation

This data set consists of 6118 genes measured across 7 time points (0, 0.5, 2, 5, 7, 9 and 11.5 hours) during the sporulation process of budding yeast. The data are then log-transformed. The Sporulation data set is publicly available at the website http://cmgm.stanford.edu/pbrown/sporulation.

Data Set	No. Of Genes in pre-processed dataset	No. of Features
a. Yeast Sporulation:	474	7
b. Yeast Cell Cycle:	384	17
c. Rat Central Nervous System (CNS):	112	9
d. Human Fibroblasts Serum:	517	13
e. Arabidopsis Thaliana:	138	8

Table 1: *Details of pre-processed datasets used.*

Among the 6118 genes, the genes whose expression levels did not change significantly during the harvesting have been ignored from further analysis. This is determined with a threshold level of 1.6 for the root mean squares of the log2-transformed ratios. The resulting set consists of 474 genes.

b. Yeast Cell Cycle

The yeast cell cycle dataset was extracted from a dataset that shows the fluctuation of expression levels of approximately 6000 genes over two cell cycles (17 time points). Out of these 6000 genes, 384 genes have been selected to be cell-cycle regulated. This data set is publicly available at the following website: http://faculty.washington.edu/kayee/cluster.

c. Arabidopsis Thaliana

This data set consists of expression levels of 138 genes of Arabidopsis Thaliana. It contains expression levels of the genes over 8 time points viz., 15 min, 30 min, 60 min, 90 min, 3 hours, 6 hours, 9 hours, and 24 hours. It is available at http://homes.esat.kuleuven.be/_thijs/Work/Clustering.html.

d. Human Fibroblasts Serum

This dataset contains the expression levels of 8613 human genes. The data set has 13 dimensions corresponding to 12 time points (0, 0.25, 0.5, 1, 2, 4, 6, 8, 12, 16, 20 and 24 hours) and one unsynchronized sample. A subset of 517 genes whose expression levels changed substantially across the time points have been chosen. The data is then log2-transformed. This data set can be downloaded from http://www.sciencemag.org/feature/data/984559.shl.

e. Rat CNS

The Rat CNS data set has been obtained by reverse transcription-coupled PCR to examine the expression levels of a set of 112 genes during rat central nervous system development over 9 time points. This data set is available at http://faculty.washington.edu/kayee/cluster.

All the data sets are normalized so that each row has mean 0 and variance 1.

4. PERFORMANCE MEASUREMENT METRICS

For evaluating the performance of clusters, Silhouette Index has been used as the metric..

Silhouette Index: Silhouette Index [6] is used as a cluster validity index, used to compare the quality of the clusters formed by the clustering algorithm. It gives a view of the compactness and separation of clusters. The value of silhouette index ranges between -1 to 1 and a good cluster will have a higher value of silhouette index.

Input parameters: The GAPS algorithm has been executed with a population size of 100 for 30 generations. As the no. of clusters is required to be provided as input in the algorithm the cluster size, selected as per [3] are listed in Table 2.

Dataset	No. Of Clusters
Yeast Sporulation	6
Yeast Cell Cycle	5
Rat CNS	6
Human Fibroblasts Serum	6
Arabidopsis Thaliana	4

Table 2: *Number of clusters used as input for different datasets.*

5. RESULTS

Biological Significance testing was done for various runs of the Yeast Sporulation dataset, from the site (http://www.yeastgenome.org/cgi bin/GO/goTermFinder.pl).

It results in statistically significant Gene Ontology (GO) terms used to describe the genes in the list. Genes are considered to be statistically significant if the p-value < 0.01, i.e 1% Significance Level. This test has been carried out for three different Gene Ontologies, namely – Biological Processes, Molecular Functions and Biological Components. Out of these combined results, the three GO terms having the least p-values have been selected. Results show that GAPS attains minimum p-values for each cluster as compared to two other clustering techniques, GAK-Means and Average Linkage algorithms. For example the GO terms and the p-values attained by GAPS clustering technique for cluster 1 are :

cytoplasmic translation - GO: 2181

cytosolic ribosome - GO: 22626

structural constituent of ribosome - GO: 3735

A boxplot for the p-values has been drawn to compare them in **Figure 1**. The p-values have been converted to $\log_{10}$ for better visualization and ease of comparison (i.e new p-value

= $-\log_{10}$(p-value)). Only clusters resulting in at least one significant GO term have been considered for this test. Clusters with lower p-values or higher $-\log_{10}$(p-value) values are considered to be better.

Table 3 gives the detailed $-\log_{10}$(p-value) values of each stage of the boxplot (Min, Lower Quartile, Median, Upper Quartile, Max) for all the three algorithms. It can be observed from this table that the Median value for GAPS is better than that of GAK-Means and Average Linkage. Hence, it can be established that GAPS produces significant and biologically relevant clusters.

	GAPS	GAK-Means	Average Linkage
Minimum	3.79588	3.568636	3.68987
Lower Quartile	11.65956	13.289037	14.84968
Median	27.44782	26.976456	27.02503
Upper Quartile	35.35655	35.237321	36.2214
Maximum	60.96257	58.378824	47.70774

Table 3: *Numerical Values for each step of the boxplots comparing GAPS, GAK-Means and Average Linkage algorithms, establishing that GAPS produces biologically significant clusters which are functionally enriched.*

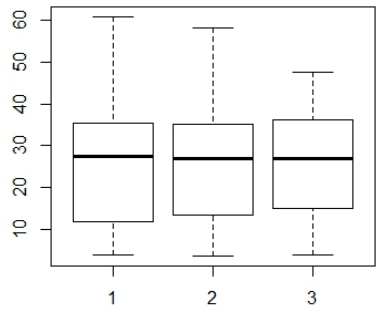


Figure 1: *Boxplot for the values indicated in Table 2; Here 1: GAPS, 2: GAK-means, 3: Average Linkage.*

Next, the value of Silhouette Index has been calculated for each of the datasets for 10 runs of GAPS with different combinations of input parameters. The best results have been listed below in **Table 4**.

It can be clearly seen that GAPS gives better results than GAK-Means and Average Linkage for most of the Datasets. For Yeast Sporulation dataset, although the maximum value of Silhouette index observed is 0.6424 (Result-1), but the Silhouette index value for the most biologically significant result has been found to be 0.6310 (Result-2). Also, it was found that no gene was placed in one of the clusters in Result-1.

Data Sets	GAPS	GAK-means	Average Linkage
Sporulation (K=6)	0.6424	0.5681	0.6366
Cell Cycle (K=5)	0.4393	0.3661	0.3938
Arabidopsis(K=4)	0.3595	0.34	-0.1792
Serum (K=6)	0.3506	0.3467	0.2898
Rat CNS (K=-6)	0.411	0.3442	0.3075

Table 4: *Comparison of Algorithms based on Silhouette Index.*

6. DISCUSSIONS AND CONCLUSION

In this paper, we have compared the performance of GAPS with GAK-Means and Average Linkage for gene expression data clustering and concluded that the point symmetry based GAPS algorithm gives better performance than the other algorithms. The performance comparison has been done on the basis of Silhouette Index values.

We have also established that GAPS gives biologically significant clusters by finding out the most significant Gene Ontology (GO) terms for each cluster and plotting their p-values (at 1% Significance Level) with respect to the other two algorithms. GAPS assumes number of clusters apriori.

In future we would like to apply some automatic clustering techniques for gene expression data clustering which can automatically determine appropriate number of clusters and appropriate partitioning.

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CALCULATING DISTANCE MEASURE FOR CLUSTERING IN MULTI-RELATIONAL SETTINGS

Olegas Niakšu
Vilnius University, Institute of Mathematics and Informatics
Akademijos str. 4, LT-08663, Vilnius, Lithuania
E-mail: Olegas.Niaksu@mii.vu.lt

ABSTRACT

The paper deals with a distance based multi-relational clustering application in a real data case study. A novel method for a dissimilarity matrix calculation in multi-relational settings has been proposed and implemented in R language. The proposed method has been tested by analyzing publications related to data mining subject and indexed in the medical index database MedLine. Clustering based on partitioning around medoids was used for the semi-automated identification of the most popular topics among the MedLine publications. The algorithm implements greedy approach and is suitable for small data sets with a limited number of 1:n relational joins.

1 INTRODUCTION

Clustering has been studied for decades in disciplines such as statistics and data mining (DM). Clustering can be defined as a DM task, where objects are being *unsupervisedly* subdivided into groups, in such a way, that objects of each group are more similar to each other than in comparison to the objects in other groups. Logically, the objects similarity measure is of key importance. The main contribution of our research is a novel customized distance measure calculation method, which reflects relational features of the input data. The method was applied for a dissimilarity matrix calculation, which was later used with partitioning clustering approaches.

Typically, existing clustering algorithms are representatives of one of the following clustering method groups: hierarchical methods, partitioning methods (e.g. k-means, pam), density-based methods (e.g. DBSCAN), model-based methods, subspace clustering, fuzzy clustering, etc.

However, the majority of these clustering methods have been created to process data in "a single table" format. Therefore, typically clustering algorithms underperform in multi-relational data.

We have applied distance based clustering with a novel compound distance measure, based on Gower and Ochiai metrics, which was created specifically for the exploratory research of publications related with DM topic from MedLine database [7]. However, the algorithm can be reused for similar multi-label text classification tasks.

Following the study [5], this research also contributes to the topic of defining DM footprint in healthcare domain, its spread, usability and characteristic features.

The remaining of the paper is organized as follows. Section 2 briefly summarizes the approaches for the clustering in multi-relational settings. Section 3 introduces a novel similarity measure calculation approach. Experimental investigation is described in Section 4 and conclusions are presented in Section 5.

1.1 Background

In our experiment, PubMed database was used, as the biggest medical database, having explicit hierarchical semantic tagging system, called MeSH [6].

PubMed is comprised of more than 21 million citations for biomedical literature from MEDLINE, life science journals, and online books. The Medical Subject Headings (MeSH) is a controlled vocabulary, which is used for indexing, cataloging, and searching for biomedical and health-related information and documents.

Each publication in our case-study has been mapped to MeSH Concepts, Descriptors and Semantic Types.

The whole search result data set with available attributes has been exported to XML format, and then transferred to a relational database.

Having MeSH vocabulary and the exported publications dataset in one database schema, allowed us to leverage semantic concept aggregation underlying in MeSH and to group articles on a higher abstraction layer using distance measure described in Section 3.

2 MULTI-RELATIONAL PARTITIONING CLUSTERING FOR 2:N ONE-TO-MANY RELATIONAL ENTITIES

According to Van Laer and De Raedt [9], when upgrading propositional algorithm to the first-order learners type, it is important to retain as much of the original algorithm as possible, and only the key notion should be updated. In case of distance-based approaches, the distance measure or its direct derivative similarity measure is the key notion of choice.

As it was proposed by T. Horwath and S. Wrobel [2], instead of forming an explicit hypothesis in the form of first-order clauses, we can store all available objects, comprising aggregated distance measures. As a next step, we compare each object, with neighboring objects.

In our case study, relational data representation includes *one-to-many* relational joins between the entities *Keyword*

and *MeSH Concept*, *Keyword* and *MeSH Descriptor*, and between *MeSH Semantic Type* and *MeSH Concept*.
MeSH definitions of these entities are as follows. *Descriptor* is used to index citations in MEDLINE database, and for cataloging of publications. Most *Descriptors* indicate the subject of an indexed item, such as a journal article. MeSH *Descriptors* are organized in 16 categories, each of them is further divided into subcategories, where descriptors are arrayed hierarchically in twelve hierarchical levels.
A *Descriptor* is broader than a *Concept* and consists of a class of concepts. *Concepts*, in turn, correspond to a class of *Terms* which are synonymous with each other. Thus MeSH has a three-level structure: *Descriptor* → *Concept* → *Term*. Every *Term* is assigned to one or more *Semantic Types*, which assign the broadest ontological meaning to a T*erm*. There are only 132 different *Semantic Types* in MESH. In our experiment, we have de-normalized entity-relationship structure in a way that entities *Term* and *Concept* have been merged into entity *Concept*.
Summarizing, MeSH controlled vocabulary allowed us to extract additional semantic information from the keywords assigned to the articles.
Formally, in our study, first-order instances of Articles A are represented by the predicate *Article* A, and the following ground atoms: Concept - C, Descriptor - D, and Semantic type - S. Let us assume that our case study's dataset's instance example I:

I = A (art1),

with defined background knowledge BK:

C(art1, "Benpen"),
D(art1, "Penicillin G"),
S("Benpen", "Antibiotic").

The vocabulary of this example consist of the predicate A and the background predicates concept C, the descriptor D and the semantic type S, with the following argument types: A(a1: name), C(a1: name, a2: discrete), D(a1: name, a2: discrete), S(a1: name, a2: discrete). The structure of ground atoms repeats a subset of relational data structure. More precisely, the entities *Concept* and *Descriptor* are joined to the entity *Article* through the entity *Keyword*. But, since *Keyword* is in one-to-one relation with *Article,* it was substituted by it.

3 THE SIMILARITY MEASURE IN MULTI-RELATIONAL SETTINGS

In this section we will describe an approach how to combine different similarity measures in a way, suitable to multi-relational structures, in particular considering our use case example.
Very often, in complex data structures, there can be no objectively "best" distance or similarity measure, or at least formal proof would be too expensive. Therefore, there are certain trade-offs when selecting optimum similarity measure. Since the data in our case study does not form Euclidean space, we require more robust distance measure. Gower's general coefficient of similarity [1] is one of the most popular measures of proximity for mixed data types.
Using Gower's general similarity coefficient we can compare values of predicate arguments. Gower's coefficient of similarity s_i is defined as follows:

$$s_{i,j} = \frac{\sum_k w_k s_{ijk}}{\sum_k w_k} \qquad (1),$$

where: s_{ijk} denotes the contribution provided by the k_{th} variable dependable on its data type, and w_k is assigned weight function. In other words, the similarity measure of the two objects i & j, is a sum of normalized weighted similarities of each object's variable k (attribute of the entity).
The calculation of s_{ijk} depends on the data type as described below. For nominal variables:

$s_{ijk} = 1$, iff $x_{ik} = x_{jk}$, and $s_{ijk} = 0$, when $x_{ik} \neq x_{jk}$ (2)

For numeric variables:

$$s_{ijk} = 1 - \left|x_{ik} - x_{jk}\right| / r_k, \qquad (3),$$

where r_k is a difference between max and min values of k'th variable. As in the case with nominal variables, s_{ijk} equals to 1 when $x_{ik} = x_{jk}$. And s_{ijk} equals to 0, when x_{ik} and x_{jk} represent maximum and minimum values of the variable.
Binary data type in Gower metric can be treated as a nominal data type, where, $s_{ijk} = 1$, iff the compared values equals to 1. Additionally, it shall be stated, that for the cases where all variables are of binary type, another similarity measures might be more preferable, like Jaccard similarity coefficient.
Furthermore, to compare two value lists in the case of comparing objects with one-to-many relations, we propose to use Ochiai (Ochiai-Barkman) coefficient [7]:

$$s_{l1,l2} = \frac{n(l_1 \cap l_2)}{\sqrt{n(l_1) \times n(l_2)}} \qquad (4),$$

where l_1, l_2 – nominal value lists, n(l) – the number of elements in l.
In a relational data structure, the compared objects are represented by a number or relations and relational joins. For each attribute of a relation, denote it as a variable *k*, which is considered to be a part of the selected search space, atomic similarities s_{ijk} have to be calculated using Gower similarity for a specific data type, value lists using Ochiai coefficient extended by Gower similarities for numeric and binary data types. Finally, the overall similarity measure between two objects is calculated as a weighted sum of s_{ijk} according to (1).
A relational data model has always to be treated with care, and certain preprocessing, de-normalization has to be applied. Considering the whole available relational data might be impractical. Hence, only valuable entities and attributes have to be selected. There are different recommendations on the relational feature selection, e.g. as described in works of R.T. Ng and J. Han [4].

The selected entities of the data model shall be analyzed for de-normalization possibility, assuming their relational join type. Entities with one-to-one type joins typically can be easily merged. For the entities connected with one-to-many joins, Ochiai with Gower coefficient for numeric, binary data types shall be used. *Many-to-many* related entities in many cases can be de-normalized to one one-to-many relationship.

In our case study a compound object *Article*, has value list variables (vectors) *Concepts* and *Descriptors.* And variable *Concept* is in fact is a part of a predicate pointing to the variable *Semantic type.*

Furthermore, applying the generic Gower similarity coefficient to the predicates C, D, and S, we have constructed the following compound similarity measures to compare two instances of article A:

$$sim_{A1,A2} = \frac{w_c simC + w_d simD + w_s simS}{w_c + w_d + w_s},$$

where

$$\mathrm{simC} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} s_{ij}(concept_i(A_1), concept_j(A_2))}{\sqrt{m \times n}},$$

$$\mathrm{simD} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} s_{ij}(descriptor_i(A_1), descriptor_j(A_2))}{\sqrt{m \times n}},$$

$$\mathrm{distS} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} s_{ij}(semantictype_i(A_1), semantictype_j(A_2))}{\sqrt{m \times n}}.$$

Since the similarity measures s_{ij}(concepts), s_{ij}(descriptors), and s_{ij}(semantictypes) measure the similarity among nominal values, only formulas (2) and (4) have been used in our case study.

In essence, *simC*, *simD*, and *simS* calculate similarity of the value lists (accordingly *Concepts, Descriptors*, and *Semantic Types*) which are relationally joined to the central entity *Article*. Other known approach for this task is described by Horwath, Wrobel et al. [2], where the authors proposed to calculate influence function, the cost of which equals to the effort of the lists equalization. However, our proposed, simple match calculation requires less computational effort and is reasonable for the lists with non-repeating values.

Another important aspect is the determination of weights for the overall similarity measure (1) calculation. Some authors, e.g. T. Horwath and S. Wrobel propose a simplified approach, by not using weights at all. This simplification in many cases may be unadjusted, because of the uneven nature of the data. In our experiment, two approaches have been used: the statistical one, where weights are proportional to the number of tuples of the relevant entities; and expert based, where weights have been experimentally adjusted and normalized by the domain expert.

In the first case weights have been calculated as follows:

$$w_c = \frac{n_c}{n_c+n_d+n_s}, w_d = \frac{n_d}{n_c+n_d+n_s}, w_s = \frac{n_s}{n_c+n_d+n_s} \quad (5)$$

The described weight distribution is reasonable in the cases, when we want to level the importance of the each list value variable according to the relative number of tuples in each entity.

In other examples, having more diverse set of variables, this statistical approach might be appended or changed by the domain expert knowledge and empirical experiments. If that is the case, for the calculation efficiency, it is important to store all s_{ijk} values, for further experiments with different w_k values. In opposite case, if only the resulting s_{ij} are preserved, when in order to change the weights, the whole similarity matrix shall be recalculated from a scratch.

According to our experiment results, the described similarity measure derives stable values, meaning that small changes on a term do not cause big changes in distance values. The experiments with real data have shown that in some cases it is even too stable and lack some responsiveness to the data changes. However, this is easily solvable by fine-tuning weight parameters w_c, w_d, w_s. First of all, in order to automatically extend the distance measure to varying arities, we assigned initial weight values proportionally to the sizes of Concept, Descriptor and Semantic Type nominal value lists, as shown in (5). Later we underwent a series of trials with subjective w_c, w_d, w_s values, based on subjective domain expertise.

Finally, the dissimilarity value was calculated as follows:

$$dissim_{A1,A2} = 1 - \mathrm{sim}_{A1,A2} \quad (6)$$

The algorithm, calculating full dissimilarity matrix for the set of articles, has been implemented in R. R libraries "cluster" and "fpc" were used, for the different partitioning around medoids (PAM) implementations [3]. Due to a large search space, extended by joined relations, the algorithm requires a vast computational power. Multiple iterations of distances between each object and its selected related compound entities have resulted in the algorithm complexity of $O(n^2 L_c^2 L_d^2 L_s^2)$, where L_c – the length of list of *Concepts*, L_d – the length of list of *Descriptors*, L_s – the length of list of *Semantic types*.

Moreover, it is well scalable, and our further step will be parallelization of this algorithm.

The results of PAM clustering application with the described similarity measure for exploratory analysis of publications indexed by PubMed are presented in the next sections.

4 EXPERIMENTAL INVESTIGATION

The dissimilarity matrix calculation algorithm has been implemented in R language, and the resulted matrix of dissimilarity measures has been used with PAM clustering, implemented in R. Totally 2.284.453 similarity values have been calculated. After a few iterations of code optimization, overall achieved performance of an average size data set for 100 similarity values was in the range of 40-60 seconds on one core of Intel i7 CPU. The parallelization gave a huge effect, since each distance measure is independent and thus can be calculated in parallel. However, data exchange between nodes required by the parallelization had a negative impact and had reduced the positive effect of the

parallelization. As a further research step, the algorithm recoding with its further parallelization in mind is planned.

For the evaluation of the overall clustering quality, cluster's *silhouette* value has been used. The *silhouette* value depicts the quality of each object's cluster. Cluster's *silhouette* value is derived in the following way. Let a(i) be the average dissimilarity between object *i* and all other objects of the cluster A, to which it belongs. For another cluster C_1, let $d(i,C_1)$ equals to average dissimilarity of *i* to all objects of cluster C1. Then, let calculate d(i,C) for all the remaining clusters $C_{2..n}$ and assign the smallest of these d(i,C) to d_min(i). The *silhouette* value of an object *i* is defined as follows:

$$silh_i = \frac{d_min(i) - a(i)}{\max\{a(i), d_\min(i)\}} \qquad (7)$$

And the cluster's *silhouette* value is an average *silhouette* value of all its members. Values near 1 mean that the object *i* is assigned to a correct cluster. In contrast, values close to -1 mean that it is likely that an object is assigned to a wrong cluster. And the *silhouette* value around 0, means that the object *i* can be equally assigned to the selected or the nearest cluster.

In our case, trying different number of clusters, the maximum achieved *silhouette* values were in the range: 0.20 - 0.30. Objectively, that means the overall clustering result is unsatisfactory, and shows that the found clusters are poorly describing the data set.

However, considering a non-trivial task of scientific publications semantic grouping, the whole exercise was not fruitless, and gave us some interesting insights.

Regretfully, there is no point of reference or golden standard to compare our results with. Therefore, comparison to other possible clustering methods is planned for further research step.

The application of clustering with the described similarity measure on relational data of MedLine and MeSH has shown that there are no large and very popular topics, and the research within DM application in healthcare area is extremelly diverse.

Also our research results have revealed a couple of clusters with a higher research interest. Among them we can mention the following relatively more popular research areas: DM applications within protein structure analysis, specific patient profile search, text mining of medical text, public health legislation documents mining, commerce practices (fraud detection), disease diagnostics, survival prediction, natural language processing information retrieval, image data analysis.

5 CONCLUSION

A compound dissimilarity measure calculation algorithm for multi-relational data structures has been created, implemented and tested with a real world data clustering task. The proposed dissimilarity measure aggregates Gower similarity coefficient and Ochiai-Barkman coefficient and is applicable for different relational data models.

However, the presented approach has not been formally tested yet and requires further experiments and formal evaluation. Initial comparison tests have been made by using the same use case data converted to a propositional form and applying k-means, PAM, and CLARA clustering algorithms. Still it has resulted in another set of low quality clusters, with less interesting practical information.

Hence, the next planned research activity will include approbation with classified multi-relational data sets and comparison to another clustering methods.

The main known shortcoming of the implemented algorithm is its overall performance, due to the applied greedy approach. Though this approach was suitable for our case study, in other cases large data clustering algorithms CLARA or CLARANS [4] might be used instead of PAM.

Conclusions on DM research within healthcare domain

The practical case-study results presented in 4th section are not homogeneous and hence are not generalizable. Instead, we provide a few atomic conclusions of the analyzed case study clustering task:

- Oncology diseases are on the top of the mined disease list. Cardiovascular diseases are only on the third place after nervous system diseases.
- Interestingly, too little attention is currently paid to chronic diseases, which are believed to be the biggest challenge of modern healthcare systems because of the aging population.
- There is an outstanding number of articles in the field of genetics, which reconfirms that DM provides powerful arsenal of techniques for high volume data analysis.

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Zbornik 16. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2013

Proceedings of the 16th International Multiconference

INFORMATION SOCIETY – IS 2013

Interakcija človek-računalnik v informacijski družbi

Human-Computer Interaction in Information Society

Uredili / Edited by

Franc Novak, Bojan Blažica, Ciril Bohak, Luka Čehovin

http://is.ijs.si

9. oktober 2013 / October 9th 2013
Ljubljana, Slovenia

PREFACE

HUMAN-COMPUTER INTERACTION IN INFORMATION SOCIETY

Human-Computer Interaction in Information Society is a conference organized by the Slovenian HCI community. The Slovenian HCI community is an informal community of Slovenian human-computer interaction researchers that started in 2008 by a group of HCI researchers and enthusiasts from the Faculty of Computer and Information Science, University of Ljubljana, XLAB and the Jožef Stefan Institute. The main idea behind the community is to connect Slovenian researchers interested in HCI in order to exchange ideas, collaborate and accelerate the development of this exciting interdisciplinary field in Slovenia and its surrounding countries.

This is the second event organized by our community. The target audience of the conference are HCI researchers and developers from academia and industry as well as other HCI enthusiasts. The conference will provide the opportunity to share research experience and establish fruitful relationships for future collaboration.

Franc Novak, Bojan Blažica, Ciril Bohak in Luka Čehovin

PREDGOVOR

INTERAKCIJA ČLOVEK-RAČUNALNIK V INFORMACIJSKI DRUŽBI

Interakcija človek–računalnik v informacijski družbi je konferenca, ki jo organizira Slovenska skupnost za proučevanje interakcije človek–računalnik. Omenjena skupnost je nastala v letu 2008 v okviru neformalne povezave raziskovalcev s področja interakcij človek–računalnik na Fakulteti za računalništvo in informatiko Univerze v Ljubljani, XLAB-u in Institutu "Jožef Stefan". Osnovno vodilo je povezati slovenske raziskovalce in razvijalce s tega področja, spodbuditi izmenjavo idej in pospešiti razvoj tega zanimivega interdisciplinarnega področja v Sloveniji in sosednjih državah.

Ta konferenca je že drugo srečanje, ki ga organizira naša skupnost. Ciljni udeleženci konference so raziskovalci s področja interakcij človek-računalnik iz akademskih krogov, industrije ter tudi ostali, ki jih navedena problematika zanima. Konferenca je priložnost za izmenjavo izkušenj in navezavo osebnih stikov za bodoče plodno sodelovanje.

Franc Novak, Bojan Blažica, Ciril Bohak in Luka Čehovin

KINECT KIOSK USER EXPERIENCE EVALUATION

Ciril Bohak, Matija Marolt
Faculty of Computer and Information Science
Univerity of Ljubljana
Tržaška 25, 1000 Ljubljana, Slovenia
Tel: +386 1 47 68 483; fax: +386 1 426 46 47
e-mail: {ciril.bohak, matija.marolt}@fri.uni-lj.si

ABSTRACT

In this paper we present an evaluation of Kinect Kiosk user experience. We have created an example of evaluation system where users can decide which parameter values of the user interface are suitable for them. Our example shows how we can collect user feedback in form of voting system to adapt the user interface for average user. Such setup also allows user profiles that can store the information of user interface preferences for an individual user. The presented evaluation of touchless interfaces is novel and shows how user interface designers as well as user experience designers can create better user interfaces by using presented evaluation.

1 INTRODUCTION

In recent years more and more touchless systems are emerging that allow a novel user experience. Devices such as Microsoft Kinect, Leap Motion controller and others allow users to interact with systems in different ways. A new kind of an interaction, triggered new interface designs adopted for touchless interaction. While most actions in such interfaces are simple and rely on moving the cursor on a screen by moving a hand and selecting or clicking buttons with hovering over them or making certain gesture with a hand (close the palm of the hand), less attention was given to adapting the user interfaces for different setups of such systems. Using a Kinect sensor might be satisfactory in combination with big screens or even projectors, however it is surely not satisfactory with small screens. The problem is that graphical user interface (GUI) components do not adapt for different screen sizes which results in unusable applications due to too small fonts, images, buttons, and other components.

A lack of evaluation studies led us to try implementing our own evaluation interface for presented interface. We have relied on an user-centered user study where user can choose what best suits his needs. One of very important points of touchless interfaces is that they usually have to be well adjusted for individual user which results in storing user profiles for groups of users or even individuals. Such profiles can be set in advance according to basic parameters of individual system and current user.

In the following section we present the related work on evaluation of interfaces and on touchless interfaces. In Section 3 we present our evaluation interface and in Section 4 we present an use-case with Kinect kiosk. We discuss whether such framework implementation and its usage is meaningful or not in Section 5. At the end we point out the possible future extensions of presented framework and its future use in the final section.

2 RELATED WORK

An evaluation of user interfaces has been done since early beginnings of user interface design. Questions on how and if we can measure usability were discussed in 1980's [4] and early 1990's [1]. Several attempts on how it can be done were developed in following years when IBM research presented the questioner evaluation method developed and described by Lewis in [8]. In presented method researchers have presented use of the developed method on several use-cases.

During same era Nielsen has presented several papers on usability engineering and improvement of human computer interaction. Heuristic evaluation of user interfaces as an informal method of usability analysis was presented in [11]. Later Nielsen also presented how can such method be used for finding usability problems in applications [9], later incorporated in a book [10].

Many usability studies of mainstream user interfaces were conducted. A comparison of usability methods for interactive health technologies is presented in [7]. State-of-the-art in automating usability evaluation of user interfaces is presented in [6]. The article presents which aspects of usability studies can be automated and to what extend. Some evaluation studies were also performed on touchless systems [2]. In the work authors present a gesture controlled user interface and evaluative study of its usability.

We use user-centered user interface evaluation as a base for implementation of presented evaluation interface. An example of using user-centered user design and evaluation can be found in [5]. An adaptive use interface and its evaluation is presented in [12].

While presented literature covers many aspects of user interface evaluation none has presented an automated user-

centered evaluation of touchless interfaces which is presented in following sections. System which use new kind of interfaces such as Microsoft Kinect or Leap Motion were not yet evaluated in a described manner. In following sections we first present our approach to automated user-centered evaluation of touchless interfaces and later on present an use-case with the Kinect kiosk.

3 EVALUATION INTERFACE

While designing the Kinect kiosk system we have faced several important decisions on what parameters to use while designing kiosk user interface. Such parameters are font size, image size etc. We also had an idea on using known user parameters - its height and distance from screen - as well as of actual system - size of screen and it's resolution - in defining an user interface adapted for individual user. To create such system one must make sure that it will fit end-user expectations and will be easy to use, which suggested using user-centered evaluation during development.

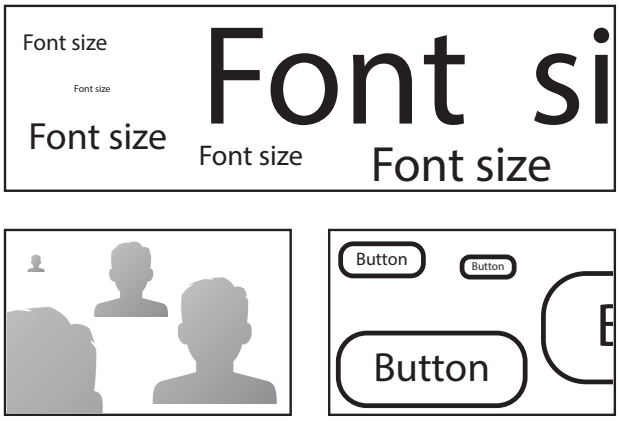


Figure 1: Selected user interface parameters.

3.1 Defining evaluation parameters

Throughout the development of our system we have isolated a small set of parameters that are crucial for defining a good usability. These crucial parameters are (also presented in Figure 1):

- **font size** - which defines font sizes for all parts of interface including titles, buttons, content font size and others;
- **image size** - which defines the size of images showing individual elements that user should be able to recognise at the using distance;
- **button size** - which defines the size of the button which user has no problems selecting/clicking;
- **click duration** - which defines the time period user has to hold a cursor over an user interface element, such as button, for interaction action, such as selecting or clicking.

If the above user interface parameters are set properly for individual user we increase usability of such system as well as improve systems user experience. Defining the best values of presented parameters for individual user is a problem we cope next.
If we want to optimise the selected parameters we have to know some properties of the system presented in Figure 2. For usability study we have to know the physical properties of the system, such as screen size, screen resolution and distance to user. According to these system properties we can try optimising the parameters of user interface.

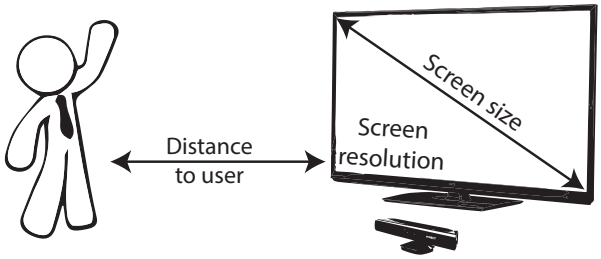


Figure 2: Relevant system properties.

We have decided to use user-centered user interface evaluation for optimising the above mentioned user interface parameters according to known physical properties of the system. To perform such evaluation we have designed a dedicated assessment system, described in following section, where users were able to select a preferred setting for an individual user interface parameter.

3.2 Assessment system

Assessing the optimal values of parameters led us to development of dedicated assessment system. We have designed a system in form of nonlinear wizard, presented in Figure 3, where user can decide which parameter to optimise next. The system records users values for individual parameter in a file. After completing all the tasks (or just few of them) user, can conclude his selection and allow new users to assess the user interface.
Each individual step of wizard presents optimising the individual user interface parameter. In case of font size, the system displays several options of font sizes and user selects the best suited one for reading longer content. User selects his choice by hovering over the preferred example. Optimising other parameters is similar except for parameter of click duration. In case of click duration the user is presented with several choices of click duration in form of boxes that switch

a color on successful interaction. When an user decides on best duration he selects the choice.
All the data is stored in a file immediately after action to prevent possible data loss if the system crashes. Users also do not have to fill-in questionnaires after the experiment since their feedback is already collected by assessment system.

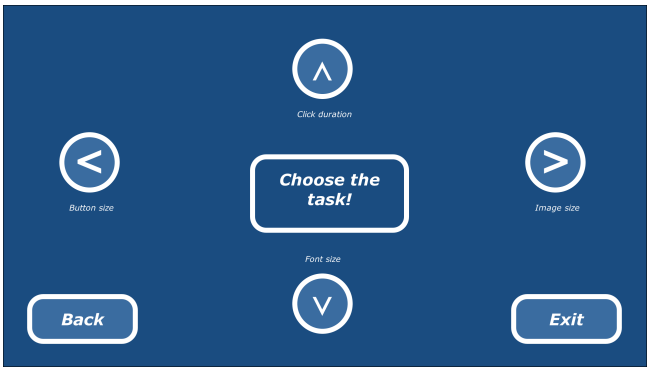


Figure 3: Assessment system.

4 EVALUATION OF KINECT KIOSK

As an use-case we have conducted user testing on Kinect kiosk presented in [3]. The Kinect kiosk is a system dedicated for kiosk presentations with use of Microsoft Kinect sensor. It also consists a web kiosk framework for content display and deployment. A case study was conducted at SIRikt 2013 conference. Users were high school teachers of different age and background. The actual setup consisted of large scale television with diagonal of 42" and screen resolution of 1280 by 720 pixels. System was used at distance of 2.5 meters. Testing conditions were real-life like due to numerous people grouping around the set-up and trying interacting with the system.
The main goal of evaluation was to determine the values for previously mentioned set of user interface parameters. We have obtained feedback from 21 users. Some users have skipped some parts of testing for various reasons (such as lack of time, lack of interest, etc.). Users also performed tests in various order, some even repeated the individual steps of evaluation.
In the step of selecting the appropriate font sizes system displays 6 boxes containing a text with different font size ranging from 8 to 36 pixels in size as shown in Figure 4. Users task is to select the box where the content has his preferred font size. Image sizes ranged from 48 to 192 pixels, buttons sizes range from 64 to 256 pixels and click durations range from 0.1 to 3 seconds. There were also 6 choices for selecting the preferred value of other user interface parameters. All the values for user interface parameters are presented in Table 1. Parameters are dependant on physical properties of the system. Parameters for size are presented in screen pixels

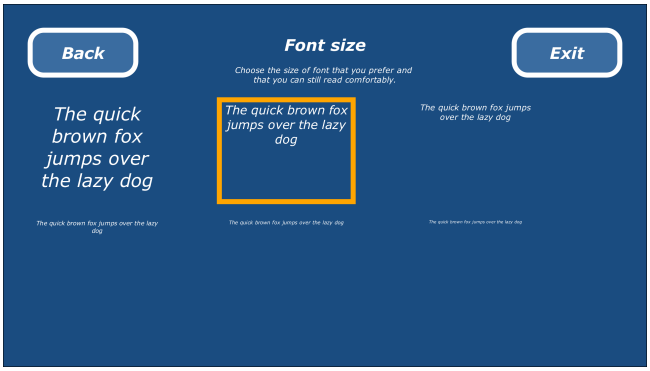


Figure 4: Assessing font size parameter of user interface.

(px) while parameter values for click duration is presented in seconds.

case	font size	image size	button size	click duration
1	36 px	192 px	256 px	3 s
2	24 px	160 px	160 px	2 s
3	16 px	128 px	128 px	1 s
4	12 px	96 px	96 px	0.5 s
5	10 px	64 px	72 px	0.25 s
6	8 px	48 px	64 px	0.1 s

Table 1: Values of evaluation parameters.

4.1 Evaluation results

With the use of collected data we have chosen the values of user interface parameters that best fit the average user for use with Kinect kiosk. The user selected values for user interface parameters are presented in Table 2. The table shows cases selected by users according to values in Table 1. The "-" value shows where users did not complete certain step of evaluation.
According to the results we have calculated the value for individual user interface parameter. For size parameters we round the value to integer value, for time parameters we round the value to one decimal place. Obtained parameter values are presented in last row of Table 2 ($calc$).

5 DISCUSSION

While presented approach still incorporates separate evaluation and parameter setting for individual system it is still one of few approaches for evaluation of touchless systems. While there are more affordable touchless systems arriving to the market more usability studies and evaluations have to be conducted for their improvement as well as for integration in end-user products such as Kinect kiosk.
Presented work shows first step towards development of automatically adjustable user interface for touchless devices that will take into account physical properties of the system and will adapt according to user interaction success.

user id	font size	image size	button size	click duration
1	24 px	128 px	72 px	0.2 s
2	24 px	128 px	72 px	1 s
3	16 px	96 px	96 px	0.5 s
4	24 px	128 px	96 px	1 s
5	36 px	160 px	72 px	0.2 s
6	24 px	128 px	-	-
7	12 px	96 px	96 px	0.5 s
8	24 px	96 px	72 px	1 s
9	24 px	128 px	72 px	0.5 s
10	24 px	160 px	96 px	1 s
11	36 px	48 px	160 px	2 s
12	12 px	128 px	128 px	0.5 s
13	16 px	96 px	96 px	0.5 s
14	16 px	128 px	96 px	1 s
15	12 px	96 px	72 px	1 s
16	24 px	128 px	128 px	0.5 s
17	24 px	128 px	-	1 s
18	12 px	96 px	96 px	0.5 s
19	-	160 px	96 px	0.2v
20	16 px	128 px	96 px	1 s
21	16 px	96 px	96 px	0.5 s
calc	**21 px**	**118 px**	**95 px**	**0.7 s**

Table 2: User selected values of evaluation parameters and their final calculated values.

It shows that there are still possibilities of extending and adapting the HCI systems for individual users or groups with same physical properties or even storing settings for individual user. Personalizing the system can be achieved by recognizing user with matching physical properties, face recognition or even combination. Other possibility is integration with speech recognition as well.

6 CONCLUSION AND FUTURE WORK

We have presented how an automated user-centered evaluation system can help in designing better touchless user interfaces that are adjusted for broader use and are adapted for individual usage according to the physical properties of implemented system. A use-case shows how the proposed approach was applied to Kinect kiosk system.

Such an approach can be used for determining other user interface parameters such as sizes of other user interface components, color-scheme selection, etc. It could also be used for on-the-fly adaptation of a system that is already used in practice. One could adjust the parameters of user interface according to the responsiveness of user and his reaction times for individual interaction tasks. Systems could also adjust user interface parameters according to the distance between user and the system.

One other possibility is storing user profiles and identifying users with face recognition and other user properties. In such scenario a system would select preferred user's settings as well as adapt his profile for even better user experience.

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3D NAVIGATION NATURAL INTERACTION WITH MOVEMENT SENSOR TECHNOLOGY

Yin Ling
DITEN - Department of Naval, Electrical, Electronic and Telecommunications Engineering
Genoa University
Via All Opera Pia 11A, 16145, Genoa, Italy
e-mail: ling.yin@hotmail.com

ABSTRACT

This paper presents our designed three dimensional (3D) natural interaction navigation system using Micro-electro-mechanical systems (MEMS) CHR-6dm with ZigBee wireless technology for broader interactive coverage range usage. Related sensor interface software and sensor data observation are presented. Furthermore, local machine platform realization for Google Earth (GE) 3D navigation using movement of human beings is illustrated. In the end, global heritage navigation effect using this developed 3D gesture navigation system is shown.

1 INTRODUCTION

Currently, intelligent networking and computing platforms, such as PCs, tablets, PDAs, mobile phones, smart objects, etc., play an ever more important role for people and their social life. User interaction technology is a key factor of these machines, as they can better understand and support the expressions of people. Natural interaction is defined based on human senses, like: gestures, expressions, movements, hearing, vision, and so on. Therefore, natural interaction application design could provide more sensing capabilities for new machines to support human spontaneous ways of discovering the real world [1].

In order to capture the human senses, a variety of sensor technologies have been designed and integrated for natural interaction paradigm realization. For instance, Microsoft's Kinect, as a three dimensional (3D) motion sensing video camera with real-time dynamic capture, image recognition, microphone input, audio recognition, social association interaction, has also been used in gesture-based human-computer interaction (HCI) [2]. Another popular game console is Nintendo's Wii Remote Controller – Wiimote which contains accelerometer, Infra-Red (IR) camera, wireless Bluetooth connectivity, speaker and vibration motor. As a natural input device, demonstrator kit with Wiimote applied for e-teaching is developed and evaluated [3].

Considering natural interactive design and application, the sensors which can express natural senses of human beings could better help people to interact with machines using more natural and direct presentation. Both of natural interaction exemplifications and sensor technologies which are typically used as natural interaction facilities are two critical focuses in our research work.

Micro-electro-mechanical systems (MEMS) attitude and heading reference system (AHRS) is chosen as main used sensor system in this research about 3D natural interaction navigation using gesture. Corresponding cognition load carried by communication is reduced as this sensor technology could transmit gesture to computer and this embodied interaction is understood as more natural and direct expressions than traditional interaction ways. The effects of using embodied interactions to improve learning performance have been analyzed by some previous research. Barsalou indicates that embodied states can truly influence cognition and be influenced by cognition as well. This is called Embodied Cognition: when we perceive, act, interact with things and events in the surroundings, our bodies can link minds to the world [4, 5].

We put MEMS AHRS sensor system in natural interaction exemplification for this research project. In that GE technology supplies visible geographical and 3D navigation functions, we connect GE navigation programming and development technology with user sensor data input to realize natural interaction 3D navigation via gesture symbol expression. The better movement analysis and tracking abilities supplied by MEMS sensor induce more flexible and a diversity of gesture interactive design opportunities. Additionally, in order to extend the limited coverage distance of Wiimote and Kinect, we apply ZigBee wireless technology instead of Bluetooth to our research project. The larger wireless coverage range can help to realize more actual virtual world exploration in computer-assisted cinema with virtual reality technology. At the same time, we construct local machine software platform utilized in standalone application.

This paper makes these main contributions. Firstly, the hardware prototype of movement sensor system with ZigBee wireless technology is designed and developed for the purpose of larger coverage range gesture interaction tool realization. Secondly, software construction of natural interaction system implements human being's gesture interaction that control 3D navigation. Thirdly, local machine system development and 3D gesture navigation

practise explore the platform construction and application of human computer interaction system.

2 RELATED WORK

L.Y.Zhang et al. [6] describe their paradigm of GE interaction with videos which are geographically and perspectively placed as "viewports" inside the world. They use GPS and compass to collect location and direction information that causes a natural organization of information that is superimposed on maps that can be browsed and queried.

T. Matsumoto et al. [7] present a new mobile HCI design with "Full-Embodied Web" concept that applies natural embodied interactions to a special mobile device for augmenting users' experiences in real world by acquiring information from social web resources. GPS sensor and camera with 3D accelerometers are exposed through the web service technology to construct embodied interaction for integrated web application.

Kamel Boulos et al. [8] design the usage of depth sensors such as Microsoft Kinect and ASUS Xtion and provide this natural user interface (NUI) to control 3D virtual globes, such as: GE also including its Street View mode, Bing Maps 3D, and NASA World Wind.

Different from these systems, we exploit the advantage of inertial measurement unit (IMU) and MEMS sensor technology in processing movement information and ZigBee-assisted technology to realize broader coverage range and better freedom than camera-supported sensor system and Bluetooth wireless assisted sensor system with the development possibility of more diverse gesture interaction designs. In addition, IMU and MEMS sensors also can support finer movement information measurement than GPS for outside usage.

3 3D MOVEMENT SENSOR SYSTEM

3.1 CHR-6dm AHRS Hardware

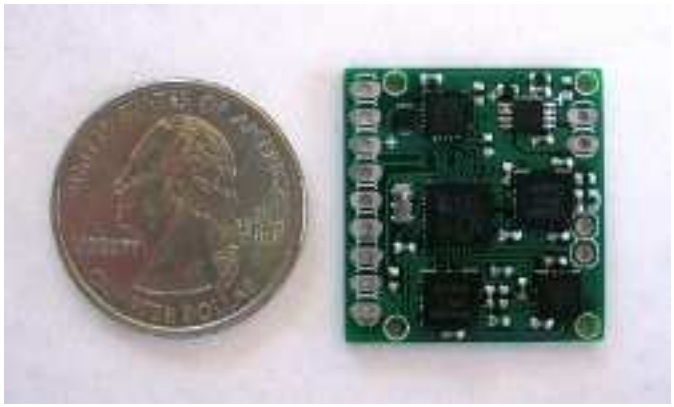


Figure 1: *CHR-6dm AHRS hardware.*

Our chosen CHR-6dm board as figure 1 shown above integrates one 3-axis gyroscope, one 3-axis accelerometers, and one 3-axis magnetometers with the Extended Kalman Filter (EKF) embedded on the board. This board is a cost-effective orientation sensor providing real time yaw, pitch, and roll angle outputs at up to 300 Hz [9]. These three angles informations are attitude estimation results calculated by embedded EKF module that needs 3-axis gyroscope, accelerometers and magnetometers all together.

In addition, one Xbee series 2 OEM RF module is connected to this CHR-6dm sensor system because of the broader coverage range, longer battery supporting periods, priority of faster connection to network and lower cost of ZigBee technology [10]. This wireless connection could help gesture communication with much better freedom.

3.2 CHR-6dm AHRS Interface Software

The AHRS interface pc software running on computer connected to CHR-6dm movement interaction sensor system is provided by CH Robotics company and it is realized by C# programming technology with all source code and library resources availability.

To successfully use this CHR-6dm AHRS system for movement tracking, some setup and calibration are needed to accomplish. The procedures details are described and sensor signal observation picture is embedded below,

1. Serial port connection
2. Magnetometer calibration

Normally, Magnetometer measurement is influenced by ambient parameters, like: temperature, magnetic perturbations introduced close to the sensor. Therefore, magnetometer should be calibrated by magnetometer calibration method[1] before correctly and scientifically use this sensor system. Via magnetometer calibration window in this interface software, user need to click "start data collection" firstly. During the process of data collection, user also need to rotate sensor to cover almost all possible angles. After data collection, calcibration computation can output calibration matrix which are needed to write to RAM or FLASH.

3. Yaw, pitch and roll angles calibration

In order to setup navigation coordinate system, yaw, pitch and roll angles are needed to calibrate. In EKF window of this interface software, Mag Ref Vector is to calibrate yaw angle and user should orient sensor to the direction of perpendicularity to the gravity before setting yaw reference according to yaw reference setting[2]. For pitch and roll angles calibration, user should put sensor with x and y axis in the directed moving coordinate system and set accel reference following pitch and roll calibration procedures[3]. These setting result are also required to update to RAM or FLASH as well.

4. Sensor measurement signal observation and analysis

On Figure 2 displayed below, EKF estimated angles about yaw, pitch and roll, measured angular rates of yaw, pitch

[1] http://www.youtube.com/watch?v=PnbZK2mpY04
[2] http://www.youtube.com/watch?v=Y1PbymP0oAU
[3] http://www.youtube.com/watch?v=ZJN3kUOMaMw

and roll, could be observed with real time measurement property. On the graph of estimated angles, yaw, pitch and roll angles characterized by different colour fluctuate in real time following user gesture, and they are utilized to modulate GE view rotation on the screen. Additionally, this AHRS interface software also provides data storage function for off-line data analysis.

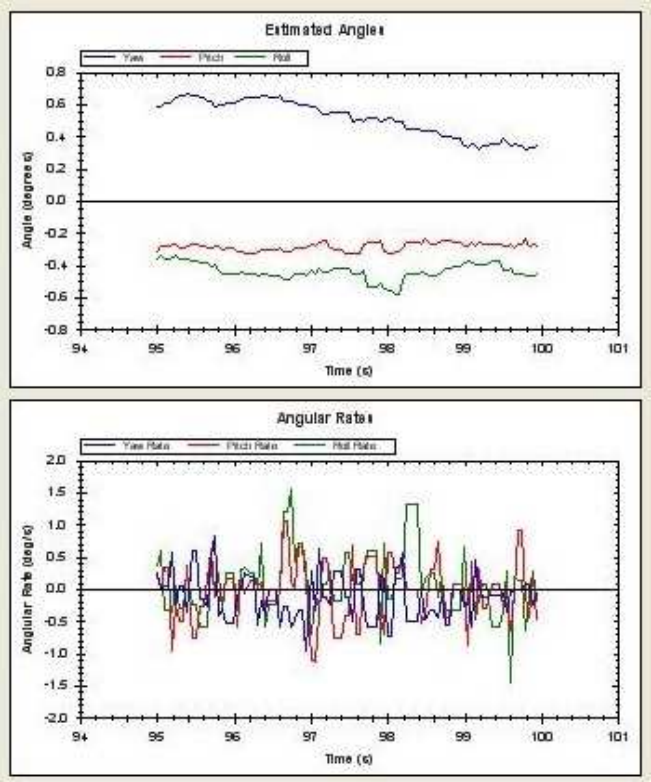


Figure 2: *sensor signal observation by CHR-6dm AHRS interface software.*

4 3D NAVIGATION PLATFORM SYSTEM WITH GESTURE INTERACTION

In order to represent the cubic, direct and natural effects and advantages of gesture interaction, we choose GE navigation technology which may help to explore 3D buildings, imagery, terrain, cities, places and businesses as interaction and navigation platform by virtual journey. For the purpose of prototype realization of 3D navigation platform system using gesture interaction, local machine platform with C# calling GE COM API technology, windows API technology and event-driven method is constructed.

GE provides individual free version, Plus version, and Pro version. GE free version lets you fly anywhere on Earth to view satellite imagery, maps, terrain, 3D buildings, from galaxies in outer space to the canyons of the ocean. For individual development, individual free version is quite enough for platform prototype construction.

After GE is installed successfully, open Visual Studio and create a windows application project, and choose "add reference…" in "Project" menu, then switch to Tab "COM" and choose "Google Earth 1.0 Type Library". Once the reference of EARTHLib is added in this proect, we can call the interface to develop application program.

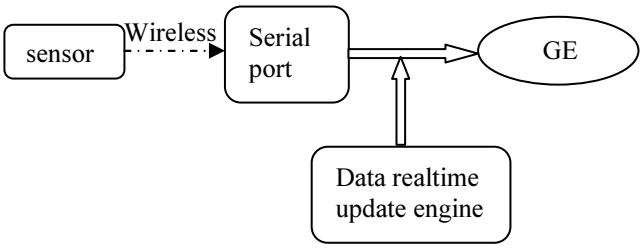


Figure 3: *3D navigation local machine platform architecture.*

This developed 3D navigation local machine platform as the architecture figure 3 with the c# programming mainly covers these components below,

- Serial port data packet receiving on computer with fixed periods
- Serial port data package processing
- GE view showing and resizing
  The view size of GE could be resized by user preference.
- Sensor data real-time update to GE view navigation by data realtime update engine
  Sensor data realtime update engine controlled by timer, can update GE view navigation and rotation according to sensor data that measures user movement.

5 NAVIGATION REAL EFFECT USING 3D GESTURE INTERACTION TOOL

Applying this developed 3D embodied navigation platform both including hardware and software system to real navigation experience and making it more interesting and meaningful, some specific global heritage funds (GHF) points navigation integrating professional world heritage culture knowledge are supported in GE using JavaScript programming technique, such as: Chavin de Huantar, Peru; Lijiang Ancient Town, China; Cyrene, Libya.

When user moves CHR-6dm sensor system following pitch angle, this Earth will rotate with latitude variation. If user moves sensor with yaw angle rotation, this Earth will move following longitude modification. Roll angle rotation will induce zoom in or zoom out. The relationship between the navigation and angles could be understood from Figure 4.

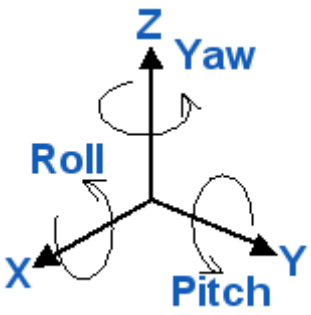


Figure 4: *view navigation and attitude angles.*

Regarding the heritage places interested by user, they can rotate CHR-6dm sensor system to modulate longitude and latitude with zoom in/out to move GE view to arrive at heritage position. Vibration on z axis in Figure 4 could stimulate this heritage knowledge window appearance as Figure 5 for more profound heritage culture knowledge acquirement by user. When user is experiencing virtual world heritage exploration via this tool, they could feel more natural, direct and interesting. The feedback from some users of this virtual world exploration reflects positive usage evaluation.

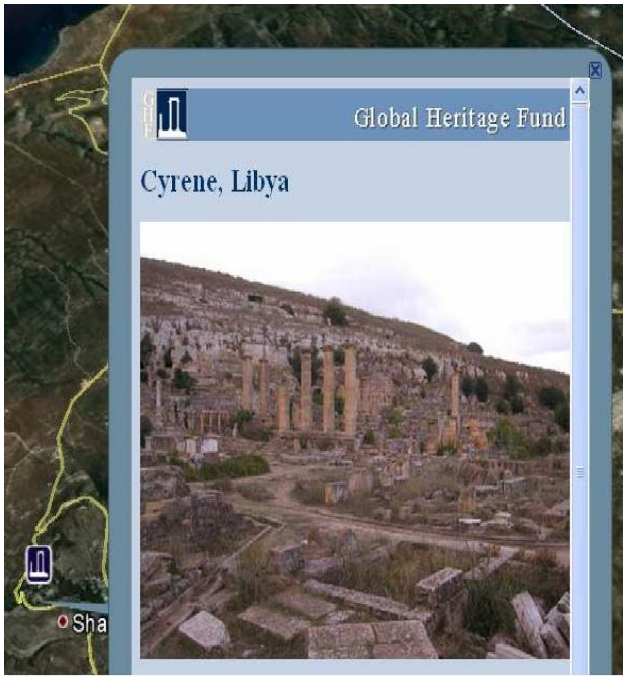


Figure 5: *3D embodied navigation zoom screenshot.*

6 CONCLUSION

For the purpose of realizing natural interaction application taking full use of human natural senses with broader interactive coverage range, we develop one suite of wireless sensor system integrated with CHR-6dm AHRS and ZigBee technology. The software architecture and technological methods are described. The 3D embodied natural interaction navigation effect is provided by the screenshot of navigation result. This research with hardware and constructed software platform proves the feasibility of this designed 3D natural navigation interaction with embodied information.

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CONNECTING PHYSICAL OBJECTS WITH SOFTWARE. TECHNOLOGY ENHANCED PLAYING WITH BLOCKS TO FOSTER LEARNING.

Daniel Joerg, Martina Lucht, Tobias Schwandt
Fraunhofer Institute for Digital Media Technology IDMT
Business Area Human Centred Media
Ehrenbergstrasse 31, 98693 Ilmenau, Germany
Tel: +49 3677467-361; fax: +49 3677467-467
e-mail: {daniel.joerg; martina.lucht; tobias.schwandt}@idmt.fraunhofer.de

ABSTRACT

The innovative shaping of human-machine-interfaces includes technological implications for consumer behavior and could result in significant paradigm changes for the way computers are used for business, for private and for learning purposes. If we use trends in the entertainment industry (e.g. Wii or Kinect) as an indicator for a new need for physicality in interaction with digital media, we can determine the potential of this physicality for learning and creativity. In this paper the theoretical assumptions and practical implications of tangible user interfaces (TUIs) for learning issues are discussed. For that we propose a new input device named STID that takes haptic skills of human body into account.

1 INTRODUCTION

Starting point for the following paper is the widespread thesis, that active object-lessons facilitate learning processes. The child actively constructs knowledge by interacting with its environment and everyday objects [1]. This means primarily physically-active actions in relation to and with physical objects ("objects-to-think-with") [2, p. 2] - therefore instructions are getting reduced while exploring and experimenting are being challenged [3]. Accordingly we attempt to involve these possibilities in human-computer-interaction.

2 THE RELEVANCE OF PHYSICAL EXPERIENCE IN THE (DIGITAL) LEARNING PROCESS

Based on Piaget's developmental psychology research in the early 20th century it is assumed that "[…] mental action is grounded in a physical substrate" [4, p. 1713]. This suggests that cognition initially arises from actions and operations. When children and adolescence grow up, individual experience forms cognitive patterns, which determine how and what we perceive and feel, what we remember, how we judge and argue [5]. There is some evidence for the assertion that we better remember those experiences in which we were constructively involved. The generation-effect for instance proposes an improvement in memory performance if the learner is permitted to elaborate and construct the knowledge content [6] [7] [8]. More over studies showed that if physical activities are embedded in this elaboration and construction process there will be a higher probability to remember absorbed knowledge, in contrast to the knowledge gained only by listening [8, p. 12]; [9, p. 404]. This is based on the fact that memory encoding through physical activities occurs multi-modally and automatically – no special strategy is needed [8, p. 30ff]. This implies that there is a functional relationship between kinesthetic driven interactions and learning objectives that influences the learning process positively and leads to a knowledge structure that can be accessed independently of the presented modality.

Supported by these evidences we emphasize the introduction of additional multi-sensory stimuli, most especially for haptic movements, in digital learning contexts to augment the audio-visual modes. Cognition, driven by audio-visual perception is not the only ability needed to process symbolic information; our brain requires a body as an additional resource to support mental abstractions with respective tactile and/or spatially perceived information. Therefore we propose a useful connection of real objects to digital learning software in a way that ordinary objects serve as input devices to virtual processes.

3 TANGIBLE INPUT DEVICES IN THE LEARNING SECTOR

Emphasizing naive physical skills and body awareness in the Human-Computer-Interaction (HCI), are typical for what Jacob et al. [10] describe with *Reality-Based Interaction*. Thus, the direct manipulation of physical objects – the so called 'natural interaction' – can help to reduce the mental load in the HCI and accelerate learning processes [11].

The innovative development of tangible-user-interfaces is a forward-looking research field, which includes new implications for user behavior and the way that computer software needs to evolve, to be used in this new model of interaction. We understand the trends in the entertainment industry (e.g. Wii or Kinect) as an indicator for a new need

for physicality in interaction with digital media. Thus our approach tries to take up these trends to determine what kind of physicality is appropriate for learning. The empirical results analyzing the haptic perception in digital contexts are mixed. These indicate, that explorative learning efficiency correlates with the (useful) integration of haptic objects [12] [13]. Manches et al. also found advantages for physical materials in a numerical partitioning task compared with using a graphical interface [14]. More over Antle attests hands-on input interaction to be conducive to learning if they are audio-visually enhanced [15]. Triona and Klahr [16] and Marshall et al. [17], however, didn't notice any differences in learning with physical and virtual materials.

Nevertheless, the relevant research findings in cognitive psychology seem insufficient to develop workable models. More general the influence of different body movements for cognitive processes is investigated under the heading of *Embodiment*, but the influence of activities of the whole body while learning with digital media is still massively underrepresented. First positve results in this regard has been made in the acquisition of factual knowledge, learning motivation and self-efficacy of the learners [18].

A look into the established learning theory models provides no detailed findings for this area. For example the common Cognitive Load Theory model examines only visual and auditory stimuli [19]. A deepening of scientific knowledge about haptic and learning seems therefore to be a desideratum. The interest of the proposed project is, to generate empirical evidence on the relationship between haptic perception and acquisition of knowledge in the digital context. These studies are primarily used for STID (Shiftable Tangible Input Device) to elicit the potential of the concept and to formulate specific user groups and context-specific requirements.

The STID concept includes the idea to involve ordinary haptically manipulable objects in the interaction with the computer to different learning purposes. This approach has already been implemented in similar forms [20] [21] [22]. However, such approaches require items that are either connected with a wired connection to a computer or even are equipped with electronics, thus cannot be described as everyday objects.

4 NEW LEARNING APPROACH WITH A TANGIBLE USER INTERFACE

4.1 STID (Shiftable Tangible Input Device)

We call the actual concept, to that this paper is directed, STID. The goal is to build a bridge between physical and digital world combining both by letting the physical world authentic. The physical world should be fully perceptible and not only projected or simulated through tactile feedback like in some augmented reality approaches, while the virtual world reflects the real world and adds digital options. By combining - but not scrambling - both worlds, the concept STID can push an important criterion for creative thinking and learning: The ability to find new relations between non-related experiences.

For the purpose of combining the physical and virtual world advantages, ordinary physical world objects will be placed in front of a digital system which recognizes the objects with a webcam and visualizes them directly on the computer screen in the same arrangement as in the physical world. If, for example, an object is added or taken away in the physical world this activity can be seen on the screen showing the parallel virtual world. Thus we focus on the idea of parallel actions of physical objects and their equivalents mirrored on a computer screen - according to the concept of mixed reality [23].

The variety of the computer input opportunities will be significantly enhanced that way and accordingly the possibilities to find a solution to a given problem and to complete a quest. Creative processes of thinking can take place using physical objects to access a greater potential of human cognitive capabilities. For us it is not about the dichotomous logic: either physical or virtual world; rather we plan to investigate new forms of human-computer-interaction by involving both worlds, using the advantage of both to reach additional options: In addition to the possibility for such haptic manipulations in physical space, a "metrical assistance" shows the three-dimensional size of the respective object. Moreover the virtualized objects in the digital environment can be stored and duplicated; further the physical attributes of the object, such as motion / color / size / function / gravity / magnetic charge, etc. can be changed in the virtual world, conceivably in a way that would be impossible or impractical in the physical world. Thus the action potentials of both "worlds" are taken into account. With STID new learning scenarios for different domains are possible: For example experimental chemistry lessons where students can use physical test tubes and bottles filled with colored water to do different experiments. The students handle the tubes and the water, but the system pours and mixes chemical reagents. Thus they see on screen what would actually happen. Or in mathematics lessons could the assembly of conventional wooden bricks be used to illustrate principles of geometry and calculation transmitted by the visualization skills of the digital system. Students could explore chemical processes

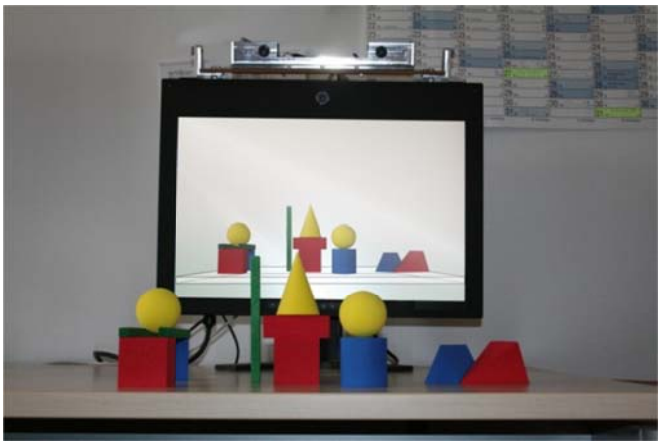


Figure 1 *The virtual 3D images, the physical objects and the cameras for the object recognition*

and mathematical laws, instead of reconsidering them mentally.
The tactile feedback just emerges through the active haptic perception, meaning the contact with the physical objects. If a tactile feedback that corresponds with the virtually changed attributes (e.g. gravity) is not given directly (in the real world) it would be important to evaluate the consequences for the cognitive performance. According to above mentioned theory we assume that the dissonance between real objects and virtually reflected objects leads to a better understanding by exploring which fosters a process of reflection and therewith of learning.

4.2 Technical aspects

From a technical perspective especially the technology of object recognition and visualization will be important. The objects must be identified and detected in their practical arrangement in real-time and immediately displayed on the screen. Because the detection of a three-dimensional object would require a 360 degree rotation, our approach for visualization is to apply the principles of pattern recognition. However, existing systems can detect only those patterns that were previously implemented, so at present the input is thus limited to a predetermined selection of physical objects. Technical requirement for STID is a camera system, which recognizes objects in 3D space. For this purpose, an algorithm is used that is previously trained to recognize specific objects. For receiving and transmitting the image an ordinary webcam will be used. With a resolution of 640 × 480 pixels a camera can provide a sufficiently detailed picture to test the first algorithms for pattern recognition. An important property for the selection of the camera is an open source software architecture for querying the image information. The recognition of objects should be markerless, thus the objects carry no additional identification marks, as already implemented by Ladikos et al. [24].

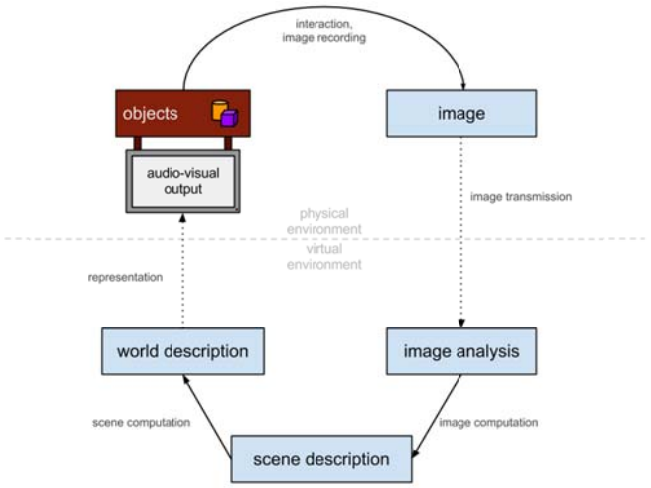


Figure 2 *conceptual program execution for the image and pattern recognition and the processing of the data*

The technical development of the application is split into two projects. The first part deals with the incoming images from the webcam. Key element will be a pipeline to detect and compute the position of several objects inside of an image by using different algorithms for image and pattern recognition. The result will be a new library for three-dimensional detection and tracking of objects based on non-stereoscopic images. Within this library image processing algorithms are implemented based on existing approaches, such as scale-invariant feature transform (SIFT) [25] and combined with algorithms for 3D reconstruction of objects in space, like Hoiem et al. [26] already described. An alternative approach is the use of 3D Distance Maps [27].
Second part of the project realized the processing of the scene and digital presentation of the physical world. The project uses a technology created for game development based on cross-language, multi-platform application programming interface (OpenGL, OpenGL ES). Main task of the project is the representation of tasks and the processed 3D models from part one. The system should be adjusted adaptively to the user for example by recognizing different object sizes. For the generation and analysis of the tasks a scripting language like LUA will be used.

4.3 Next Steps

After the technical realization a first study is being conducted to measure learning effects regarding the speed and the duration of the knowledge acquisition. The question is, what influence the haptic perception has on the acquisition of mathematical principles of the calculation of a surface and volume. Because of the already existing knowledge of older ages about this area, the age of the groups will be between 8 to 10 years. Comparing three groups of probands who learn the principles of surface and volume calculation (1) through the physical stacking of blocks, and the assistance of software (STID), (2) through the virtual stacking with a mouse and software, (3) by conventional methods of learning with pen and paper with the help of a teacher, the relevance of haptics in learning processes can be examined.

5 SUMMARY AND CONCLUSIONS

According to theoretical assumptions thus far obtained, the contributions from haptic perception and motor skills in the digital context can possibly enhance learning efficiency. However there have been not enough scientific studies about how to use and assess tangible user interfaces in special learning contexts. Theoretical assumptions support a greater consideration of physical skills since then the body will become the reference point in the interaction with digital functions as it is for the real world. It also seems obvious that physical activities are essential for any kind of experiences in our physical world and thus beneficially enhance intellectual skills acquisition. In order to continue this approach empirically, the mentioned empirical scenario will be performed. In a longer perspective it will be necessary to classify different input and output devices, the

associated user actions to build new TUI-Learning taxonomies.

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IMPLICIT PHOTOWORK BASED ON EYE-GAZE DATA

Bojan Blažica
XLAB Research
Pot za Brdom 100, 1000 Ljubljana, Slovenia
e-mail: bojan.blazica@xlab.si

ABSTRACT

This paper presents a demo application for exploring the viability of using eye-gaze data for implicit human computer interaction in the context of photo collection management. The application takes advantage of eye-gaze data to augment interaction with photo collections and aid photowork tasks such as browsing, selecting and searching. It builds on the premise that the time a user spends viewing a photo is correlated with the user's personal affinity for that photo.

1 INTRODUCTION

Photowork is a term first used to describe personal information management concerned with photos. It encompasses tasks such as viewing, browsing, selecting, sorting and filtering photos. The way these tasks are handled by users changed notably with the advent of digital photography. First, digital photography increased dramatically the amount of photos an average user takes and, second, digital photography moves photos to new mediums that escape the limitations of paper (the almost only medium for analogue photography). On the one hand, the fact that digital photos are cheap to take eases the decision of the user whether to take a photo or not, but on the other hand this leads to overwhelmingly large photo collections, which make the 'consumption' of photos or photowork more tedious. Some typical examples are the retrieval of a specific image for which we do not know exactly when or where it was taken nor where did we store it (Whittaker et al. [1] report that users fail to find 40 % of photos), or making a small selection of 'best' photos from a recent holiday to show to friends.

Luckily enough, storing photos in digital format also opens up enormous potential for developing methods and algorithms to ease the problems mentioned above. Photowork in the age of digital photography has been tackled in different ways: from clustering to social network analysis, image recognition and photo-meta-data analysis. As none of the available state-of-the art takes into consideration the user's personal relationship with the photos, we explored the possibilities arising from a more personal perspective on photowork in [2] and [3]. With a series of experiments using a tablet application and a tabletop multitouch display we confirmed that the time a user spends viewing a photo, called viewing time, is correlated with his/her affinity for that particular photo. Our notion of the user's affinity for a photo concurs with Chalfen's notion of importance of a photo in the home-mode: "And although artists, art historians, and art critics frequently speak of 'important' and 'valuable' images, we are dealing with a different notion of importance here. In the home-mode, images are indeed important in an intimate context, and these images are valued by small groups of biologically and socially related people" [4].

In the experiments in [2], where a tabletop multitouch display was used, the participants were asked to browse through a set of photos scattered on the display and the viewing time for each photo was stored. Only the photo currently in the application's focus was sharp, while all the others were blurred out as can be seen in Figure 1. This is how the application knew which photo the user was currently looking at. In the experiments conducted in [3], where a tablet application was used, we avoided the problem of determining which photo the user is looking at by allowing the user to browse photos only in full-screen mode. In both cases we could have used an eye-tracking device, but at the time it was unavailable to us.



Figure 1: *Determining which photo the user is looking at without an eye-tracking device by blurring out all photos, except the onei n focus.*

2 DEMO APPLICATION

To test the use of an eye-tracking device in the realm of photo collection management, we created a demo application called 'Implicit Photowork Demo'. It is a simple desktop application with two windows. The first window allows the user to select a folder with the photos he/she wants to browse (Figure 3), while the second window is used to display the 'best' 5 photos according to

the user's affinities (Figure 5). While the user looks at the photos, the application updates a list of how many times and for how long the user looked at each photo. These viewing times are then used to determine the user's favourite photos. The application is also able to give graphical feedback about eye-gaze data (Figure 4) and provides eye-gaze calibration and validation procedures.

The workflow for the application is as follows: the user first undergoes the procedures of calibration and, optionally, validation. This is done by looking at 5 specific points on the display. Next, the user loads the photos he/she wants to browse. Currently the application supports the following formats: '.jpg', '.png' or '.gif' and provides some sample photos for testing purposes. Once the photos are displayed in the main window, the user looks at them as he/she would do normally (Figure 3). While looking at the photos, the user is implicitly signalling to the application his/her affinities for the photos. After the user has finished browsing, he/she can press the 'Show results' button, which will cause the results window to pop up. In this window the 'best' 5 photos will be displayed from right to left (Figure 5). Each time the 'Show results' button is pressed, a new window with updated results appears.

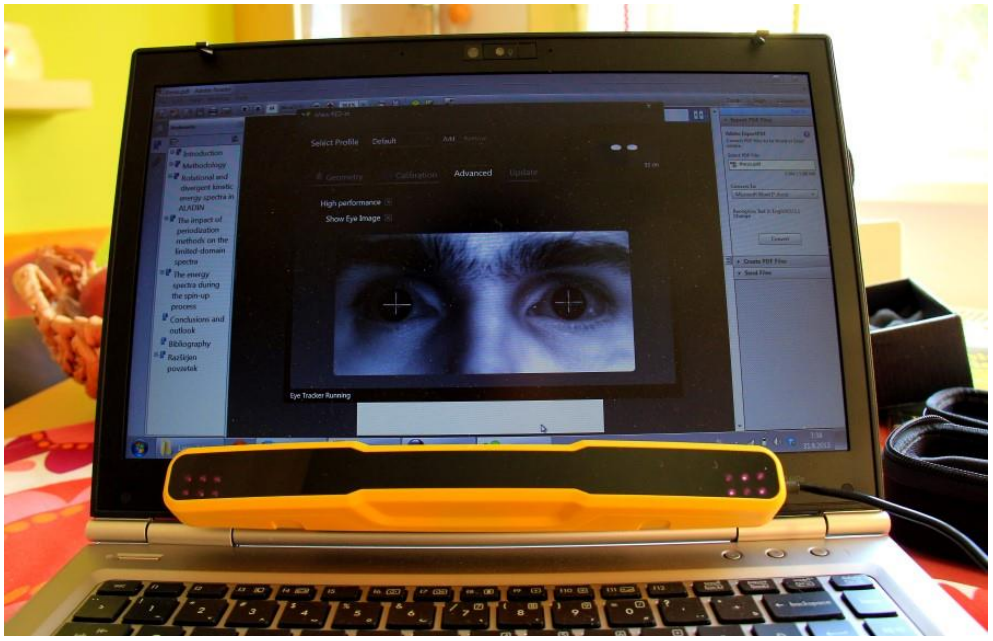


Figure 2: *SMI's RED-m eye tracker and the application used to calibrate it.*

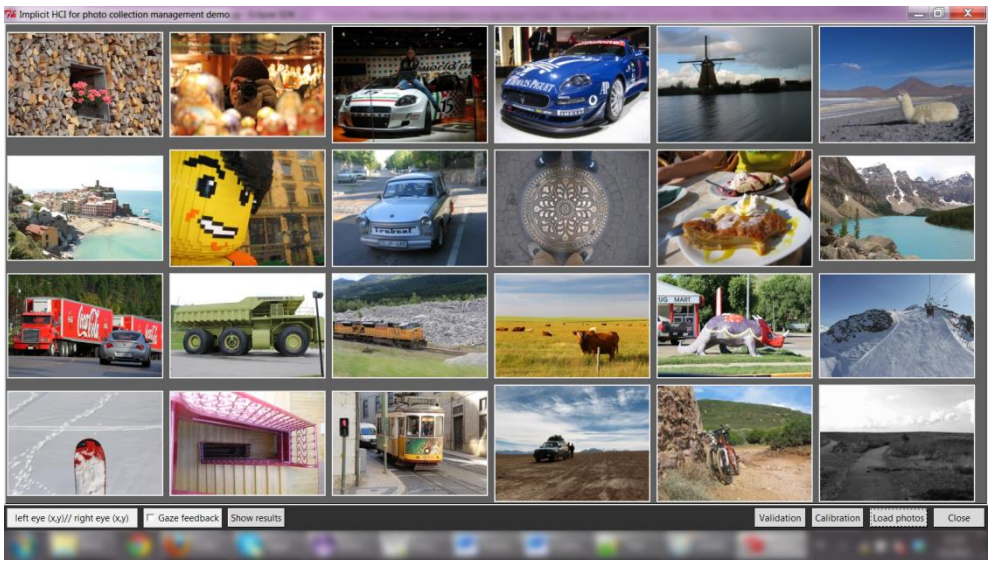


Figure 3: *The demo application's main window filled with test photos for browsing.*

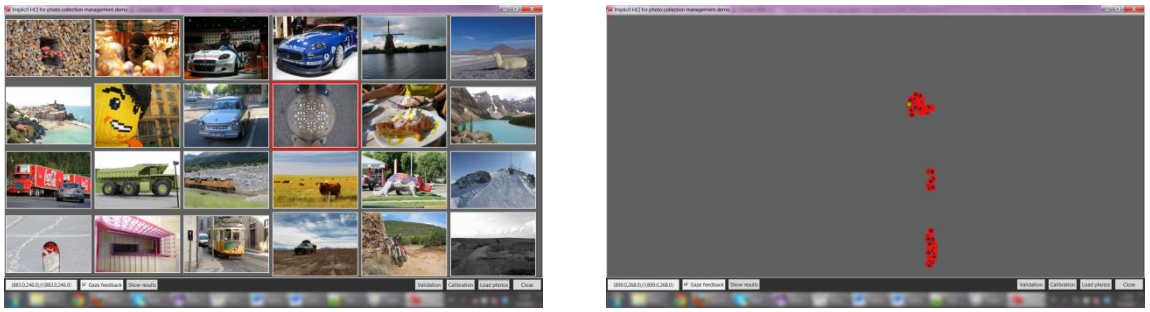


Figure 4: *Graphical feedback for eye-gaze data. In the left image the application highlights with a red frame the photo the user is currently looking at, and in the right image the application marks the current gaze with a green dot, while grey dots mark previous eye-gaze data points.*

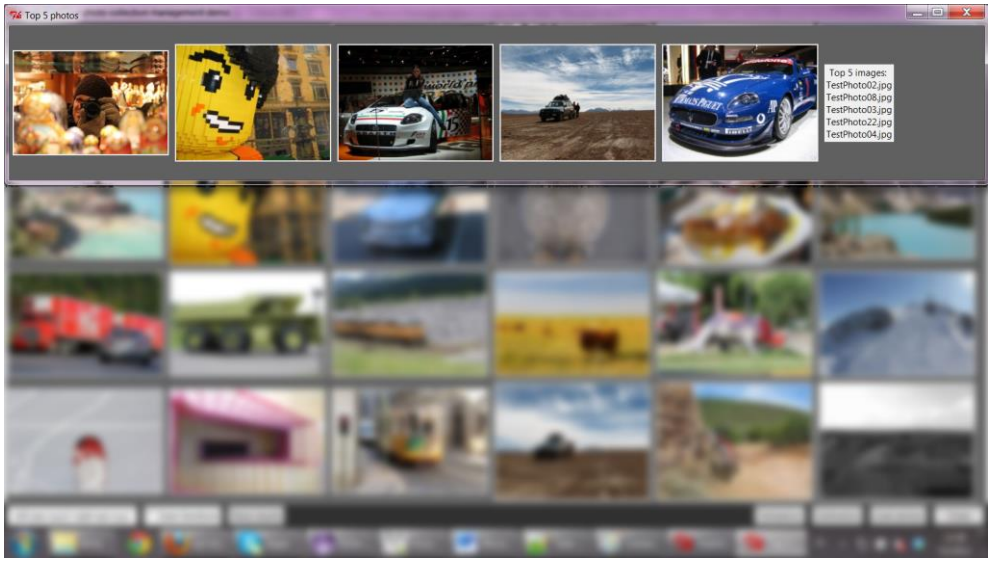


Figure 5*: The 'best' 5 photos according to user affinity are displayed in the Results window.*

3 IMPLEMENTATION

The device we used was SMI's RED-m eye-tracker[1]. This is a portable eye-tracker suitable for monitors, tablets and laptops from 10 to 22 inches in size at an operating distance of 50 cm – 70 cm. The sampling rate can be set to 60 or 120 Hz. The accuracy of the device is 0.5°.

The demo is implemented in Python and builds upon the 'DataStreaming' example from SMI's SDK. For the GUI components, Tkinter[2] was used. The only other requirement for the demo application is the PIL[3] package that was used for handling photos.

[1] www.smivision.com/en/gaze-and-eye-tracking-systems/products/redm.html
[2] http://docs.python.org/2/library/tkinter.html
[3] http://www.pythonware.com/products/pil/

5 DISCUSSION & FUTURE WORK

The lowering prices of eye-tracking devices and the inclusion of eye-tracking features in mass-production commercial devices like Samsung's flagship phone S4 or prototypes like Tobii-Lenovo's concept eye-tracking laptop[4] suggest a shift of focus in terms of eye-tracking research. From researching eye-tracking itself, the hardware and algorithms needed to support it, and the use of eye-tracking in laboratory conditions for usability studies or psychometric evaluations to researching eye-tracking as a means of human-computer interaction.

Eye-tracking as an interaction method or user interface can be classified under the term natural user interface. It has been argued that what makes natural user interfaces *natural*, is the way that this interfaces reuse skills [5] that users already posses and thus feel natural to use or make the

[4] http://www.tobii.com/en/gaze-interaction/global/demo-room/concept-laptop/

user feel like a 'natural' [6]. Interaction based on eye-tracking fits to this point of view perfectly as the skill it reuses – human vision – is one of the basic skills we have and predominantly rely on. Besides the straightforward exploitation of the exact information where the user is looking and what he/she is looking at, eye-gaze interaction can also take advantage of other eye-gaze movements like saccades (rapid eye movements used when scanning a visual scene), fixations (gazing at a single location) and smooth pursuit (continuous eye movement when following a moving object). The question here is not only how to interpret these eye-gaze events, but also how should an application respond, how should the response differ in relation to the context in which the application is used, is there an eye-gaze-based interaction paradigm that can be used by every user or should this kind of interaction be tailored to each individual user and so on.

We consider the presented application as a first step towards understanding the above questions and finding appropriate answers (at least for the context considered, i.e. photowork). Preliminary experiments with the Implicit photowork demo application confirmed that eye-tracking is indeed a viable way towards implicit human-computer interaction in photo collection management and that it could be used as envisioned in [2, 3]. These experiments were not strict and a more rigourous evaluation is imperative as well as comparative study on how implicit HCI for photowork differs based on whether it taks place on a tablet or on acomputer equipped with an eye-tracker. Currently, the implemented functionality only considers where the user is looking at and how long he/she spends viewing a particular location/photo. In the future, the application should also consider eye-gaze movements, which will enable to advance the research on how to measure a user's affinity for a photo described in [2, 3]. For example, quick erratic exchanging of saccades and fixations could indicate that the user is searching for a photo, while a more steady sequence could be interpreted as a sign of the user browsing through the collection. Based on this information, the application could adapt its behaviour like displaying photos in lower resolution in order to be more responsive while searching for a photo.

6 CONCLUSION

The Implicit photowork demo application presented shows how eye tracking and eye-gaze data can be exploited to implement implicit human-computer interaction in order to aid photo collection management. The idea of using viewing time as a measure for the user's affinity for photos – already successfully tested in [3, 4] – can now be extended with eye-gaze data made available by eye-tracking devices, which opens up new research questions, for example: how to handle eye-gaze events (e.g. fixation events) in general as well as in the context of photo collection management. The availability of commercial mobile devices (e.g. Samsung Galaxy S4) with rudimentary eye-based interaction and the identification of tablets as devices with great photowork potential [7] testify of the importance of research in eye-gaze based implicit human-computer interaction for personal photo collection management.

Acknowledgements
The author would like to thank the company SensoMotoric Instruments (SMI) for landing their Red-M device and thus granting him hands-on experience with eye-tracking devices. This research was funded in part by the European Union, European Social Fund, operational program for human resources, development for the period 2007-2013 and by the Slovenian Research Agency.

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A WEBSITE USABILITY TESTING TOOL

Franc Novak[1], Denis Špelič[2], Borut Žalik[2]
[1]Jožef Stefan Institute; Jamova cesta 39, 1000 Ljubljana
[2]FERI- University of Maribor; [2]Smetanova ulica 17, Maribor
Phone: +386 1 477 33 86, +386 2 220 74 15
e-mail: franc.novak@ijs.si, denis.spelic@uni-mb.si, borut.zalik@um.si

ABSTRACT

This paper presents a low-cost website usability testing tool that records user's mouse movement when performing search query on a web page. After a given time-out the web page is blurred and only some region around the mouse cursor remains transparent. The tool can be regarded as an automated version of the conventional squint test and can be used for the validation of the website design from the perspective of user cognitive load.

1 INTRODUCTION

Visual design is a fundamental issue of graphical user interfaces implemented in electronic systems since the first bitmap displays appeared in the early 70s of the last century. Beside elegance and attractiveness, which are the attributes of aesthetic relevance, visual design is intimately concerned with the selection of the employed visual elements in order to enhance user interaction. As K. Mullet and D. Sano state in their fundamental work [1], [2], the visual designer enhances communication by carefuly selecting the elements to be emphasized. Reducing a design to its essence, regularizing the elements of a design and combining elements for maximum leverage are established techniques for the simplification and refinement. Appropriate balance of scale and contrast is another important issue and different techniques for managing their relationships have been proposed, among them the squint test, which is also the subject of our contribution.

As suggested in [2], squint test is a helpful technique for establishing perceptual layers, sharpening visual distinctions and revealing figure/ground relationships of a given design. In practice, squint test can be performed by simply partially closing the eyes in order to distort the vision of the display. From the perceived shapes of the displayed elements one can establish a high-level view of the visual hierarchy of the design. The squint test puts the design through a quick checklist of Gestalt principles to see if they've been applied correctly to achieve the design's purpose [3].

Visual analysis can be used for understanding how visual information functions for its intended audience and purpose. A five-step visual analysis process described in [4] employs squint test when analyzing the nature of visual communication. Squint test is used for tracing the eye path and identifying the major visual elements that draw user's attention. As the author states, the proposed procedure was originally developed with a goal of providing common framework and language for both design evaluation and group communication. The ultimate goal of the performed visual analysis is to increase the quality of the resulting information product. Similar application of squint test is proposed in [5].

Advances in semiconductor technology in the 2000s offered new possibilities of tracing eye movement. The popular eye-tracking technique employs a camera that focuses on both eyes and records their movement as the viewer looks at some kind of stimulus [6]. Extensive research and application of eye-tracking technique in usability testing has been reported by J. Nielsen and K. Pernice [7], [8]. Although the eye-tracking can be regarded as mature and widely adopted technique it still faces some problems due to the difficulties in calibrating the instrumentation. As mentioned in [9], eye tracking equipment may reduce the test validity by notably slowing the system response or by requiring users to re-calibrate between tasks. And the last but not least, the cost of eye-tracking equipment may well prove to be prohibitive to some, and it is possible that similar results may be achieved by a less costly procedure.

In this regard, S. A. Johansen and J. P. Hansen [9] investigated the validity of two low-cost alternatives to eye-tracking technology. In the first case they prompted the users to report from memory on their own eye movements during a single web page search. In the second case they asked some experienced web designers to predict the eye movement of a typical user. Performed experiments have shown that users could remember 70% of the web elements that they had seen while the designers could only predict 46% of the visited elements. Achieved results are not perfect but they do justify further research.

It should be noted however, that requiring the user to memorise his/her part of a search on a web page repesents a cognitive load which might in some cases prove to be a limitation. On the other hand, the more clear and consistently structured web page the easier way to browse it and less cognitive load required memorizing the performed search. The approach presented in this paper exploits the fact that a well-designed website requires less cognitive load when performing a search query and vice versa. Recording and analyzing successful or unsuccessful attempts of a given search query provides useful

information to the designer for improving the website. A squint test is employed in order to more clearly expose possible weakness of the design. After a given time-out the web page is blurred and only some region around the mouse cursor remains transparent. The movement of cursor is recorded as the user tries to fulfill the requested task. The developed tool that can be regarded as an automated version of the conventional squint test can be used for the validation of the website design.

At this time, a prototype version of the tool has been implemented and tested only at some elementary usability test scenarios. Initial results are promising and we hope that we shall be able to provide some experimental case studies in the following days.

Since the reported website usability testing tool shares some similarity with eye-tracking, let us briefly describe the basic features of this technique.

2 BASIC FEATURES OF EYE-TRACKING TECHNIQUE

When the user observes a web page his/her eye movement is not smooth. Instead the eye moves and rests at a certain position and moves again and rests at another position, etc. The fixations that typically last around 200 ms during reading a text and 350 ms when observing other scenes can be recorded. The resulting data can be visualized in the form of a heat map or a gaze plot.

A heat map is a a graphical representation of data where the individual values are color-coded according to the amount of fixation locations at individual points of the observed screen. Presented data can originate from a single user or a group of users accessing the same document or screen. Although most of the reports employing eye-tracking refer to the visual analysis of web pages, the technique can also be applied for the analysis of printed documentation, manuals, etc.

A gaze plot is a visualization of the sequence of fixations of a single user. A series of enumerated dots indicates the sequence of user's eye movements. The size of a dot corresponds to the time that the user spent at the given fixation. This visualization technique is specially useful for monitoring individual user's eye movements and detecting possible difficulties when localizing the desired element or information on a given document or a web page.

The following illustrative example is borrowed from OGAMA (OpenGazeAndMouseAnalyzer): An open source software designed to analyze eye and mouse movements in slideshow study designs [10]. For the music slide shown in Figure 1, both the heat map and gaze plot are shown in Figure 2. In the heat map, green areas indicate short fixations, yellow areas correspond to increased durations of fixations, while red spots show the places with most intence fixations.

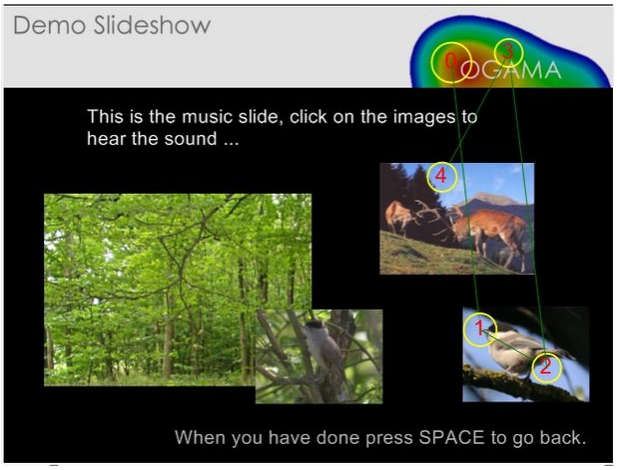


Figure 1: *A music slide (courtesy of OGAMA)*



Figure 2: *Heat map and gaze plot of the music slide (courtesy of OGAMA)*

3 WEBSITE USABILITY TESTING TOOL

As mentioned before, the developed website usability testing tool is actually an automated version of the conventional squint test with additional features of recording user's cursor movements and generating reports in terms of heat map, gaze plot and video recap of the performed actions.

In the first step, the user gets the instructions of the task to be preformed. This is typically a search query on a given website. The target website is presented to the user for a short time (a few seconds) and then it is blurred and only some region around the mouse cursor remains transparent. The user continues his/her search by moving the mouse cursor around until the goal is reached or the action is suppressed (i.e., the user gives up, unsuccessful to accomplish the task).

The following figures illustrate individual steps when the user was requested to to find the information about a bank loan at the website of Nova Ljubljanska Banka (NLB) for a new apartment. Figure 1 shows the initial dialog screen which explains the required task. The target website of Nova Ljubljanska Banka is shown in Figure 4, and its blurred version in Figure 5, recpectively.

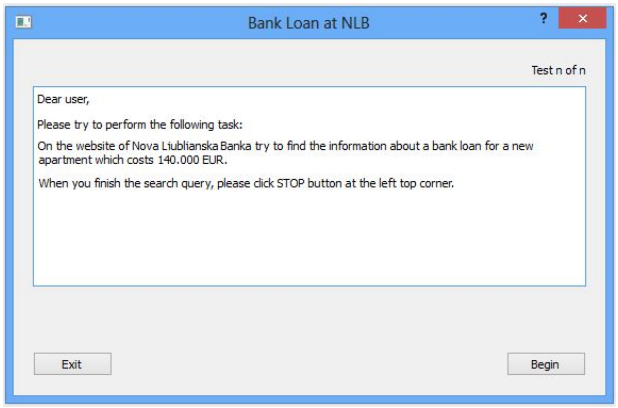


Figure 3: *First step: Description of task*

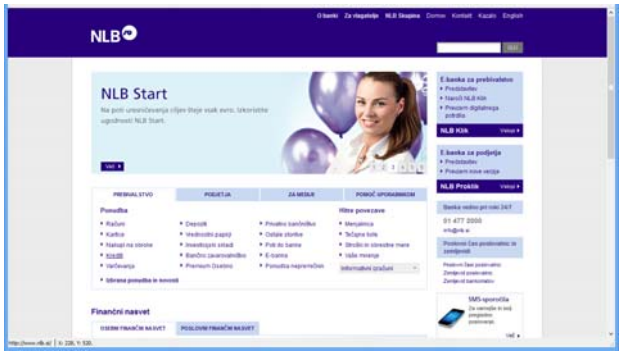


Figure 4: *NLB website (unblurred)*



Figure 5: *Blurred NLB website*

Heat map for the above case is shown in Figure 6 and a gaze plot of one of the participants is shown in Figure 7. While the heat map is used as a general indication of quality of a website, a gaze plot reveals individual parts of the website that impose particular difficulties to users.



Figure 6: *Heat map*



Figure 7: *Gaze plot indicating performed cursor movements*

For complex web pages, the user can (optionally) deblur the screen for a moment and continue the search query. The moderator can program the number of the allowed deblur attempts and their durations as well as the level of blur and the amount of space around the mouse pointer. Moderator's user interface is shown in Figure 8.

Heat map provides a quick overview of most frequently visited parts of the website, yet it does not reveal other parameters such as the sequence of visited elements on the screen and consequently the length of the cursor path

performed for the given task, which are relevant for assessment of efficiency of the analyzed website and identification of possible problems in navigation, layout design and visual distinction of elements of GUI. For this purpose, a final report for each participant is generated. An example is shown in Figure 9. Beside essential data collected during performed task, the report also includes participant's comment which may prove useful in future attempts to improve the website design.

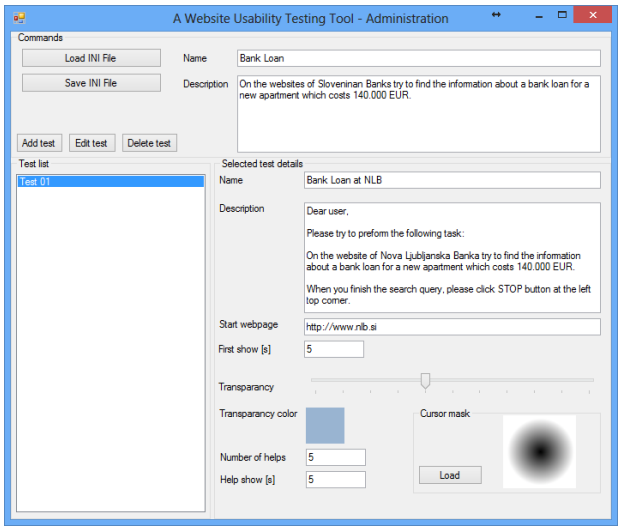


Figure 8: *Moderator's interface*

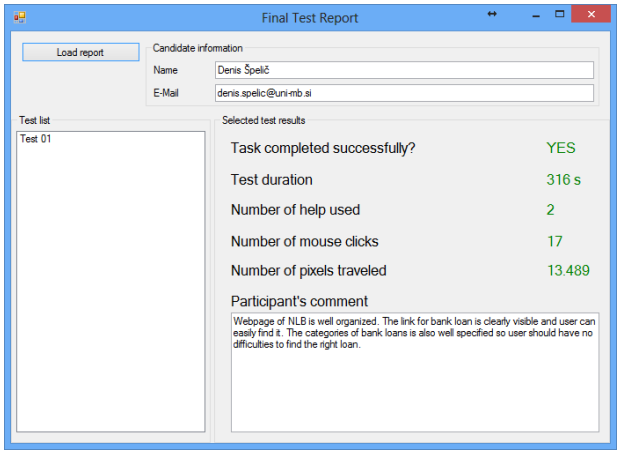


Figure 9: *Generated report*

Originally, the tool was developed as a supplementary aid for the course Human – computer Interaction. It can be used for the evaluation of web pages from visual communication point of view. Besides, it was also intended for practical exercises in usability test. Collected data can be exploited to acquire contextual information that might be helpful for designing user interfaces for specific target audience.

6 CONCLUSION

Presented user interface efficiency evaluator is a platform independent application written in C++ using the Qt library, that helps webdesigners determine how intuitive a website is. Proposed approach can be regarded as a low-cost alternative to eye-tracking. Furthermore, it can also be used for experimental case studies of assessing mental load imposed by a given website search query, as well as for acquiring contextual information from specific user groups, which may prove helpful in interface design in assistive technology applications.

7 ACKNOWLEDGMENT

This work was partially supported by the Slovenian research Agency under grants P2-0098 and P2-0041. The authors would also like to thank Klemen Forstnerič for his contribution in implementating the tool.

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WIRELESS MEDICAL DEVICE AUDIO ALARM

Marko Pavlin
In.Medica d.o.o.
Levičnikova 34, 8310 Šentjernej, Slovenia
Tel: +386 7 3934959
e-mail: marko.pavlin@inmedica.si

ABSTRACT

Audio alarming system for medical devices requires attention at some very specific segments. The clinical environment is full of disturbances and every alarm sound is not an exception. This paper presents some aspects of (audio) alarming within clinical environment and associated problems. Low power operation and limited resources for implementation are just on top of the problems related to the user experience. The presented solution is following the specific standards and is flexible enough to provide audio signals, which can be generated with small microcontroller. The described alarm generator was evaluated in laboratory and during clinical evaluation in real clinical environment with patients. The results are presented at the end of the paper.

1 INTRODUCTION

The fundamental requirement for every medical device is to operate safely. The patient monitoring equipment indicates device failure or urgent condition of the physiological parameters through the alarm system, which is part of the device's user interface.

The state of every patient treated in the operation theatre (OR), high dependency unit (HDU) or intensive care unit (ICU) is monitored on a regular basis. Before making decision about patient treatment, the caregivers must consider many data sources with very heterogeneous information. In addition to patient's medical history, radiology images, biochemical analyses they rely on data generated by vital signs monitors. This live stream of data is beyond cognitive capabilities of a nurse, therefore parameter limits are set to detect adverse situations. When one or more vital signs are out of predefined limits, the physiological alarm is triggered. Second type of alarms is technical alarm, which is related to the medical device operation. Every medical device may have its own set of alarms and can vary for every patient and every procedure.

The patient's safety can be compromised with issues related to the alarm efficiency. The alarm problems may cause severe injury or death of a patient [1]. The United States Food and Drug Administration (FDA) keeps records of all device-associated adverse events, which resulted in suspected deaths, serious injuries and malfunctions [3]. The FDA Manufacturer and User Facility Device Experience (MAUDE) database was queried within the time period from 1997 to 2011. The advanced search was set to »Audible alarm« product problem and »Death« as the event type. The results for each year are shown in Fig. 1. The alarms can be repeated, exciting, confusing and annoying. Sometimes the hospital staff removes permanently these alarms [2].

The diagram in Fig.1 correlates with the IEC60601-1-8 standard, which was prepared in 2001 providing guidance for alarms application, their performance and safety requirements and testing procedures.

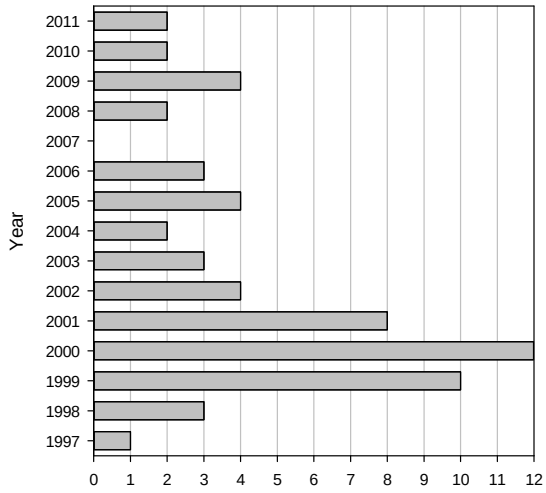


Figure 1: *Number of deaths caused by medical device audio alarm failures (per year from 1997 to 2011).*

The alarm related issues associated to medical devices have been reviewed in literature. It has been pointed out that alarms are less than optimal due to poor design and implementation. One of the main reasons was that the cognitive capacity and processing mechanisms of the user were not taken into account [2]. The authors summarized suggestions of characteristics of an ideal alarm sound to be: easy to localize, resistant to masking, ensuring other communication and easy to remember.

2 AUDIO ALARMS IN CLINICAL DEVICES

Audio alarming signals are present not only in the clinical devices but also in other parts of industrial and transport segments. The efficiency of alarms is diminished by increasing number of false alarms, excessive loudness and nuisance, which also limits the localization [6,7].

2.1. Localization

Human ear uses two principal mechanisms to predict sound location. The interaural time differences are dominant at low frequencies and interaural level differences dominate at mid to high frequencies [8]. Ideal alarm sound have to be harmonically reach within wide frequency spectrum to provide good localization.

2.2. Number of alarm sounds

The increasing number of alarms is a result of increasing quantities of data generated by patient monitoring equipment. The number of alarms may quickly exceed the cognitive capabilities of the medical staff. The resulting ignorance of some alarms can generate problems and critical mistakes in the health decision-making process [9]. The number of alarms should take into account the human ability to remember about seven pieces of unrelated information, where alarm sounds are only one of the items the hospital caregivers have to process in parallel. The number of alarm sounds should therefore be limited. This can be realized by using intelligent alarming systems, where the main limiting factor for implementation represents the variety of different patient monitoring equipment without practical options to cooperate via common data processing channel. One of the promising options could be electronic medical record (EMR) system, which may introduce some level of intelligence in alarming systems. However, EMR is not available in all hospitals. Additionally, automated alarm processing provides only better prioritization and could not diminish the number of alarms. The clinicians have to process all alarms and alerts anyway [10]. Another way to reduce the number of alarms is to standardize the alarms and assign specific alarms for specific functions, which trigger the alarm sounds. This is partially handled with IEC60601-1-8 standard by introducing some sort of auditory icons. These auditory icons are sounds, which are related to its function.

2.3. Speech

Some research evidence indicates that synthetic sounds are harder to learn than other types of sounds. A study [11] compared synthesized alarm sounds with speech. The later clearly showed the advantage to instantly symbolize the problem without any erudition required. The speech processor however is beyond limitations of low power embedded device for wireless patient monitoring.

3 AUDIO ALARM IMPLEMENTATION

The most straightforward implementation could be the playback of a recorded version of the alarm sound. There are two main issues with implementation within wireless medical devices. The embedded electronic system has limited resources and power consumption should be kept low to avoid bulky batteries. Sound playback from one of the standard formats, like MP3 is available as single-chip solution [4]. Unfortunately, the device like that is not qualified for medical use. The validation process of such a device could be long, expensive or even not possible. The solution is an own implementation of the alarm system, which is optimized to the available processing hardware and power capabilities. It is more efficient to generate alarms within the existing software code of the embedded device.

Function	Description
Clock generator	Provides all required clock signals to digitally construct the alarm tones, their envelopes and sequence.
Amplitude controller	Controls single tone amplitude modulation: rise time, fall time and sustain amplitude.
Tone sequencer	Sequencer provides correct alarm tone sequence and set the required tempo.
Tone generator	Polyharmonic generator combines funda-mental and higher harmonic sine waves to single tone.

Additionally, there are many advantages: the software validation is required in any case, the smart alarm system can be more flexible, the validated code can be standardized and reused in many devices and possible corrections during validation process are much easier in order to meet the IEC60601-1-8 specifications.

3.1 Programmable audio synthesizer

Four building blocks of the audio signal generator are listed in Table I.

3.2. Amplitude controller

The amplitude controller dynamically sets the tone amplitude. A variable volume also provides proper tone start and end. The tone should start from zero amplitude and end to zero amplitude to avoid unwanted noises. The tone amplitude rise decay is controlled with this module. Rise and fall times define the pervasiveness of the tone, which is related to the level of the alarm urgency.

3.3. Tone sequencer

The tone sequences are defined by standard 60601-1-8. The characteristics of the sequence depend on type and priority of the alarm. The sequencer sets the characteristics of a single tone and provides delays between the tones. Higher priority alarms have more tones and the sequence is

repeated. The tempo of the higher priority alarms is faster than that of the lower priority alarms. Both, the different number of tones and different tone tempo help to distinguish the priority of the alarm.

3.4. Tone generator

Two tap IIR filter shown in Fig. 2 can be used as a very effective sine wave generator. Response calculation at current discrete time step $g[n]$ requires only two results from the past calculations $g[n\text{-}1]$ and $g[n\text{-}2]$. The mathematical operations are limited to multiplication and subtraction (Eq. 1).

$$g[n] = 2\cos\beta g[n-1] - g[n-2] \qquad (1)$$

During initialization two values have to be set for each frequency:

$$g[-1] = 0 \quad (2) \qquad g[-2] = 2\pi \frac{f_x}{f_s} \qquad (3)$$

The algorithm, also known as Goertzel Algorithm can be implemented in a typical embedded microcontroller with limited processing power and memory space.

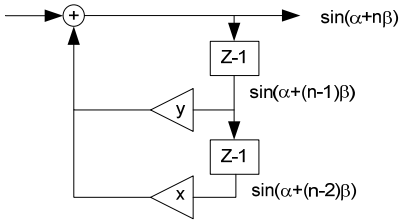


Figure 2: *Two tap IIR filter as signal generator (Goertzl algorithm).*

The initialisation coefficients can be calculated in advance to avoid inclusion of a floating point library into code. During development and code testing, the library routine for trigonometric functiuons occupied 2560 bytes of code and additional 288 bytes of constants. After optimisation with the pre-calculated tables for Goertzel initialization, the initialisation routine occupied only 131 bytes of code and 35 bytes of constants.

3.5. Implementation

Presented audio alarm system was implemented in wireless patient monitoring interface. The interface replaces the cables between a patient and a vital signs monitor. The device has no patient monitoring functions and no physiological signal processing.

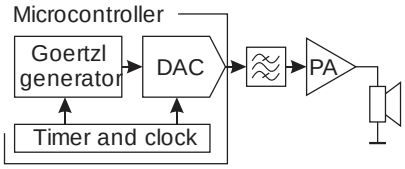


Figure 3: *Alarm generator block diagram*

The implementation of physiological alarms would require much higher validation effort. However, the technical alarms are implemented with all recommendations. Block diagram of the alarm sound generator is shown in Fig. 3. Microcontroller internal timer provides time base for Goertzl algorithm for generating polyharmonic tones. The same timer synchronises the amplitude modulator and the sequencer. The calculated sequential data feed the Digital-to-Analog Converter (DAC) at the sampling frequency rate. The sample rate was set to f_S= 25kHz (Eq. 3), which is above the normal audio hearing range. The DAC output is filtered with five-pole RC band-pass filter. Despite its simplicity, the filter proved to be effective and inexpensive solution, which has passed the tests in the process of evaluation.

4 EVALUATION OF ALARM GENERATOR

Two sets of tests were done during the evaluation process. First, the technical performance was evaluated. The second part of evaluation was performed during clinical evaluation of the device.

4.1. Technical evaluation

Technical evaluation process was conducted by measuring the following features: spectral analysis, signal to noise ratio, amplitude test and sequence test. Spectrum analysis tests were performed to verify the spectral content of the signal and to estimate signal to noise ratios. The diagram in Fig. 4 shows the measured spectrum of a single tone with the fundamental frequency and four higher harmonics. The code for the Goertzl algorithm provides adjustable amplitude for each harmonic. With fine adjustments, the harmonic contents of each frequency component can be altered to generate the proper tone.

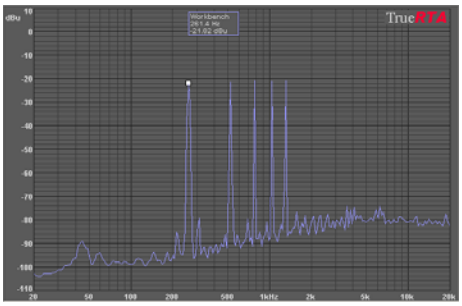


Figure 4: *Single tone spectrum with fundamental frequency and four higher harmonics. Note C4(262Hz) is shown.*

The test was repeated for all tones associated to notes from C4 to C5. The generated frequency spectrums were measured and the error between required and actual frequency of every harmonic was calculated. The results for all tones and all harmonics are shown in Fig. 5. The error was kept below 0,2% for the first four frequencies (fundamental and three harmonics). At the fourth harmonic frequency, the error was higher, but kept below 1% (Fig. 5). The frequencies at the fourth harmonic are higher and sampling frequency should be higher to minimize this error.

From practical point of view, the 1% error in the fourth harmonic frequency cannot be heard by an average listener.

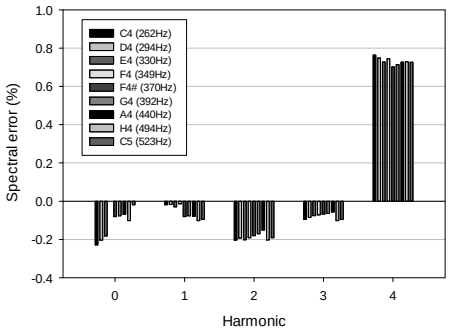


Figure 5: *Spectral errors of generated tones for fundamental frequency and four harmonics.*

The signal to noise ratio was measured with True RTA spectrum analysis software running on PC with sound capture card. The measured SNR was between 68dB and 70dB, which is considered as excellent result.

The last technical test was the measurement of amplitude and note sequence. The test was performed with digital oscilloscope. The generated signal envelope and timing of the signal pulses were measured. The results were compared to the requirements from IEC 60601-1-8.

4.2. Clinical evaluation

The device was evaluated within clinical environment (Fig. 6). The clinical investigation of the wireless device looked at the performance of the system in an intensive care unit, compared the fidelity of the data and tested the usability. The usability test evaluated how the system performed during user actions and tested primary operating functions of the user interfaces. Within the usability test, the sound alarming system was tested. During the test no complains about audio alarming system were delivered.

5 CONCLUSION

Development of an audio alarm generator was presented. The alarming within clinical environment requires special attention. The implementation of audio alarm generator within low power embedded device ia s challenging issue. Every microampere counts when developing small low power embedded interface for patient monitoring. At the same time, the result should provide same level of quality and flexibility when compared to “larger brothers”. The most attractive part of the presented solution is flexibility, because it provides porting the solution to any embedded microcontroller device with at least one timer and one DAC (internal or external). The quality and performance was tested and proven during technical evaluation within the laboratory as well as during clinical evaluation in the real clinical environment with real patients.



Figure 6: *Intensive care unit during clinical evaluation.*

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HOW TO PROVIDE HEALTH-RELATED INFORMATION BY MOBILE COMPUTING?

Barbara Koroušić Seljak
Computer Systems Department
Jožef Stefan Institute
Jamova cesta 39, 1000 Ljubljana, Slovenia
Tel: +386 1 4773363; fax: +386 1 4251038
e-mail: barbara.korousic@ijs.si

ABSTRACT

The paper describes an approach taken by a mobile application eDietetik for the presentation of health-related information that is not allowed to be provided as a health claim. In this case, a mobile device running the application interacts with consumers, translating health-related information in an understandable and unambiguous way. Moreover, it may present an interface between different human stakeholders (i.e. consumers and manufacturers, consumers and health-care providers, manufacturers and policy-makers).

This paper presents a mobile application eDietetik aimed to support Slovenian consumers with special dietary needs in the selection of foods and drinks [1]. The application provides services tailored for people with coeliac disease, phenylketonuria, diabetes, arterial hypertension, and people with acute or travelers' diarrhea.

eDietetik instantly identifies selected nutrients and non-nutrients in food items using the camera on smartphones. A user simply points the smartphone's camera at the barcode on the product packaging, and the application identifies the product by the barcode, and displays whether the product matches the user's dietary needs (Figure 1).

The application is compatible with iPhone and Android, Symbian and Windows8 smartphones.

1 INTRODUCTION

In some diseases, dietary recommendations and guidelines are defined in a clear way. For instance, coeliac patients are educated to consume gluten-free food to control the disease. Gluten-free food cannot contain any wheat, rye, barley or mixtures of these grains. And any incidental gluten in a food must be less than 20 parts per million (ppm) in order to carry the gluten-free label. In Slovenia, the threshold of 20 ppm is defined by regulation [2].

However, there are other diseases, where dietary recommendations are unclear and undefined by regulation. Examples include infective diarrhea and inflammatory bowel diseases, where probiotics may help treat or prevent the disease. As the evidence from controlled studies is not convincing yet, the Slovenia has not allowed any statement (health claim) to be used on food labels, advertising that health benefits can result from consuming a given food or from its probiotic bacteria [3].

The rest of the paper is organized as follows. In Section 2, we discuss the current literature on human-computer interaction (HCI) issues for mobile computing in the context of mHealth systems as well as health claims. In Section 3, we present the approach taken by eDietetik to interact with a consumer on probiotic claims in a legal way. In Section 4, we summarize our findings, draw conclusions and provide directions for future research.

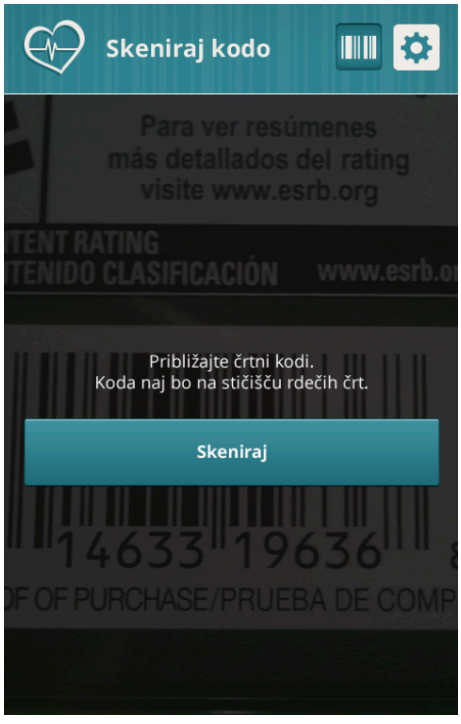


Figure 1: *eDietetik.*

2 HUMAN INTERACTING WITH MHEALTH

With the availability of mobile information resources, different interpretations of mHealth are evolving as people proactively seek out information from diverse contextual perceptions. mHealth applications are required to provide not only

- an efficient healthcare delivery via standardized electronic data interchange and standards-based enforcement of the confidentiality and security of health data, but also
- a delivery of any information in an understandable, unambiguous and legal way.

Studies have found that concepts in desktop computing are unsuitable for the mobile computing environment [4]. The main reason is that both a human and a mobile device involve a high degree of mobility. Special considerations include high-speed interaction, limited attention capacity, and context (time and space) dependency.

3 EDIETETIK INTERACTING WITH CONSUMER

The application informs users about the content of a given scanned food so that it displays its nutritional profile and a symbol interpreting the profile as "positive" or "negative" (Figure 2). The "positive" interpretation means that a given scanned food has the content of critical nutrient or non-nutrient below a given threshold. This threshold is provided by a default value that can be redefined by the user in his personal settings.

In this way, complex information about

- food composition data that are collected in a scientific way following EU standards [5] and
- national dietary recommendations and guidelines [6]

are interpreted by a computer (smartphone) for a human (consumer with special dietary needs). The user is supported with an information that may ease his decision on food purchase in order of seconds.

eDietetik also displays an information about the food product's name, producer, country of production, image and prices in different markets, provided by our users.

For eco-conscious users, carbon footprint is calculated and interpreted with a symbol in four different colours, i.e. green, yellow, orange and red.

In this way, information about foods and drinks is displayed for consumers with special dietary needs because of coeliac disease, phenylketonuria, diabetes and arterial hypertension. For these diseases, dietary recommendations and guidelines are specified in a clear way:

- Coeliac disease: gluten in a gluten-free food must be less than 20 ppm;
- Phenylketonuria: a safe amount of phenylalanine to be daily consumed by a patient is defined by his physician;
- Diabetes: the carbohydrate intake per day and each meal is defined by the patient's physician;
- Arterial hypertension: daily sodium intake must be less than 2400 mg or defined individually by the patient's physician.



Figure 2: *Information about the food content.*

3.1 Probiotic information instead of claim

Although some studies of both children and adults have shown that probiotics may help treat and prevent infective diarrhea and inflammatory bowel diseases, we are not allowed to claim any statement about probiotic beneficial nutritional or physiological effects in eDietetik. We follow the Slovenian directives as well as the Directive 2000/13/EC on the approximation of the laws of the Member States relating to the labelling, presentation and advertising of foodstuffs, to be replaced by Regulation 1169/2011 as of 13 December 2014.

For users with special dietary needs because of diarrhea, the application eDietetik displays

1. scientific and lay names of probiotic cultures (strains) contained in probiotic-filled foods as well as
2. the concentration of probiotic bacteria

without any symbolic interpretation.
The information about probiotics is obtained from the manufacturer producing a given scanned food product. If cultures are unspecified or the concentration of bacteria is unknown, the information is interpreted as incomplete. Similarly, if any probiotic culture does not fit with the cultures from the list of scientifically proven probiotic cultures or the number of bacteria is less than a threshold, the application warns the user about that (Figure 3). The default threshold (one billion) can be redefined by the user in the user's personal settings.

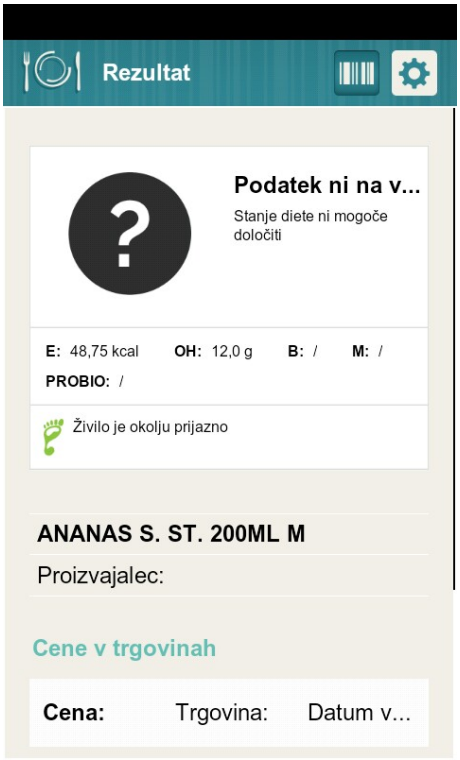


Figure 3: *Information about a new or unrecognized food.*

In this way, we provide eDietetik users with an information about probiotics and then it is up to them and their physicians to decide whether a given food product satisfies their dietary needs.
Collecting the information about probiotic-filled foods available in Slovenia, we realized that most products advertised as "probiotic" foods provide no information about the concentration of probiotic bacteria on food labels. Last year, the European Food Safety Authority (EFSA) rejected all probiotic health claims dossiers it had been sent for reasons such as inadequate strain characterization.

The application eDietetik also enables users to send us description and photo of new food products and those food products that are still unknown to our system (Figure 6). In this way, we are able to provide an interaction not only between consumers and eDietetik but also between consumers and manufacturers (human to human over a mobile device).

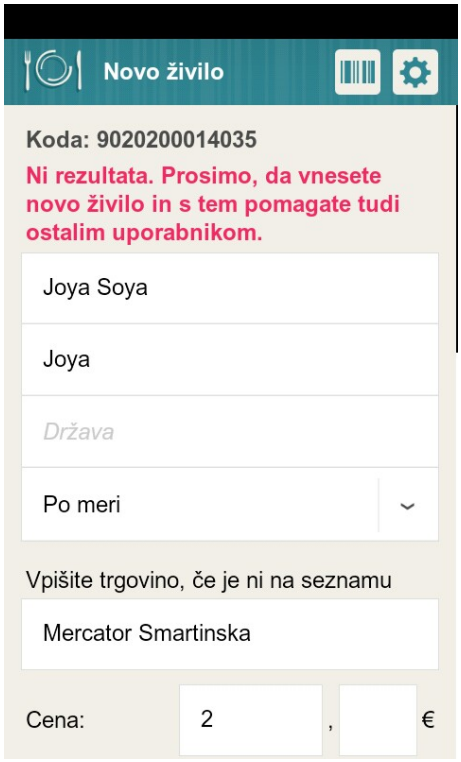


Figure 4: *Information about a new or unrecognized food.*

3.2 eDietetik Website

The mobile application may be uploaded to a smartphone from a website [7], where more information about diseases, dietary recommendations and guidelines, medical societies, and food manufacturers is provided.
There is an interesting tool *Food calculator* that can be used for the dietary assessment of a selection of foods or a meal (Figure 5). The application interacts with the user providing more detailed information about nutrients relevant for his disease. An unexperienced user may select food portions from pictures presenting three different portions as typically consumed in Slovenia. Foods can be searched by using a search facility or by exploring the list of already categorized foods.
The history of the usage of the eDietetik mobile application can be viewed in the *User's settings* section.

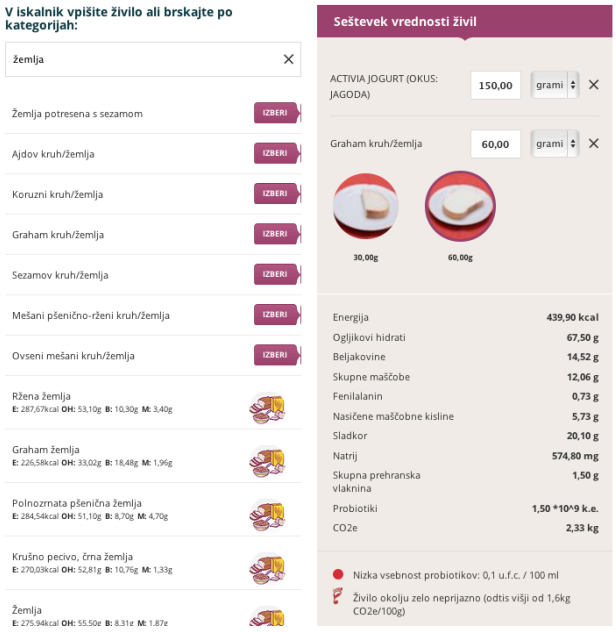


Figure 5: *Food calculator.*

4 CONCLUSION

We developed a mobile application eDietetik that informs Slovenian consumers about health and nutritional claims on foods and drinks. The paper describes an attempt of eDietetik to present probiotic information instead of health claims in a legal way.

In the near future, we are going to evaluate the mobile application in a clinical setting, where a degree of perception of probiotic information will be studied. The application will also undergo a different type of assessment and authorisation. The assessment of the application functionality in terms of technology (image capturing and barcode recognition) have been performed in our laboratory, and will be finalized by a group of experts (dietitians, physicians and food analyists) who will assess the application functionalty in terms of health-related information and food composition data. In addition, the application will be assessed by a group of patients and environmentally conscious consumers for the user friendliness of the application. We will do our best to receive a certificate like HONcode [8] that guarantees that the online health information is useful and reliable.

Currently, there are more than 10,000 users of OPEN that all have rights to access eDietetik as well. In average, every day, approximately ten new users register, and few ten users actively use some of the OPEN functionalities. In addition to the OPEN users, eDietetik will be actively used by most members of the Slovene Celiac Society (few hundreds) and the Slovene PKU Society (few tens). Patients will be informed about the application by dietitians at different hospitals. We have also introduced the application to the Slovene Nutritionist and Dietetic Association, and to school and kindergarten teachers (few hundreds) who daily plan meals for children. As these potential users of eDietetik have different computer (and mobile device) literacy, most probably we will need to adapt the underlying concept of the human-computer interaction to the specific needs of the users.

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TOWARD IMPROVED EMERGENCY CALL SERVICE: A USABILITY TEST CASE STUDY

Miha Ristič[1], Franc Novak[2],
[1]Jožef Stefan International Postgraduate School, [2]Jozef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
e-mail: miha.ristic@afnarija.eu, franc.novak@ijs.si

ABSTRACT

This paper describes the initial steps for the improvement of emergency call service. For instance, persons reporting an accident or similar event and the officer receiving the call are often under stress, which distracts the communication process and becomes a barrier to information transfer. We try to identify the main deficiencies when processing a received call and explore alternative ways of recording the main information content. In this regard we performed a usability test case study for assessing the efficiency of recording information either on a blank paper or in a prepared paper form. Implementation details of the usability test are described.

1 INTRODUCTION

In Slovenia we have two emergency telephone numbers the first is "112" (International emergency telephone number) and "113" which is emergency police telephone number. In police structure this service is named Operation and Communication Centre (OCC) and widely recognized by users as telephone number "113" as a police emergency number. The Republic of Slovenia has eight OCCs on regional level and one on the state level covering all eight regional OCCs.

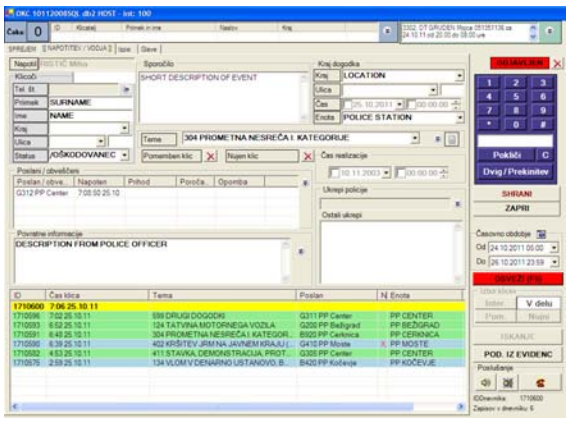


Figure 1: *current GUI OCC screenshot*

The emergency telephone number 113 receives yearly more than half million calls, out of which there are 40% that require police intervention. From the above it is clear that a reliable operation of computer/communication infrastructure and human resources is a prerequisite for efficient performance of OCCs. In this paper we primarily focus on the acceptance of a call, which is only one of the operations performed when someone calls the emergency telephone number 113. Due to stress, communication noise and other factors the process of receiving and recording faces problems and is occasionally error prone. In order to improve the efficiency of the communication we try to identify the main deficiencies when processing a received call and explore alternative ways of recording the main information content. For this purpose we performed usability test case study for assessing the efficiency of recording information either on a blank paper or in a prepared paper form. Implementation details of the usability test are described in the following sections.

2 USABILITY TESTING ISSUES

According to J. Rubin and D. Chisnell [1] "a product or service is truly usable when the user can do what he or she wants to do the way he or she expects to be able to do it, without hindrance, hesitation, or questions". While this definition might sound a bit too broad for our case, we definitely stick to its attribute *efficiency*, which is defined as "the quickness with which the user's goal can be accomplished accurately and completely and is usually a measure of time". In our case the situation is actually reversed. Efficiency means what quality level of the recorded information can be achieved within a given (short) time limited by practical circumstances and is a measure of committed errors. Furthermore, the term error in our case denotes either erroneous or missing information item.

Different testing methodologies can be found in the literature [1-6]. A reader may get a bit confused since there is no established terminology, and it happens that similar techniques are denoted in different ways. We follow J. Rubin and D. Chisnell [1] who define three basic test techniques: exploratory (or formative), assessment (or summative), and validation (or verification) tests at a high level. The above tests are associated with specific points in

the product life cycle. The fourth, the comparison test, can be regarded as an integral part that can be used in conjunction with any of the other three tests. It is not associated with any specific lifecycle phase.
The usability test case study that we performed can be regarded as a comparison test in conjunction with assessment test. In assessment test, basic conceptual model is defined and the test is used to evaluate how effectively the concept has been implemented. In this test, the user performs given tasks, the interaction with moderator is supposed to be low, and quantitative measures are collected as result. The role of comparison test in this context was to compare two alternative solutions. Important feature is that in order to acquire statistically valid results, the alternatives should vary along a single dimension. Usability test performed in our case may seem to be simple and trivial, however we believe that adhering to the above test concepts will allow us to continue our work on more complex issues.

3 TEST PREPARATION

The goal of the designed usability test was to assess two alternative ways of recording information either on a blank paper or in a prepared paper form. From the very beginning we faced the difficulty of making the experiment objective and such that it could be repeated and tested by different persons in the same way.
Initial problem was, how to perform a telephone call. The idea of generating a call together with emotions, stress, mistakes, etc. was discarded due to the difficulties to imitate it in a realistic way. After a lot of discussions we decided to use a recorded telephone call. However, due to additional formal restrictions we could not use real recording from 113, so we prepared simulation of a call to police emergency telephone.
In our usability test we followed the guidelines from Usability.gov [7] and the book of B. Nielsen and H. Loranger [3].

3.1 Documents

Before real testing has been conducted we prepared the following documents: usability test plan, consent for video taping, guide for moderator, reminders for (traffic accident, crime and minor crime), notes, scenarios.

Usability test plan is a document where everything is written about the test, how it will be done, who are the participants, what kind of training do they need, all procedures, ethics, how measurements will be done, envisioning all the possible errors and limitations of a test. It is a document, which is forcing you to think and to prepare your self for usability test and to anticipate mistakes and errors which will occur while the test is conducted.

Consent for video taping is a consent that you can record a testing subject and obligation from your side to tell the participant, what you will do with this recording latter. Consent is a document which can make a lot of problems to disappear if you have it.
Guide for moderator is a document that instructs you what to do and how to do it. It serves also as a reminder not to forget something.
Questionnaires prepared for the participants to put down important information items communicated to them via simulated emergency calls.
Notes, basically this is your grading paper. Here you write what you will grade and what will happen. All questiones which you will ask participant are written here. It is a short summary of **Usability test plan**, but it is a specialized document for grading.
Questionnaires – for later analyis you need demographic data and data how, participants comprehend test. From these questionnaires you try to discover how the participants see problem and how they solve it. We prepared many different questionnaires such as demographic, before test and for after test.

3.2 Recordings, scenarios

As mentioned before, neither a real telephone call nor a genuine recording from the 113 centre was an option. So we made our own scenarios. In preparing the scenarios we have taken care to include similar amount od information as it is the case in real life when someone calls the police officer via emergency telephone line.
We prepared fourteen different scenarios and recorded them. Since this was the first time we performed experimets like this, we did not have an idea how much materials we actually needed. So, for the beginning we decided to select four scenarios for our usability testing, and keep the remaining for possible future experiments.

3.3 Participants, locations

The next step was acquisition of participants whose background and abilities are representative for our testing process. Due to a low budget we could not afford any monetary compensation for the participants, so we counted on friends. We searched for four police officers with experience from the work in OCC and four people, who had not experience and knowledge about police. Soon we met another obstacle in that the participants that volunteered to take part in our research at different times and consequently have their free time on different days at different time slots. They also live at different places, some rather distant from others.
Taking into account all these limitations we decided to perform tests at different places and times but special attention was paid to provide the same experience on either location. Three different locations were used including office and home.

Eight participants were involved, among them five male and three female. The average age of the participants was forty one years. The youngest participant had trhirty-two and the oldest fithy-eight years. Half of them work in police and have experience from this kind of work and the other half had no such experience. Two of participants had high education, two higher and four of them secondary education. All of them participated in this kind of testing for the first time. Participants from the police have the average of twenty years of working experience in this kind of work. Only one participant never called to any kind of emergency telephone 112 or 113.

3.4 Equipment

For testing purpose we prepared laptop computer, miniDV camcorder, pencils, blank paper and many printed reminders and notes.

Initially, a **laptop** was planned to serve both as audio player of the prepared scenarios. In addition, we also considered the possibility to use the laptop as a stopwatch. However after some preliminary attempts we decided to use it only for playing the simulated calls.

Camcorder was set to record the participants during the test sessions. It was mounted on a stand, so that we did not need to engage additional moderator. Since an analogue camcorder was used we later had to transform all videos to digital format in order to be able to play them on computer and have control over play, pause, rewind and stop option.

Pencils, blank paper and paper forms were used by participants to note down the information they received from the simulated calls.

Notes were used by the moderator to note down observations of the behavior of each participant.

4 PRACTICAL EXPERIENCE

Before performing real sessions it is necessary to prepare checklist for getting ready. Here again we followed the guidelines proposed in [1]. A checklist includes the schedule with all the necessary details to conduct the session. Before starting a real session you check if the participant had filled out and signed permission to record. Next you explain to the participant the task that he/she is going to perform. Afterwards you move to the testing area and prepare to test. Participant and moderator position themselves according to the prepared environment. And the recording starts.

The sessions were performed in the following way. We tried to follow the same protocol for all the participants. Here, the guide for moderator played a speciall role. All instructions to participants were read from the guide directly. In this way we managed to create a critical distance between the participant and the moderator even if they were close friends.

We explained to the participants that they would listen to four simulated emergency calls and that they would be asked to note down the information they receive. We gave the participants time to ask questions. We noticed that most of the participants felt unconfortable in the presence of a camera, so we tried to relax the situation with nonformal conversation but still focused on the test.

Before the actual start we explained to the participants, what kind of call they can expect (traffic accident or serious crime). We explained, that their task was to produce a document containing all the information necessary for the police dispatch. Then session started. A screenshot of a recorded session is shown in Figure 2.



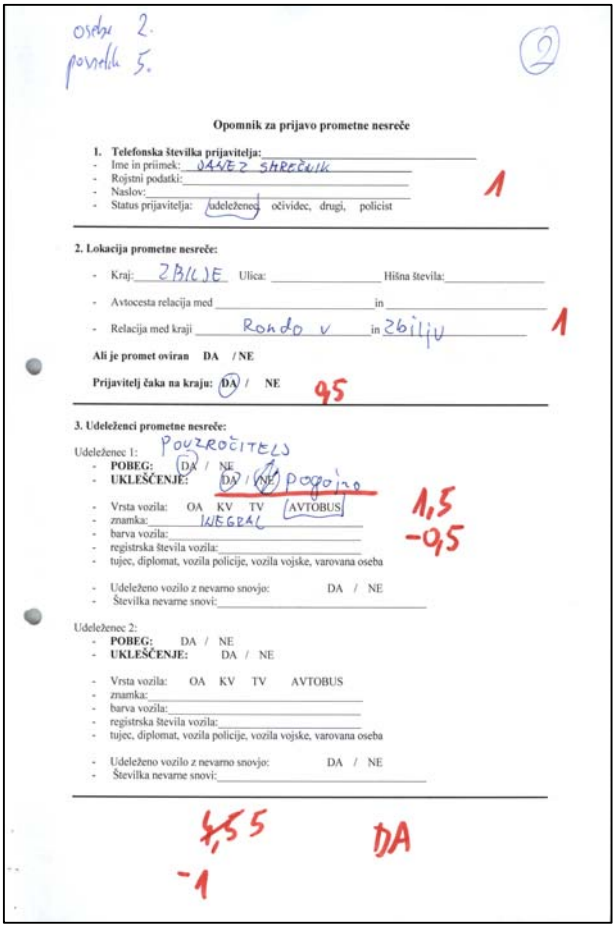
Figure 2: *A screenshot of a recorded session*

	Scen. 1	**Scen. 2**	**Scen. 3**	**Scen. 4**
# of data items	9	12	12	7
call duration (sec)	17	17	20	13
# of sec. per data item	1,8	1,4	1,6	1,8

Table 1: *Information content and duration of individual scenarios*

Table 1 shows the information content and duration of individual scenarios. The first row gives the number of information items (i. e., important facts communicated by the call that are relevant for the decision on police dispatching). The second row shows the duration of individual simulated calls. The third row shows the amount of information received per second in each case. In some recording some information item repeated, but in the table they are counted only once.

For illustration we give an example of a filled form in Figure 3. The red marks (marked by the moderator after accomplished test) indicate to what extent individual information items have been recorded. Due to the lack of space only a part of the form is shown.



Opomnik za prijavo prometne nesreče

1. Telefonska številka prijavitelja:
- Ime in priimek: JAVEZ SREČNIK
- Rojstni podatki:
- Naslov:
- Status prijavitelja: udeleženec, očividec, drugi, policist

2. Lokacija prometne nesreče:
- Kraj: ZBILJE Ulica: Hišna število:
- Avtocesta relacija med in
- Relacija med krajiRondo v in Zbilju
Ali je promet oviran DA / NE
Prijavitelj čaka na kraju: DA / NE 95

3. Udeleženci prometne nesreče:
Udeleženec 1: POVZROČITELJ
- POBEG: DA / NE
- UKLEŠČENJE: DA / NE Pogojno
- Vrsta vozila: OA KV TV AVTOBUS
- znamka: INTEGRAL
- barva vozila:
- registrska število vozila:
- tujec, diplomat, vozila policije, vozila vojske, varovana oseba
- Udeleženo vozilo z nevarno snovjo: DA / NE
- Številka nevarne snovi:

Udeleženec 2:
- POBEG: DA / NE
- UKLEŠČENJE: DA / NE
- Vrsta vozila: OA KV TV AVTOBUS
- znamka:
- barva vozila:
- registrska število vozila:
- tujec, diplomat, vozila policije, vozila vojske, varovana oseba
- Udeleženo vozilo z nevarno snovjo: DA / NE
- Številka nevarne snovi:

1,5 -0,5 1,5 5 DA -1

Figure 3: *An example of a filled form*

- ????? - DS - Šmar. 154 - NN - fric Aleksander - bel kombi	27.10.2012 17:32 Robi Travnik Z. ob. → Tržaška PN AC Tržaška R master bel C4 Lj tablic
M kdaj Šmart 142 Elektronski merilni aparat Fric Aleksander – GRADBIŠČE Bel kombi – napis elektro fric	Kraja – Merc. Smart 154 Merili inštr. Fric Aleksander Be kombi elektro FLINK

Figure 4: *Four examples of recording on a blank paper*

The examples of noting down the information from the call are shown in Figure 4. Although the notes are written in Slovene it is apparent that the participants shortened words in order to speed up the recording. Questionmarks in the upper left part indicate an unreadable note.

5 LESSONS LEARNED AND CONCLUSION

After the completion of tests we critically assessed the performed procedure and analyzed the results. Expectations that we could control the whole test where not completely met. We could control the initial segments, when we have made interviews and giving instructions, however, in critical moments during test, the participants reacted in their own way. Consequently, some additional measures should be taken in future.

We were also a bit surprised since the majority of participants finished their task in thirty to fifthy seconds. For the moderator it was impossible to observe everything and record it in the notes in such a short time. In this regard, video recording proved to be of a great help.

Another remark concerns grading of the achieved recordings. All information items are not of the same relevance for the decision for dispatching police officer on the place of event. So in our future work we plan to add weights to individual information items and thus achieve better estimation of the recordings.

Analysis of the recorded notes shows that filling the forms provides better information content for subsequent processing than the notes on blank paper. On the other hand, filling the forms takes much more time than notes on the blank paper. This drawback will be alleviated when one becomes acquainted with the form after a certain number of recordings.

The described usability test is just the first step toward the design of a new user interface. Further research will be directed toward dynamic organization of user interface adjusted to specific predefined cathegories of events.

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Zbornik 16. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2013

Proceedings of the 16th International Multiconference

INFORMATION SOCIETY – IS 2013

Sodelovanje, programska oprema in storitve v informacijski družbi

Collaboration, Software and Services in Information Society

Uredil / Edited by

Marjan Heričko

http://is.ijs.si

10. oktober 2013 / October 10th, 2013
Ljubljana, Slovenia

PREFACE

This year, the conference “Collaboration, Software and Services in Information Society” is being organized for the thirteenth time as a part of the “Information Society” multi-conference. As in previous years, the papers from this year's proceedings address actual challenges and best practices related to successful collaboration as well as to service and software engineering. It is important that, from a technical point of view, ICT-based services are designed and architectured in a way that provides adequate performances even in the case of handling large digital data sets, and that they support service interoperability and their evolution in order to be adaptable for new contexts of use. However, even a technically perfect service will not be accepted by consumers if developers do not take into account the specifics and needs of real users as well as other factors that influence acceptance, including factors related to privacy and personal data protection. Introducing the persona concept as well as semantic annotations and ontologies into software and service engineering processes might contribute to our common goal – to provide useful and well accepted advanced information solutions and services. Formal modeling of learning content and processes can provide better results in personalized learning. Communication with a computer as well as with other actors can be improved by using a new generation of HCI interfaces that are based on gesture and speech recognition. And having a successful implementation of our own language speech synthesizer may result in easier communication and better accessibility of ICT-based services and solutions.

We hope that these proceedings will be beneficial for your reference and that the information in this volume will be useful for further advancements in both research and industry.

prof. dr. Marjan Heričko
CSS 2013 – Collaboration, Software and Services in Information Society Conference Chair

PROGRAMSKI ODBOR / PROGRAM COMITTEE

Dr. Marjan Heričko
University of Maribor, Faculty of Electrical Engineering and Computer Science

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University of Maribor, Faculty of Electrical Engineering and Computer Science

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University of Maribor, Faculty of Electrical Engineering and Computer Science

Dr. Luka Pavlič
University of Maribor, Faculty of Electrical Engineering and Computer Science

TOWARDS OPEN MEDICAL IMAGE BASED COLLABORATION

Peter Rogelj[1], *Primož Petrič*[2,3]
[1] University of Primorska FAMNIT, Koper, Slovenia
[2] National Center for Cancer Care and Research, Doha, Qatar
[3] Institute of Oncology Ljubljana, Slovenia
e-mail: peter.rogelj@upr.si, ppetric@hmc.org.qa

ABSTRACT

Collaboration related to medical images is limited due to restrictions following security regulations for personal information privacy. In addition, the large size of medical image data sets and related files is prohibitive in terms of fast and efficient exchange of information. Therefore, such collaboration is limited to individual institutions or formal regional or national networks and is largely based on exchanging the anonymized files over dedicated ftp servers and offline review and communication of medical experts. In this paper we propose an alternative approach, i.e. a web based system that enables worldwide open cooperation. Our system assures the security of patient information during data exchange and provides the online processing capabilities, while users may freely develop their personal networks and use their own collaboration principles. The proposed concept follows requirements analysis for three selected types of collaboration activities: education, medical research and medical consultations, and is demonstrated on a practical implementation for collaboration in radiation oncology.

1 INTRODUCTION

Medical images provide irreplaceable source of information for medical diagnosis, treatment planing and medical interventions. Nowadays the handling of medical image data is supported by medical information systems, e.g., PACS for medical image archiving and communication, and enforcement of DICOM communication standard. Several computer based tools for image processing and visualization are also available to support image related tasks in specific medical practices.

Medical image data contain sensitive personal information [1] i.e., information on individual patients or diagnostic and treatment procedures. Consequently, privacy security is the main reason for restricting medical information systems, especially image based ones, to individual institutions, user groups or closed regional/national networks. Such regularized formal systems provide support for specific collaboration activities, however may provide serious limitations for others, especially less formal and more geographically dispersed ones. We have identified three types of collaboration activities that require image data exchange and benefit from information system support, i.e., education, medical research and medical consultations. We have analyzed requirements related to these activities and propose an alternative information system concept to support them. Opposite to formal systems, the general idea is to promote collaboration freedom with systems that secure personal information while offering data exchange and data processing. The concept tends to upgrade existent collaboration principles based on already established personal networks. In this paper we present the concept and demonstrate it by a practical implementation of a web application for medical collaboration in radiation oncology.

2 REQUIREMENTS ANALYSIS AND SYSTEM DESIGN

Cooperation based on medical images is important for very different activities. We have identified and focused to three activity types that are impeded by personal information sharing limitations and have large growing potential. These cooperation activities are research collaboration, educational support and medical consultations. We have analyzed requirements of each of them in order to obtain general characteristics required for a widespread medical information system.

Research cooperation in the field of medicine is often interdisciplinary. When medical images are involved, certain image processing tasks may be required to conduct the research, which links medicine with computer science. Data and procedure analysis may also require other research disciplines, e.g., mathematics, physics, chemistry, etc. The access to patient personal information is not needed as long as collaboration results do not need to be linked with other (clinical) data. Personal information is, therefore, only required as a link to other/supplementary data. Depending on the research topics, different tools for data processing or analysis may also be required.

Educational support tends to simplify data and information exchange between teachers and students. In a typical scenario, teachers prepare assignments for students and provide relevant data first. The assignments may be equipped with some guidance material, e.g., lecture slides or relevant published manuscripts. Second, when tasks are completed by the students, solutions must be returned to teachers for revision. Furthermore, teachers may respond

with comments and/or corrections. Personal data is not needed in the process, the stress is in data exchange and tools required for completing the assignments. Furthermore, teachers may require some tools for analysis of student solutions. It is also advantageous if the assignments can be reused for another student group.

Medical consultations enable physicians to exchange their opinions about certain medical cases in order to make better treatment decisions. When a treating physician requests an opinion from a consultant, e.g., a colleague or an expert, he needs to collect the patient data and send it to the consultant along with some description that includes eventual list of medical symptoms. The response is expected in a form of free text and may be supplemented by graphical data related to original medical images. Patient's personal information is only important for the treating physicians and not for the consultants. The process may require certain tools to help analyzing the data, preparing the consultant response, comparing different opinions or applying them to consequent treatment procedures.

A typical use case of all the identified collaboration types involves sharing of some medical image data, that is already available in some clinical information system. Furthermore, certain tools need to be available to support the cooperation. From all the three types of collaboration, we have identified the following general principles of an open medical collaboration system:

- The collaboration system should not be directly connected to clinical information systems to assure privacy security. The link between the systems may be users/physicians or some gateway under their control.
- Personal information is only relevant for the data owner, i.e., the person who provides (imports or creates) the data to the collaboration system and is not relevant for any other system user. The exchanged data should be anonymized. Any personal information that may be required for collaboration activities may only be shared manually in a form of free text data description and under responsibility of the data owner. Personal information may be added back to the anonymous data when exported from the system to enable further usage of collaboration results (e.g., in clinical practice), however only if the user that exports the data already owns the personal information, i.e., only by the original data owner.
- Users may only access their own data items and items that are shared with them by other users. Access to the data enables user to see the item (inside the system) and add (import or create) subsequent data, i.e., data items that additionally define or interpret the original data.
- A user may share some data item with other users if and only if he/she has a sharing permission on that item. Sharing permission is always granted to the owner. Other users may obtain sharing permission on some data from users that already have sharing permission on that data. Sharing permission also allows user to download the data from the system.
- There must be a possibility for users to process the data. Due to eventual restrictions on the data and due to better user experience, it is advantageous if the processing can be performed inside the collaboration system, using system integrated tools.
- In addition to medical images, some other data types must be supported to store image related data for its interpretation, further processing or usage. Each type of data is related to specific knowledge that must be integrated into the system to enable data visualization interpretation and/or creation inside the system.

We have focused on the field of image guided radiation therapy, specifically to activities related to contouring in gynaecological malignancies. Contouring is a task in which 3D structures are identified and located in the medical image by the radiation oncologist. Typical structures in image guided gynaecological radiotherapy include the Gross Tumor Volume (GTV), High Risk Clinical Target Volume (HR CTV), Intermediate Risk Clinical Target Volume (IR CTV) and organs at risk (OARs). Defining the structures, especially the HR CTV and IR CTV requires a lot of knowledge and experience, although recommendations have been published to support it [2] Because the consequent treatment and the treatment results highly depend on the selection and delineation of the region of interest, we see high possibility of cancer treatment improvements through increased cooperation abilities offered by the information systems. There are certain needs of educational support, medical consultations as well as research cooperation in the field of contouring that led us to design a web based information system dedicated to these needs. The system was designated as the Platform for Online Image interpretation and Training with Contouring capabilities, hence, ContourPoint. ContourPoint is used as an example to illustrate the proposed concept of medical collaboration systems in our present paper.

In our general concept an image based medical collaboration system comprises three basic views: data view, image view and messaging view. They enable users to browse their data, visualize, create and process the data, and communicate with each other.

In the data view, the user can browse and manage data that he owns and data that was shared with him by other users. The data is a collection of data items. Different types of data items are required to support different types of medical data. However, irrespective of its type each data item has a name, description and owner. The description category allows the item owner to equip each item with the key information that is required for the thorough understanding of the data by the users. Data is hierarchically organized with case data items in the top level and actual medical data in lower levels of data hierarchy, for the illustration of data hierarchy and item data types see Fig.1. In ContourPoint, the following types of data items are supported:

- A case is the topmost data item type used to meaningfully organize medical data. Except of the name and description which is defined by the case owner it

does not contain any medical information, however it serves as container for other data items.

- An image is a central data item type and is used to store raster 2D and 3D medical images. Images are typically imported to the system using DICOM file format. Image data item does not contain any supplementary data, e.g., overlays, vector graphics, etc., which needs to be stored in additional data items.
- A structure folder is a data item type subordinate to an image and serves as a container of interrelated structure delineations, e.g., it may contain several delineations of one structure (e.g. HR CTV) provided by different users (HR CTV1, HR CTV2, etc.).
- A delineation is a data item type subordinate to a structure folder and provides a geometrical representation of an imaged structure in a form of a set of closed planar contours (e.g. HR CTV1).
- An overlay is a data item subordinate to an image and provides raster data to be overlayed on that image. The meaning of the overlay is not predefined and can be specified by its name and description. It may be used, for example, to show distance deviations to several contours for each individual image voxel [3].
- An attachment is a data item subordinate to a case and comprises a data file of arbitrary type. It can be used to additionally describe a case, e.g., with detailed descriptions, videos, photos, papers etc.

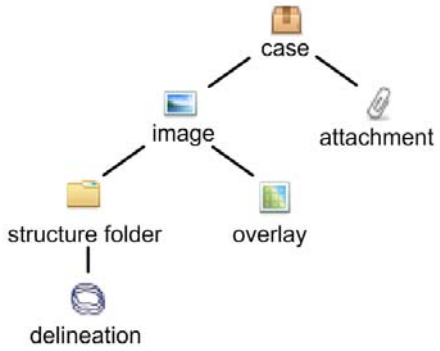


Figure 1: *Hierarchical structure of ContourPoint data item types. System support for each item data type is required to enable data visualization and processing.*

Image view is used to visualize medical images and related data items as well as to create and process data with system integrated tools. Server and client side processing tools may be available to enable complex operations and good real-time user experience. In ContourPoint client side tools enable creation and editing of delineations while server side processing is planned for delineation analysis. Beneficial to the user experience is the ability to simultaneously visualize the observed image, subordinate data and other case data, e.g., other images and attachments.

Messaging view is used to control communication between the users. Users may communicate with each other using messages. Each message may have multiple recipients, i.e., other system users, and comprises a message in a form of free text and eventual data item shares. Here, users may select which data items to share within the message, limited by their own data sharing permissions. Users can share data items they own and data items for which they received sharing rights from other users (by messages). When sending a message user may pass his sharing rights to the recipients or restrict further sharing of included data items. In the messaging view users can access the received and sent messages as well as their contents including the shared data items.

Note that data items in each case may be owned by different users, e.g., one user may create a case and define required structure folders while one or more other users may provide delineations. The concept is general, the only required difference to support different medical disciplines is in the selection of supported data item types and processing methods.

In our concept a special care was taken to secure the personal information. Medical data is imported from DICOM files and anonymized before sharing. To use collaboration results in other systems data can be exported, however only by users that own the required personal information. For example, in ContourPoint only the user who imported an image is able to export all delineations that were contoured on that image and for which he owns sharing rights, including those delineations provided by other users. On the other hand, delineations contoured on an image provided by some other user can not be exported.

3 RESULTS

The proposed concept was tested on ContpurPoint system in three collaboration scenarios, involving the education purposes and medical consultations.

In the first scenario, ContourPoint system was used for educational purposes. A contouring course for gynaecological radiotherapy was organized in March 2013 in collaboration between the Aarhus University Hospital (Denmark) Institute of Oncology Ljubljana (Slovenia) and Varian medical systems. The course was held in Aarhus, Denmark. Sixteen radiation oncologists and medical physicist from several countries attended. The course faculty pursued the following strategy to optimize the problem-based learning experience for the participants: (1) two anonymized clinical scenarios with detailed clinical case descriptions, full DICOM data sets of medical images and published contouring recommendations were made available to the participants several weeks before the course. ContourPoint system was used as the platform for this interaction. The users were asked to perform contouring of the requested regions of interest in ContourPoint as the pre-course homework, simulating the radiotherapy clinical conditions. After completing the contouring task, the faculty shared the reference (teachers' consensus) contours with participants, enabling them to

compare their work with the "master delineations". (2) Actual hands-on contouring course was then held in Aarhus. The experience, obtained during the pre-course homework, was very valuable since it sensitized the faculty to the most common contouring errors/inconsistencies that needed particular attention during the theaching process. In addition, the participants have already gained some knowledge before the actual course, enhancing the effectiveness of their learning. (3) Following the course, the participants were granted access to additional two contouring cases, giving them an opportunity to consolidate the knowledge gained during the first two steps and continue with their learning even after the course was over. Staying in touch with the theaching material, teachers and other participants on ContourPoint platform even after the course may represent an important advantage when compared with the conventional structure of a teaching course.

In the second scenario, ContourPoint system was used by three members of the faculty of a European Society for Therapeutic Radiation Oncology (ESTRO) school. The members of the faculty used ContourPoint to exchange their opinions in order to create the consensus contours for several image data sets. The consensus contours and other results of their consultations were used as teaching material at the actual teaching course.

In the third scenario, a radiation oncologist, facing a challenging case in his clinical practice, used ContourPoint to consult a colleague about the optimal contouring solution for this particular case.

4 DISCUSSION AND CONCLUSION

According to our literature review and the review of cross border telemedicine systems [4] the idea of open collaboration system for medical purposes has not been porposed before. All analyzed systems were designed for collaboration inside closed user groups, usually coordinated by individual institution. The open concept, however, follows the idea, which has already been proved by many social networking services, that users can build their personal and professional networks by themselves if they can use them efficiently to support their interests. Users, supported by system services for data security and confidentiality also take their responsibility for legal factors that in other cases hinders system growth. Compared to two most widely reported global services, i.e., Swinfen Charitable Trust [5] and iPATH [6] our concept differs considerably; in addition to its openness it offers advanced features that support the collaboration and does not govern the collaboration process. In contrast to several other systems, e.g. [7, 8] the concept does not tend to integrate synchronous user collaboration tools and builds on top of existent user communication principles. All these differences make the proposed concept complementary to formal medical networks.

The proposed concept for collaboration based on medical images enables users to collaborate based on medical images and image related data without any geographical or organizational limitations. The e-learning possibilities, enabled by the ConturPoint system offer an important adjunct to the conventional teaching techniques. Modern radiation oncology techniques, based on meticulous contouring of the regions of interest have been shown to improve the rates of cancer cure while decreasing the treatment side effects. However, the spread of these techniques and knowledge in the parts of the world where they may be most needed, remains impeded by the various, including economic, reasons. The systems as the one proposed here may in fact represent a replacement for conventional radiotherapy contouring courses, significantly reducing costs of education. The possibility of real-time medical consultations may improve the quality of care in specific clinical situations. Quality assurance and quality control of clinical studies represent just one aspect of the research potential, offered by our open system platform.

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CONTENT ANALYSIS SYSTEM FOR IMAGES

Petri Rantanen, Pekka Sillberg, Jari Soini
Department of Software Engineering
Tampere University of Technology - Pori
P.O.Box 300, FIN-28101 Pori, Finland
Tel: +358 40 8262890; fax: +358 2 6272727
e-mail: jari.o.soini@tut.fi

ABSTRACT

This paper presents a concept architecture developed for managing digital data. The paper introduces the basics of a simple task-based system, which can be used for scheduling content analysis tasks on remote back-ends. The interaction between client software, front-end service, and content analysis back-ends are illustrated in combination with an optional feedback mechanism designed for improvement of analysis results. The paper describes the system components and overall system architecture, and also explains how task generation and data analysis are implemented. The presented concept architecture is applicable to various forms of media, but the focus of this paper is on image content.

1 INTRODUCTION

The research topic deals with the challenges of managing vast amounts of data. Currently, there is a huge amount of digital data stored in many different kinds of digital storage, even at individual level. Moreover, the stored data is not only big, but it is also unstructured. The problem is simply how to manage all this stored digital data. Tampere University of Technology is involved in a large national research project called Data to Intelligence (D2I). The aim of the D2I project is to study and develop methods and tools for the management, processing, and utilization of large amounts of data captured from the environment, Internet and many other sources. In addition, new business opportunities are being developed around this material. As part of this project, the study focuses on examining the challenges related to processing digital data automatically. For example, humans can process text, images, videos, audio, and other forms of data effortlessly, but these are the most difficult to process automatically by computer.

2 TASK-BASED ANALYSIS SYSTEM FOR IMAGE CONTENT

The system consists of a front-end service, which provides a REST API for the clients, and can be used to execute search queries, modify content on the front-end, and can also be used to connect external accounts of 3rd party content storage services. The front-end does not store any actual content, but only maintains a metadata base, which is used for resolving the links to the content stored on external accounts. In addition to being capable of retrieving content and the associated metadata located on external accounts, the front-end can utilize various content analysis engines for the process of extracting additional metadata. In the scope of this paper, the focus is on content analysis engines capable of image analysis, and more specifically, content-based image retrieval [1, 2].

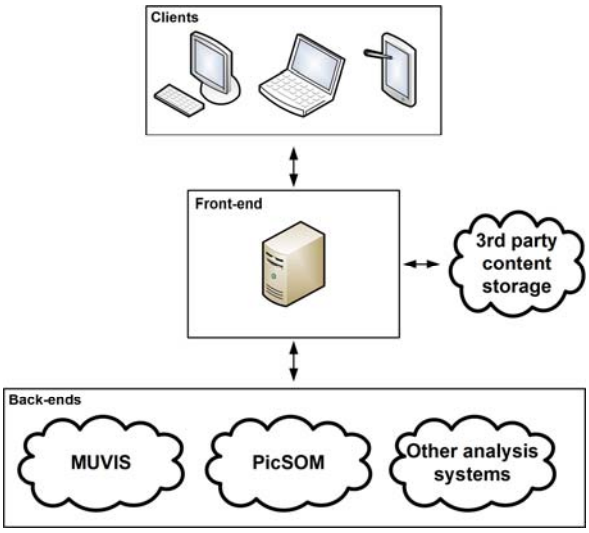


Figure 1: *Overall system architecture.*

The main purpose of the multiple analysis back-end (content analysis engine) approach is to make it possible to gather as wide a range of metadata as possible – as generally most systems are more suitable for one task, and do not perform as well with other types of tasks. For example, a back-end capable of feature extraction cannot do description text summarization. In principle, the multiple analysis back-end approach could also be used for load-balancing if there are multiple mirrors of the same back-end available, but this would require knowledge of the current load status of said back-ends, or the back-ends should be dedicated to the tasks provided by the front-end. For these reasons, in our scenario, the back-ends are responsible for their own load-balancing and resource allocation. In an ideal scenario, all analysis results would be shown to the user immediately after the content has been

uploaded, and with a relatively small content base this can be achieved, but in the case of thousands, or tens of thousands of images, there may be a significant delay before the analysis operation is completed. Depending on the overall quality of the results, this may force the user to recheck his/her images after the analysis has finished. The total time required for analysis depends on the content and is difficult to estimate precisely. In practice, the results are seldom perfect, and thus, a mechanism for user feedback is required. The feedback may be requested during the initial upload of the content, or some time after, depending on the desired use case. The overall system architecture is shown in Figure 1.

Google's Picasa was our choice for the content storage service, but any of the alternative services (Flickr, Amazon, etc.) could have been chosen as well, as the only requirements were the ability to store image content and a public REST API, which could be easily used to access the image details from the user's account. There are several advantages in using a public service. It saves the trouble of implementing "just another content storage," and also enables the use of network and storage capabilities not necessarily otherwise available for research purposes. In addition, this approach makes the testing process easier, as the participants can use the content provider's APIs and well-known web clients for adding, updating, and removing content. If the test cases are very complex, it may be necessary to implement an additional client for browsing the content, or for executing other tasks that are not possible with the default client of the content provider. Whether this kind of split between two (or more) client applications is an issue or not depends on the use cases, but for us, the resources and time saved by not implementing new image storage were well worth it.

In the current implementation, two analysis back-ends, MUVIS [10] and PicSOM [11, 12, 13] are used, which have been provided by the partners of our research project. If any other back-end had been used, that back-end would naturally have implemented our interface specifications, which is not usually possible with commercial systems. Unfortunately, no commonly used generic and free protocols exist for task scheduling to external systems. Also, there is an apparent lack of open public services that could be used for advanced media analysis (such as feature extraction), which are not limited to the extraction of basic media details (e.g. Exchangeable Image File Format metadata [14]) that can easily be extracted without the use of external analysis back-ends. It should be noted that some metadata could be extracted by uploading the content to one or several of the publicly available content storage systems, and then retrieving the metadata generated by those systems, but in addition to being a somewhat cumbersome process, it may also be in violation of the terms of service agreements of the services in question – there may be limits on what purposes the services can be used for, and what it is permitted to do with the automatically generated content.

The basic concept of the system is based on the work done on previous research projects [3, 4]. An important point to make is that even though the system is suited to work as an end-user system, its primary purpose is to work as a test platform for content analysis engines in the scope of the D2I project. From this point of view, the client interface is secondary, and the communication protocols for the back-ends are of greater concern. The communication with the back-ends is basically two-fold. In the first phase, the back-ends are provided with a workload, which they should analyze, and report their findings back to the front end. In the second phase, these results should be validated by the user, either by asking for direct feedback [5, 6] or indirectly by automatically generating feedback based on the user's actions [7, 8, 9]. These two phases form the two basic task types of our system: the *analysis* task and the *feedback* task.

3 TASK-BASED APPROACH

The communication between the front-end and back-ends is achieved by using tasks and task responses. The tasks contain information about the type of the task and the actual contents (workload). The task workload generally consists of a list of images, in which each image contains the required base details (e.g. image URL, identifier), and any optional metadata (e.g. the description of the image) that might be useful for the back-end, but is not strictly speaking required for the completion of the task. The "usefulness" of metadata is decided by using a list of predefined data group classifiers, which are specific to a certain type of a task and the back-end in question – i.e. the task contents may vary from back-end to back-end, and from task type to task type, if needed. An example of a data group classifier could be "keywords," which, if present in the configuration, would trigger the inclusion of keywords associated with images into the generated task.

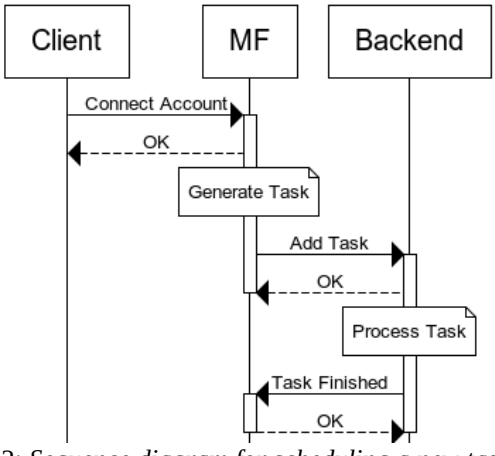


Figure 2: *Sequence diagram for scheduling a new task on an analysis back-end.*

For the content analysis, the current implementation of the system provides two task types: *analysis* and *feedback*. The *analysis* task is used for requesting media analysis work from a back-end, such as tag or keyword extraction. A

simple use case illustrating the task of type *analysis* is provided in Figure 2.

In Figure 2, the analysis task is generated after the user has connected his/her account to the system. The task generation may also be triggered by a web crawler, or by periodical synchronization with a previously connected account. If the account contains valid image content, the metadata of this image is stored in a database on the front-end, and based on this data a new task is generated for submission to back-ends. The task procession is always asynchronous, and the analysis back-end is free to initiate the actual analysis whenever it is most convenient. After the task has finished on the back-end, a notification is sent to the front-end. This notification message should contain any extracted metadata, and any possible error situations that occurred during analysis. Depending on the severity of the error, the image in question may be included in a new task, scheduled for a later execution – corrupted image data will never be successfully analyzed, but a temporary network error may resolve itself after a while. It should be noted that the task finished notification may contain only partial analysis results, which means that the back-end may provide the results progressively, or try the analysis again at a later date if needed.

Upon generation of a task, the base details of the task are added to the front-end database. These details include, for example, the list of image identifiers contained in the task, the ID of the task, the back-ends which should partake in the execution of the task, and optional user details. The back-ends may provide results for the tasks as long as the tasks are available. The tasks may become unavailable after a certain time period (expired tasks), or if all the content for the task is deleted by the user.

The user details can be passed to the back-ends, or the task can behave entirely in an anonymous manner, in which case the back-ends will not have any details about who owns the image content. The user details will never contain sensitive data about the user (such as a user name or password to the external account), and will only contain the user identifier assigned by the front-end, which can be used by the back-end to differentiate the users from each other. The URL links to image content are always provided as links pointing to the front-end, which will handle authentication to the external account, and provide necessary URL redirection for reaching the image content. This functionality can be used to hide the real user credentials from back-ends, but it also makes the back-end implementation simpler, because they only need to implement the interface for communicating with the front-end, and not all of the various authentication schemes used by the supported services. The disadvantage of this approach is the increased traffic on the front-end generated by the URL redirection requests.

The list of images and their details are dynamically generated based on the image identifiers and the available metadata. For the basic use case, depicted in Figure 2, this approach has no practical advantage, but using the system also makes it possible to give the back-ends only the task ID when scheduling the task. Thus, the back-ends may retrieve the task details just before starting the analysis, and in this way receive the most up-to-date metadata, which may contain results from previously finished analysis runs (i.e. from other back-ends). The back-end may always disregard the details provided in the *Add Task* call, and manually retrieve the task details. Disregarding the details may come into question if the analysis on the back-end is for some reason started after a very long time has passed since the *Add Task* call was received. For the basic analysis functionality this may not be required, as new images are never added to existing tasks, and submitting results for images that have been removed from the task is not considered an error. If the addition of new images to the old tasks were allowed, this would require more complex synchronization logic between the front-end and the back-ends. The same functionality can be achieved in a simpler way by creating new tasks when adding new content.

3.1 Task Results

When submitting the result (*Task Finished* call, in Figure 2), the back-ends cannot directly modify the details of the images. Instead, each image contains an *object list*, which may contain objects created either by the user, the front-end, or by the back-ends. These objects contain predefined fields for the object name, value, object type, and any special fields associated with a specific object type. The currently supported types are *metadata*, *keyword*, *face*, and *object*. *Metadata* is the simplest type, containing a basic name-value pair of information, such as GPS coordinates. *Keyword* (or "tag") and *face* are special types of metadata, and they are used when keyword-based queries or people-based queries are performed by the user. These two types may also contain coordinate (or area) information, which can be used to pinpoint the data to a specific position over the image. The face recognition data is in our case extracted by one of our own back-ends, but the metadata could also be extracted directly from the external account if the public API of that particular service supports the functionality. *Object* type is a generic container, which is stored as-is on the database. In addition to the type-specific fields each object contains an *object ID*, which should be provided by the object creator, such as the user or the back-end. If the ID is missing, it will be generated automatically – internally, a separate ID is also generated for each object, to preserve ID uniqueness. A single object can be associated with multiple images, in which case modifications to a single image can be reflected to other images. Upon submitting a new object, the submitter is also recorded on the database, and by using the submitter ID (user identifier, or back-end identifier) and the *object ID*, it is possible to update pre-existing objects. This enables the user to update his/her own objects, and the back-ends to update their earlier results. Any object creator can modify only objects it has created itself, with some exceptions; the user can

always modify objects that are associated with his/her content whether they were originally created by him/her or the automated extraction process; and back-ends can never overwrite object information explicitly modified by a user whether the object was originally created by the back-end or not. There is a possibility that a back-end might later on provide results that would be better than those the user had originally accepted, but allowing the back-end to override the user's modifications generates various usability issues. The "correctness" of a result can be strongly related to a particular user, and making an automatic foolproof estimation of improvement can be very difficult. It could be argued that the user would be more willing to preserve his/her own modifications, even if they are – relatively speaking – worse, as opposed to the idea of an automatic system repeatedly updating his/her content. If the updates happen *very* rarely, they could be confirmed manually by the user.

3.2 Feedback Tasks

The *feedback* task is often "indirectly" created by the user. Certain operations, such as changing the image description, or updating a pre-existing object can trigger the creation of a feedback task. The purpose of the *feedback* task is both to provide the back-ends with statistical information about how the users use their objects, and to enable self-learning functionality in the back-ends. If the back-ends cache information about previously analyzed images and the objects they have created, the feedback information can, in principle, be used to enhance future analysis results or point out mistakes in previous results. As the *Task Finished* may be called at any time in the future as long as the task is valid, the back-end may update its previous analysis results based on the feedback. At the very least, the information should help the back-ends to discover results that are repeatedly incorrect, or do not generally match the users' perception. If the *feedback* task also contains user details, the feedback can be targeted to a specific user, and it could affect the future analysis results of that particular user.

4 SUMMARY AND FUTURE WORK

This paper briefly presented the basic operating principles of a task-based content analysis system. The system is one solution for improving the management of a huge amount of digital data, in this case, images. The full documentation for the system, including the proposed protocol specification, is to be published as the research project (D2I) progresses. In addition to improving the basic system, research is ongoing into methods for collecting user feedback. For long-term research, there are also plans for extending the system to implement audio and video capabilities.

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CHALLENGES OF PERSONAL DATA PROTECTION IN RE-USE OF PUBLIC SECTOR INFORMATION

József Györkös, Gorazd Meško**, Klemen Lukman*, Katja Eman***
*Faculty of Electrical Engineering and Computer Science
**Faculty of Criminal Justice and Security
University of Maribor
Smetanova 17, 2000 Maribor, Slovenia
Tel: +386 2 220 7351
e-mail: jozsef.gyorkos@um.si

ABSTRACT

The re-use of public sector information is frequently treated as a novelty in software development, however efforts to re-usepublic sector information have been in place for over a decade. The icreased demand for such information can be attributed to legislation that enables appropriate access, increased internet penetration resulting in user demand for transperancy within a democratic society and commercial exploitation of data made available by public institutions. Majority of public sector information is anonymized nonetheless the re-use related processing of data could lead to the situation where anonymity is challenged. In this paper presentation/visualization of already mapped criminal acts serves as acase study of how personal data can potentially be exposed thorugh public sector information re-use.

1 INTRODUCTION: POSITIONING THE PUBLIC SECTOR INFORMATION

European Directive on the re-use of public sector information (PSI) came into force at the end of 2003 [1]. The directive provides a common legislative framework to previously unregulated European public sector information market. The directive is built on transparency and fair competition pillars of the EU policy. Tracing the history of making PSI available for re-use goes back to late nineties when the European Commission presented the green paper titled Public Sector information: A Key Resource for Europe [2]. To better contextualizethese efforts one should visualize the state of Internet penetration and user structure at the time the document was produced. One of the key observations of the green paper was on endangered competitiveness of the European industry when PSI is not treated properly as an asset for commercial efforts: "In this respect, EU companies are at a serious competitive disadvantage compared to their American counterparts, which benefit from a highly developed, efficient public information system at all levels of the administration." [Ibid.]. Issues addressed are e.g. conditions for access, pricing, copyright, privacy and liability. In annexes current situation regarding legislation and policy on access to public sector information in Member States is compared to the current legal framework in the USA. Five years - from 1998 to 2003 when the European Directive came into force - is quite a long period but just in time with almost omnipresence of internet and emergence of mobile platforms. National implementations followed immediately or even in parallel as in case of Slovenia where the legislation was adopted as early as March 2003 (Access to the Public Information Act [3]).

The legal background usually regulates existing ad-hoc market practices or sets the rationale for emerging technologies. In case of PSI both information providers and information (re)users have to adapt to new opportunities and challenges. The early period of making PSI available is marked by individual queries about public institutions or individual public power holders.

Almost fifteen years after the green paper on PSI the European Commission made available the "Vickery Study" [4] reaffirming most of the expectations noted in the green paper [2]. In this study a brief attention is given also to the categories of information that could be treated as PSI: scientific information and research data, public sector information held by cultural establishments and products of public broadcasting.

Assesment of succeeding the implementation of the directive [1] by EU member countries (MC) is made within European PSI Scoreboard [5] published by European Public Sector Information Platform (EPSI). Methodological background of EPSI ranking of the MC of EP is built on seven aspects: (1) implementation of the PSI Directive, (2) practice of re-use, (3) formats, (4) pricing, (5) exclusive arrangements, (6) local PSI, (7) events and activities. Aspects are followed by specific indicators [Ibid.].

Due to the early implementation of PSI directive and pioneering role in the region it might be surprising that the position of Slovenia in PSI scoreboard is extremely low. Slovenia is ranked in the group of countries with lowest PSI score. In aggregated score, zero points are gained for

PSI on local data, on events and activities, formats and exclusive arrangements in delivering PSI. Even we can argue with zero-point-status, it is evident, that existing initiatives are rarely systematic and/or part of the wider national PSI strategy. The Krimistat.si case study presented in this article could contribute to enhance PSI re-use challenges and partly influence the deficiencies noted by EPSI scoreboard.

2 THE PILOT: VISUALISATION OF CRIMINAL ACTS DATA

Crime mapping is the analysis and presentation of data on crime and public disorder by using Geographic Information Systems (GIS) as a component part of crime analysis [6]. In the pilot we are dealing with visual and statistical presentation based on PSI obtained by Police (General Police Directorate at the Ministry of Interior of Republic of Slovenia). The time period is limited for criminal acts from 2008 to 2012.

Visualization of data based on public sector information is also part of curricula at the Faculty of Electrical Engineering and Computer Science within Media Communication and Informatics postgraduate courses. The pilot was designed within these courses, where after introduction of basic concepts of PSI and its potentials students are requested to "invent" use-cases of PSI re-use where added value is required. The added value is not interpreted solely as an economic category but also as a means of better transparency of public institutions or increased level of information based public services. The pilot is according to its domain conceptualized and developed in cooperation with Faculty of Criminal Justice and Security at the same university.

2.1 Krimistat.si – crime sites and crime category visualization tool

Crime mapping as a public service is well known worldwide, however it is specific to different legislative backgrounds [6]. Primarily Krimistat.si was aimed for public use and not for the purpose of policing and criminal investigation. The personal data protection related decision of the Information Commissioner of Republic of Slovenia (described third chapter below) led us to the twofold approach in further development of the pilot: (a) the limited web-based software product Krimistat.si can serve both as a public awareness information service and (b) the full version can serve as a tool for police work. The difference in visualization are presented at *Figure 2*.

The *idea* of Krimistat.si was based on the next premises: *first*, reuse of public sector information principles should be fully applied, *second*, personal data must be protected thus just anonymized data should be used and finally the *third*, there are use-cases in reuse of PSI with anonymized personal data where anonymity becomes jeopardized.

Additionally, to the applicative value of the pilot we defined two intriguing research aspects: *first* is an open technology platform from the user aspect (no proprietary GIS system is needed) and *second*, aspects of personal data protection should be carefully examined.

The process of studying outturns of data visualization consisted of the following seven steps (*Figure 1*): (1) definition of the PSI re-use project, (2) obtaining an anonymized database (PSI) on criminal acts for the period 2008-2012 from the General Police Directorate of Republic of Slovenia, (3) development of a data-visualization and statistical analysis web-oriented open platform software, (4) testing and studying the effects of the use of visualized data from the aspect of accuracy, user-experience and personal data protection, (5) consulting the Information Commissioner on personal data related observations, (6) audience differentiation with respect to the advise of Information Commissioner, (7) further applications and research.

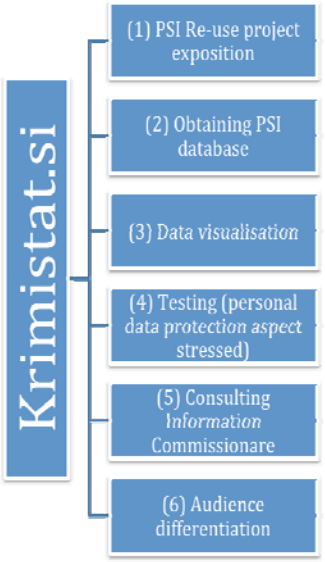


Figure 1: *Seven steps of studying outturns of PSI on criminal acts.*

2.2 Implementation Platforms

The software runs on Apache 2.0 web server with widely-used combination of SQL database and PHP general-purpose scripting language. JavaScript is used for the client. The system is integrated with Google Maps using the appropriate APIs that builds the ultimate visualized user experience. By implememntation main problems appeared in converting geo-locations from legacy database system (World Geodetic System (WGS 84 - longlat projection (EPSG:4326), MGI/Slovene National Grid (EPSG:2170)-Transverse Mercator projection) to the target format (Google Maps API based) that had to be developed for Krimistat.si. The database structure consists of criminal act records (374,491 in the observed time period) and of related

official standardized classification of criminal activities and of regional geospatial data of Slovenia.

Following the decision of the Information Commissioner (chapter 3) the need for abstraction of visual data lead us to the implementation of dynamic radius (100 to 1000 meters). We find this detail important in technical implementation context because of needed optimization. The relatively intuitive SQL query for identifying criminal act spots in radius (%s) is as follows:

*SELECT address, name, lat, lng, (3959 *os(radians('%s')) * cos(radians(lat)) * cos(radians(lng) - radians('%s')) + sin(radians acos(c('%s')) * sin(radians(lat)))) AS distance FROM markers HAVING distance < '%s'*

where haversine formula is used for distance calculation between two points on a sphere from their latitudes and longitudes. (%s is radius). The optimized SQL query is based on local (precalculated and saved in local database table) and thus less time-demanding calculation (calculate only dynamic data - user input (lat and lng from current searching point) - static data (mentioned before) are just inserted from local database) of coordinates (cos_rad_lat, rad_lng in sin_rad_lat):

SELECT (3959 * acos(cos(radians('%s')) * cos_rad_lat * cos(rad_lng - radians('%s')) + sin(radians('%s')) * sin_rad_lat)) AS distance FROM criminal_act HAVING distance < '.

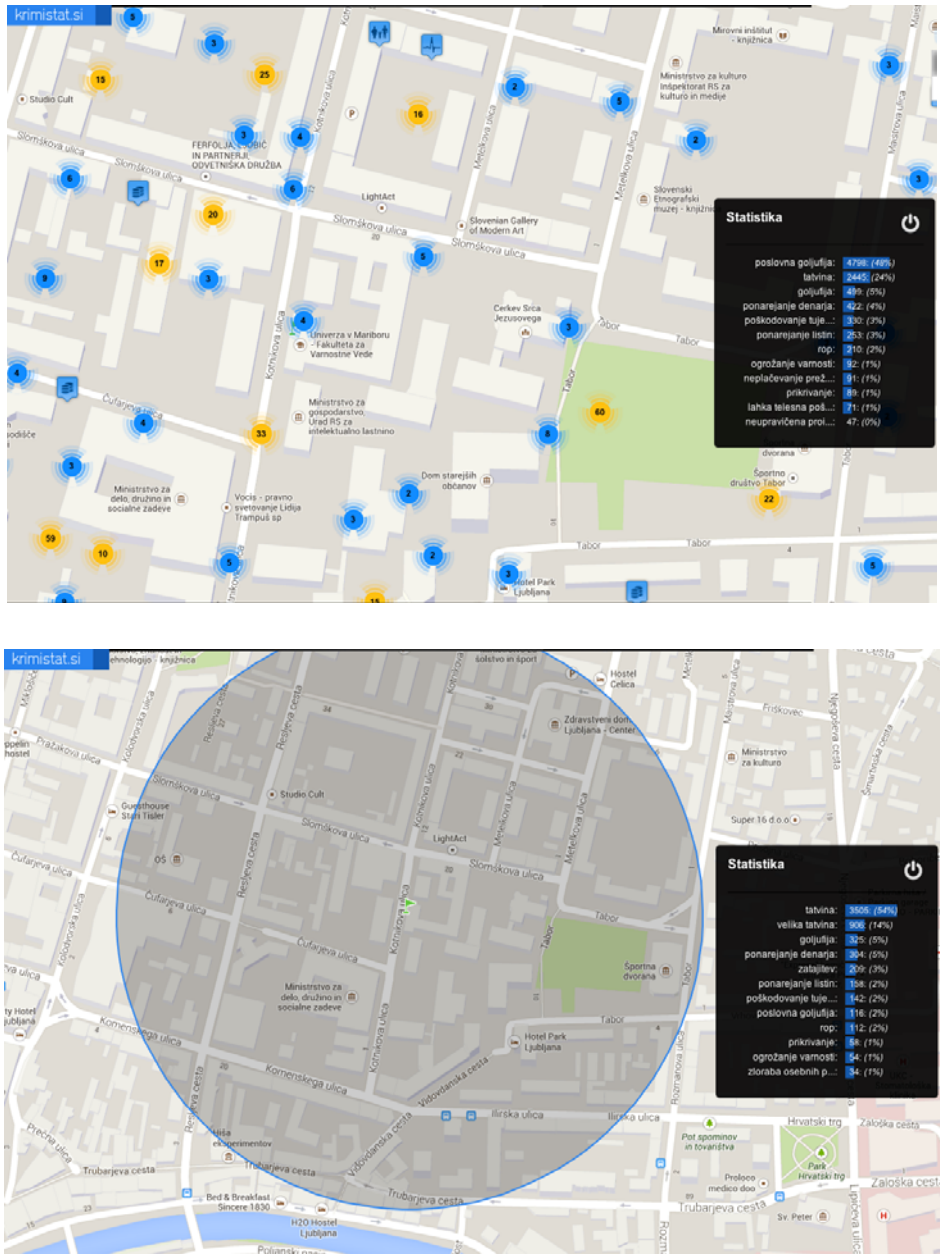


Figure 2: Visualization sample for the same geo-location: the full (above) and the limited version (below) of Krimistat.si. (the black box on the right (in Slovene) shows the statistical aspect of visualized data)

3 PERSONAL DATA PROTECTION CHALLENGES

The current legislation on PSI fully follows the provision 11 of DIRECTIVE 2013/37/EU (amendment to already mentioned Directive 2003/98/EC): "*Directive should be implemented and applied in full compliance with the principles relating to the protection of personal data*". According to the implementation in national law the obtained database on criminal acts was fully anonymized, however in the process of data visualization we faced the effect of de-anonymization of some data. Few cases showed a possibility to easily rebuild personal data using other publicly available databases (e.g. public phonebook) or simply by knowing the local terrain. This effect is emphasized in rural areas with low-density settlements and at crime committed in individual houses (imaginary e.g. at known location, denoted by street and number in city of Maribor violence in family criminal act was processed; the name of the family living there can easily be found in the phonebook). As the source data deals with announced and processed criminal activities without any information on further processing of these acts, in some cases derived information can be discriminatory.

These observations lead us to formulate the letter to the Information Commissioner (ICRS) of Republic of Slovenia with competences on personal data protection and access to information. One of the activities of the ICRS is also issuing and publishing *non-obligatory opinions, explanations, positions and recommendations with regard to personal data protection*. The letter to the ICRS was based on observations and concerns about wide public use of the Krimistat.si system as follows: (1) the Krimistat.si is based on anonymized database containing more than 300.000 records in anonymized flat-table data on criminal activities in Slovenia in the period from 2008 to 2012, (2) when geo-location data points to the individual houses the possibility of discovering the identity of individuals involved is significant, (3) the status of criminal acts further police and/or juridical processing is not known, discriminatory interpretation can not be excluded, (4) for public use criminal acts should be shown in an aggregated group of prescribed radius, e.g. 500 meter (our recommendation), (5) From the aspect of PSI re-use, information processing and visualization we have sympathy to keep the system as it is, however we feel obliged to eventual non-obligatory opinion of the ICRS, (6) Since we expect that Krimistat.si case is the first one addressed to the ICRS we hope that it will serve as a use-case.

When concerns on personal data protection were noted, the access to the Krimistat.si was limited but it was made available to the ICRS office. They replied promptly with confirmation to our concerns. The ICRS in his/her reply stressed as follows: concerns regarding economization of personal data are valid and the proposed view of the aggregated group of criminal acts in prescribed radius ICRS has concerns on radius itself that could be appropriate for urban area but less for rural one.

In the explanation ICRS references the Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data uses recital 26, where "principles of protection must apply to any information concerning an identified or identifiable person; whereas, to determine whether a person is identifiable, account should be taken of all the means likely reasonably to be used either by the controller or by any other person to identify the said person". According to the current discussions on the reform of data protection [7], basic principles will be kept or even more, the 'right to be forgotten' principle is added. How it can be implemented in indirect personal data use is not just a significant juridical but also information processing related question.

4 CONCLUSIONS

Krimistat.si is an academic pilot that follows the concepts under the term of re-use of public sector information. The evident dichotomy of available legislation and its pour facilitation in business solutions are addressd. Personal data protection is treated with specific attention and consequently the critical concerns on limited user experience are presented. The project generated a list of recommendations for providers of public sector information including guidence on data structure, on-line availability, error reporting and validation of proper use of personal data.

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A CONTENT BASED TOOL FOR SEARCHING, CONNECTING AND COMBINING DIGITAL INFORMATION – CASE: SMART PHOTO SERVICE

Pekka Sillberg, Petri Rantanen, Jari Soini
Department of Software Engineering
Tampere University of Technology - Pori
P.O.Box 300, FIN-28101 Pori, Finland
Tel: +358 40 8262890; fax: +358 2 6272727
e-mail: jari.o.soini@tut.fi

ABSTRACT

The amount of electronically stored and unclassified data is growing continuously, resulting in the need to find smart ways to manage all this data. This paper presents a smart photo service system developed for digital data management. The system enables users to search and access digitally stored photos in various ways and also offers the possibility to teach the system to offer more accurate search results. This paper focuses on the system's features, its user interface and use in practice and also gives some observations made during preliminary testing. This approach has great potential for enhancing digital data management and partly solving the issues related to information overload.

1 INTRODUCTION

This paper introduces the main features of a prototype system called "Smart Photo Service," and more specifically, the web user interface implemented with HTML5. The goal of this system is to provide a unified front-end system for automatic photo tagging and metadata extraction by utilization of multiple analysis back-ends. The use of multiple, different analysis back-ends gives results from the aspect of each back-end and as a whole may produce more accurate analysis results when combined together. It can also serve as a load-balancing feature as one back-end does not have to do everything by itself. User generated content (i.e. photos) can be stored on any third party storage system, while the front-end stores and indexes the metadata (extracted by the back-ends) of the content. The front-end can then use the collected metadata to provide certain functionalities such as searching among the user's photos as has been done in the case of the web user interface.

The system enables the user to browse all of his or her photos from different content storages, such as Picasa [1] and Flickr [2]. All of the user's content storage accounts can be connected and merged under a single service. Furthermore, the system can delegate various tasks to back-end systems, which can extract metadata from the user's photos. The tasks can contain requests to analyze photos, search for similar photos, or contain feedback for the back-end. The extracted metadata may consist of tags (or keywords), face recognition data, or spatiotemporal information.

To improve the analysis results, the relevance of user feedback plays a key role [9, 10]. Getting this feedback may require solutions such as intelligently adapting user interfaces [11] or user interfaces that can be updated dynamically [12]. The feedback for teaching the back-ends can be generated either by direct user feedback [3, 4] or collected (implicitly) based on the user's actions [5, 6, 7, 8].

The main focus of this paper is on the web user interface of the prototype. While it can be used on a typical desktop computer or a mobile phone, it was actually designed for tablet devices with touch screens. The bigger screens in tablets compared to mobile phones allow a more relaxed screen layout and the touch input allows different types of gestures and hand drawing abilities that are usually not available in desktop computers. The user interface has been used in a concept study, where a small group of students tested the main features. This study was aimed to gather feedback, new ideas and to gain a better understanding of the needs and expectations of real-world users. The prototype presented in this paper is based on the ongoing wide-ranging research project (2012-2016) From Data to Intelligence (D2I) [13] funded by the Finnish Funding Agency for Technology and Innovation (Tekes) [14, 15], in which researchers from the Tampere University of Technology Pori Unit (TUT) are involved.

2 OVERVIEW OF FEATURES

The following four features of the Smart Photo Service's web user interface are introduced:

- Browsing photo albums (Figure 1).
- Searching by content similarity and tags (Figures 1 and 2).
- Automatic tag generation using analysis back-ends (Figures 2 and 3).
- User feedback for generated tags and search results (Figures 1 and 3).

Browsing photos and searching by content similarity are illustrated in Figure 1. In this case, the photo at the top left

is the reference that the user wanted to use to search for similar photos. The rest of the photos are the similarity search results from the back-ends. Should there be more than eight results, the remaining photos are spread across as many pages as required. There are also thumb up/down buttons over every result photo. These are for sending feedback of the accuracy of the similarity search. The magnifying glass icon in the top left corner opens a search overlay, where the user may search using free text input, or by using keywords which appear in the photos. The basic view, photo album browsing, is similar to the view seen in Figure 1, but there would not be feedback buttons and no reference photo. Any photo can be used in the similarity search by content by simply long-clicking the photo. A new similarity search can be performed again from the results of the previous search. The search history is stored and the user can go back to the previous view or search result by pressing the *Back* button in the top left corner.

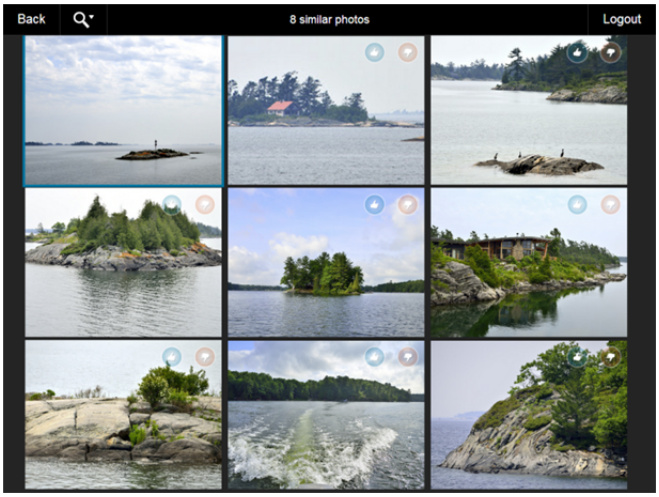


Figure 1: *Application screenshot: Results of similarity search.*

Figure 2 shows a screenshot of a full screen photo view with a search overlay. On the search overlay, the left column (*People in this photo*) lists persons automatically detected by the back-ends and manually added by the user. It is possible to modify, add, and remove tags in the photo edit mode, which is described in more detail later on. The right column (*Tags in this photo*) of Figure 2 lists the keywords in a similar manner to the persons in the left column. The center section, *Search Options*, contains the active settings for the current search activity. Here the user may select any number of tags or persons from the side columns to be included in the search. In this case, the tag *landscape* is selected for the search. The user may also add a new keyword by typing it into the input field.

The tags (see Figure 2) *animal*, *outdoor*, *sky*, and the selected tag *landscape*, have been detected from this photo by the analysis back-ends. Internally, the system may have recognized more tags, but because of a low confidence value, these tags are not shown to the user in the search view. This is to prevent the user interface from filling up with a high number of poorly matching keywords and gives more accurate results when the user is searching by tags. Detected tags (even those with low confidence values) are never removed automatically so the user may revise them by using the edit mode. In the edit mode, the keywords with a lower confidence value are listed as suggested tags (see Figure 3).

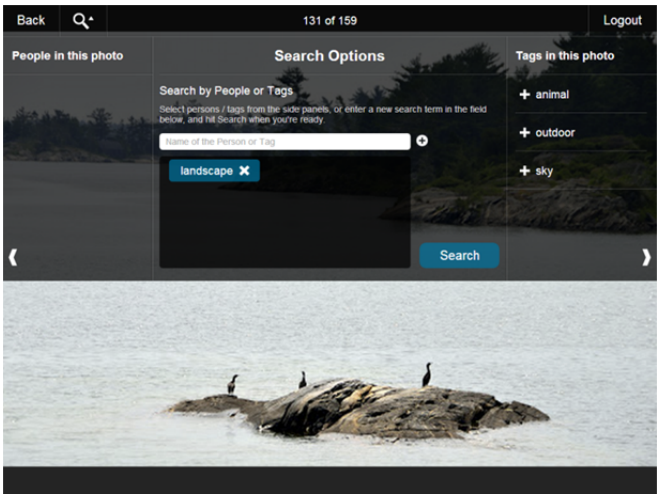


Figure 2: *Application screenshot: Full screen photo view and overlay with search and related tags.*

A screenshot of the edit mode is shown in Figure 3. The general layout is similar to the search overlay seen in Figure 2; persons are in the left column, tags in the right column and the center section contains the preview of the photo. The photo is contained in a HTML5 canvas element, which enables the user to modify the photo. For example, the user can add a new (person) marker by drawing a circle in the appropriate location and typing in a name for the marker. This is demonstrated in Figure 3, where the user has drawn a circle around a waterfowl and typed a descriptive name, *A Duck*, into the input field. By pressing the *Done* button located in the top right corner of the edit view, the changes will be sent to the server. The user may add as many persons or tags as desired, before submitting the modifications.

Tags in the upper section of the right column (*Tags in This Photo*) are the same tags as seen in Figure 2. The listing contains tags which have been manually added by the user, or automatically extracted by the system and contain a high enough confidence value. The listings have a maximum of four visible keyword elements. When there are more than four elements in the list, the list appears as a scrollable area, which allows the user to check the remaining elements.

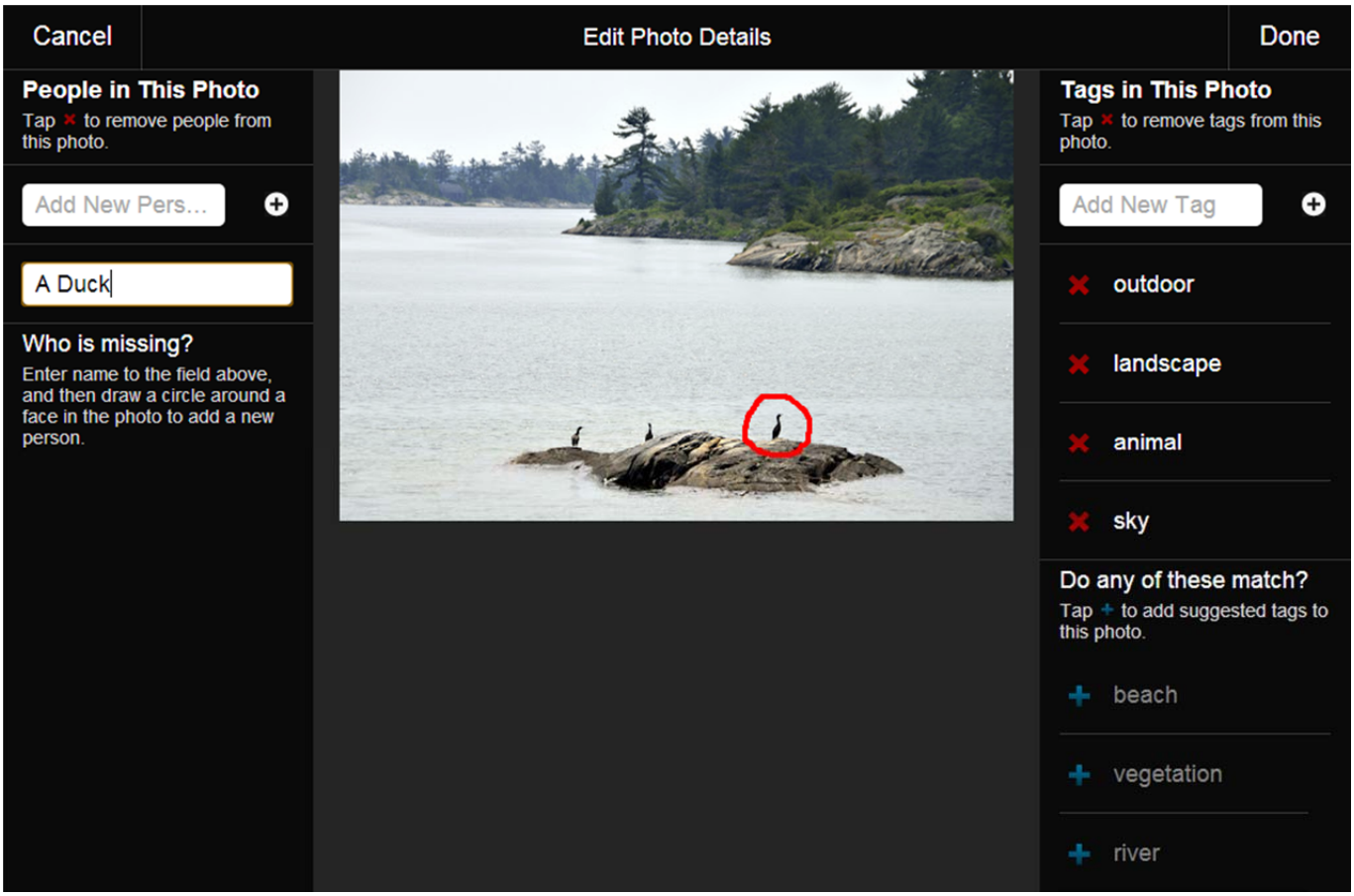


Figure 3: *Application screenshot: Edit photo details.*

The lower listing (*Do any of these match?*) contains tags (*beach*, *vegetation*, *river*) with a confidence value below the predefined threshold, and these tags are offered as suggestions. From the analysis perspective, the tags only present features detected in the photo, and thus, may or may not be *relevant* for the user. For example, the tag *water* would be a perfect match for the photo shown in Figure 3, but the user may feel that the tag has no special meaning for him/her, and decide that the tag is irrelevant despite the high confidence value of the tag.

Any suggested tag can be added to the photo by pressing the "+" button, while any tag associated to the photo can be removed by pressing the "x" button. Upon addition the tag will be removed from the lower list, and inserted in the upper list. The tag names can be edited by clicking the text of the tag. For example, the user wants to give the tag a more appropriate name. If the edited tag was generated by any of the back-ends, the modifications will be delivered to them as a feedback of the analysis results. As with the *Tags in This Photo* list, the suggestion list can also be scrolled if more than four tags are available. In practice, the quality of the tags (confidence value) often starts to decline rapidly after the first ten or so tag suggestions. This means that the user will not usually "need" to scroll down the list. The (imaginary) confidence value threshold, which programmatically divides the tags between the upper (actual) tag list and the suggestions, is strongly linked to the back-ends used and an exact value is very hard, if not impossible, to define. In our use cases, the value has been decided (and adjusted) based on trial-and-error testing and user feedback.

3 DISCUSSION

The discussion section is based on the preliminary results of the concept study, and the full results will be published later on by the respective D2I program member. The introduced prototype system was tested on a group of students who gave some interesting insights into the current state-of-the-art tablet applications and to user expectations. Fourteen test users participated in the concept study which included pre-test and post-test interviews and nine test tasks. The test sessions were also recorded by using a video recorder.

Even though the application was introduced as a concept study and on-going work, the expectations of the users were very high. The most highly valued asset of the application was the fluency of the user interface. They wanted it to be playful and fun to use, i.e. guiding the user by giving visual clues and being forgiving should the user make a mistake. They thought that the user interface should also be highly responsive and accept interactive gestures such as dragging, dropping, swiping and tapping. The users also expected to have multi-finger gestures available. Social media has also come to stay, as integration of common social media

features such as sharing with friends were requested. Sharing by e-mail was also suggested.

Many of the users used their memory and browsing for locating the desired photos, but (in principle) understood the usefulness of tagging the photos for as it would make search feature more accurate. Some users felt that the search functionalities in photo content services did not work as well as they expected, and thus, did not feel confident about the usefulness of tagging. In general, organizing, renaming, deleting duplicates and tagging were considered to be daunting and time-consuming tasks.

The further development of the web user interface will most likely be on hold as it has fulfilled its purpose during the concept study, but the suggestions and the ideas will be taken into consideration in the development of new applications and/or products by the D2I program community. A research on how to utilize user's own social media content as a keyword source and context evaluation has been started. The goal of this study is to find more accurate and better matches of tags generated by the system.

4 SUMMARY

This paper deals with issues related to data management. In the ongoing D2I research project, methods and tools will be studied and developed for the management, processing, and utilization of data captured from different sources. This paper focused on images and briefly introduced the Smart Photo Service prototype system developed during the project, from the user interface point of view. The prototype system was used in a concept study on a small group of students in order to gather feedback, new ideas and to gain a better understanding of the needs and expectations of users. The key findings of the study were that the users wanted the user interface to be very fluent and fun to use. The results of this research are going to be utilized in future applications made in the D2I program.

Acknowledgements

We would like to express our gratitude to the D2I program community members for their comments and feedback. The user study carried out by the Aalto University's user experience team provided valuable information about the feasibility of the prototype system.

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GREEN ICT
Pilot project and process for sustainable ICT solution trials by SMEs

Jari Leppäniemi, Julius Soini, Jari Soini
Tampere University of Technology, Pori Unit
Pohjoisranta 11 A, 28100 Pori, Finland
e-mail: jari.leppaniemi@tut.fi, jari.o.soini@tut.fi

ABSTRACT

A research project for seeking feedback and experience by piloting ICT solutions for a sustainable business environment was established in January 2012 in the Satakunta region in Finland. In this paper we present the participants and main goals of the project, the process for developing the technology pilots, and the main findings of the pre-study. We also provide examples of how collaborative work with different parties based on the Delphi method and close relationships with SMEs can provide a lot of information related to attitudes toward sustainability by using Green ICT.

Keywords: Green ICT, Service industry, Sustainability, Delphi method

1 INTRODUCTION

Sustainable development and environmental assets are becoming a significant market factor internationally. Green and eco-friendly products and services are multiplying rapidly, which is why this kind of business attracts investors all around the world. Briefly, Green ICT means the usage of information and communication technology in order to advance sustainable development [1,2,3,4]. According to Murugesan [1] - which is a good discussion for the topic - few years ago the term "Green ICT" was commonly used for improvements in energy efficiency, material usage and disposal [1]. Power management, virtualization and data center solutions, reuse, recycling and refurbishing are still valid actions towards sustainability. However, there are also other options for available and these "Green ICT 2.0" (or sometimes "Green by ICT") type solutions are the main focus of our project. Green ICT is especially intriguing also due to the fact that it enables eco-efficiency in almost every field of business. ICT can accelerate or enable eco-efficiency for example in transport, business trips and teleworking, dematerialization of traditional commodities, industrial processes, energy solutions for buildings and measurement of energy consumption.

Satakunta is the most industrialized region of Finland and therefore relatively one of the biggest consumers of electrical energy in the country. For this reason, the thematic based on green ICT is of great interest in the region and an extremely relevant and auspicious research subject and target for development. In the field of ICT, the concept of Green computing can also be analyzed by means of bipartition, in which one part focuses on phenomenon on small scale (in-small), and the other widely on processes and fundamentals of operations in various business domains (in-large). Some examples of that were mentioned in the first section. Approaches and technologies involving the "in-small" concept are, for example computer architectures with minor consumption of electrical energy (for example, solutions for ICT devices), software solutions minimizing consumption of electrical energy and energy extraction, in other words, technologies that can capture and further utilize small amounts of energy.

The phenomenon can be concretized, for instance, by summarizing the research of Soininen [4]. As a starting point, it is assumed that the demand for energy brought about by information technology in general is strongly increasing. One of the most notable sources of this demand is the inevitable growing supply of online services (for example, Web servers, cloud servers and server hotels). Issues associated with the energy consumption of server halls are also covered in Soininen [4].

2 PRE-STUDY

A pre-study was organized in collaboration between TUT Pori Department and Prizztech Oy, a regional development organization. The idea of the collaboration was to find out Green ICT possibilities in Satakunta in a feasibility study, which was carried out 1.1.2012 – 30.6.2012 and financed by public funds. A questionnaire was first carried out, concerning the affordability of ICT aimed at sustainable development. Fourteen enterprises were consulted based on the results of the survey. The questionnaire showed the interest of the enterprises regarding the subject: 42% of the respondents (12) expressed their interest in the Green ICT

development project. The content of the Green ICT in Satakunta (GICT) project is presented in this paper. The intention of the project is to tackle concrete practical actions with the help of such ICT-based pilots that are believed to provide the best cost-benefit and effectiveness from the point of view of sustainable development as well. The ultimate goal of the project is to support and develop the operational environment of small and medium-sized enterprises (SMEs) in Satakunta. The content of the project was defined in October 2012 to disseminate the opportunities based on Green ICT ideology and solutions developed in the pilots to potential beneficiaries in and beyond Satakunta.

The main ideas found during the pre-study (spring 2012) for green technology piloting were the following:

- Intelligent control and piloting of property solutions, including wireless solutions. These aim at cost-conscious and energy-efficient property management.
- Telecommuting solutions, which aim at reducing transport emissions and increasing work efficiency.
- Consumer electricity measurement solutions, which aim at energy-efficient living.
- RFID solutions that aim at developing efficiency of material flows in industry.
- Solutions related to the control of product or component life cycles.
- Optimization of mobile work, traffic and various modes of transportation.
- Cloud services that aim at optimization of data management, resulting in more efficient methods and energy conservation.
- Methods of energy extraction.
- Energy-efficient software and hardware solutions.

Methods of energy extraction and energy-efficient software solutions may also need some amount of advanced research as well as similarities regarding cloud services.

3 OBJECTIVES OF THE GREEN ICT PROJECT

The objective of the Green ICT project in Satakunta is to advance the innovation development of the region and the operational environment of enterprises through green ICT solutions that support sustainable development. The ongoing project is directed to two different groups of enterprises: 1) producers of technology, or suppliers of different solutions and 2) beneficiaries of technology, or in other words, corporate customers for the solutions.

The central idea of the project is to find 3-5 technology pilots utilizing green ICT (Figure 1). Each technology pilot includes many enterprises interested in the subject. The function of the pilots is to try and indicate the viability of green ICT and the opportunities it enables from the point of view of different fields of business. With these pilots, we believe it is possible to lower the threshold of enterprises to try new technology as safely and risk-free as possible because of the construction of a project consortium and the included expertise. Pilot concepts to be developed together with the operators participating in the project are sought in order to steer the measures toward subjects appropriate to the objectives of the project and guarantee their usability later on for other customer enterprises as well. In other words, the results, experiences, and designs are open. Only the core business figures are kept secret from the public. The nature of a technology pilot could be for example: improvement of a current solution or process, replacing an existing solution, or creating a totally new solution (a product, service or process).



Figure 1: *Main activities (Marketing – Exploration – Piloting and analysing) of the Green ICT project.*

In summary, the goals of the project can be subdivided into at least three groups:

1. The goal of supporting the deployment of green technology in the project is to:
   - pilot green technology solutions for sustainable development,
   - activate new enterprise-led R&D projects regarding green ICT.
2. The goal of developing the operational business environment of enterprises in Satakunta is to:
   - enhance business efficiency in enterprises,
   - gain new business for small and medium-sized enterprises in Satakunta,
   - gain information and experience of green ICT solutions,
   - gain references in implementing and delivering technology solutions.

3. The goal of the sounding out the opportunities of sustainable development technologies in Satakunta is to:
    - promote the opportunities, content and concepts of green ICT in the business sector of the region,
    - foster the innovation of various, commercially attractive sustainable development solutions.

Through these goals, this research project will contribute to the creation of new technology solutions for small and medium-sized enterprises in the Satakunta region in Finland. The project is funded by the City of Pori and the Centre for Economic Development, Transport and the Environment (ELY Centre) [5]. ELY Centres are responsible for the regional implementation and development tasks of the central Finnish government.

4 SELECTION PROCESS FOR THE TOPICS OF THE TECHNOLOGY PILOTS

The phases of the pilot projects form sequences. Since the phases of each pilot may have individual timing, the pilots are run more or less concurrently. With a written preliminary study and confidential discussions, the needs of the enterprises and possible ideas are mapped and adapted to pilot candidate posters in different ways. Next, by thorough preparation, a portion of the mapped pilot candidates are defined as technology pilots supporting the objectives of the project. The basic flow between activities will be as follows:

- Each technology idea is described by its potential benefits in different business domains in order to communicate and market the ideas to SMEs. These poster-type documents (i.e. these are ads describing one pilot candidate) can be updated during the project based on feedback and experiences.
- Potential customers evaluate these topics critically and give feedback in order to make them more valuable for their businesses. The web-based anonymous evaluation method is based on the Delphi method [6], which provides many options for gaining reliable information concerning customer preferences and the level of knowledge regarding the issues.
- The ideas are developed further based on the feedback.
- After that it is possible to prioritize the ideas using the selection tools provided by the E-Delfoi toolkit [7].

Once the ideas have been developed, the normal procedure is to organize a public competitive bidding for each technology pilot and run the pilots in order to get experiences and results for public reports. In each of the pilots, at least two enterprises/organizations and one or more suppliers are chosen to take part, depending on the technology and know-how package demanded by the pilot. Professional services required in the project will be bought from either public or private expert organizations based on competitive bidding. The leading principle is that the pilots chosen have as great a potential as possible from the point of view of the objectives of the project. Ideas left over from the pilots may be further researched and developed in later projects.

5 DISCUSSION

The Green ICT in Satakunta project will have immediate effects on development of the region's infrastructure of know-how regarding both the service structure and new ICT applications for the end users. When the technology pilots are put into action, new concepts of green ICT will gain publicity and coverage from various players within the region.

The project will increase business opportunities for the participating enterprises as well as potential for the creation of new information-intensive enterprises for the use of green ICT. New contacts and a nexus will be formed in the Green ICT in Satakunta project that are strongly associated with activation of new R&D projects.

By the introduction of green ICT solutions, we hope that the competitiveness and profitability of the economic life of the region will improve. Investments in technology solutions and standards [8] supporting the sustainable development of enterprises will increase, and their efficiency and competitiveness will improve. A nexus of experts will be formed in the region, familiarized with the development of end users' digital applications and the realization of service processes. The interest of international enterprises in establishing subsidiaries in Satakunta will grow based on the technological special know-how at hand and newly generated infrastructure.

Various technology development projects - or at least ideas for them - will arise as a result of the GICT in Satakunta project. In these projects, many new products and test runs of the products will take place and know-how in implementing green ICT solutions in Satakunta will develop significantly.

6 SUMMARY

Based on the findings of a pre-study, a research project was started in order to advance the utilization of ICT for sustainable solutions in the Satakunta region of Finland. Through the collaboration of the organizations participating in the development of businesses' operational environment, innovations based on green ICT are being generated, new development ideas are being actively searched for in regional enterprises and academic institutions, and the commercialization of ideas as a profitable business is being emphasized. The intended benefits of the project can be summarized as follows:

1. Benefits for the users of the technology: by means of technology pilots, enterprises will gain an overview of new solutions in green ICT and, taking advantage of

this information, will be able to develop their business and make suitable investments.

2. Benefits for the producers of the technology: the enterprises implementing the technology piloting will be invited to tender for the project and be able to run trials of green ICT with real clients. This may lead to a more vital service industry in the region.
3. Benefits in general: green thinking will expand and new technological product development of green thinking will be activated.
4. Enterprises situated in Satakunta have a significant opportunity to emerge in a positive light as illustrations of sustainable development and, especially, as users of green ICT.

The ultimate goal of the project is to gain practical experience by utilizing the concept of a technology pilot as a tool for promoting new ideas for the business environment and the local ITC service industry. The usage of the Delphi method as a tool for both project management and for pilot topic development would seem to open new possibilities in private/ public sector collaboration.

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CroSS: Croatian Speech Synthesizer - design and implementation

Ivan Dunđer
Department of Information and Communication Sciences
Faculty of Humanities and Social Sciences, University of Zagreb
Ivana Lučića 3, 10000 Zagreb, Croatia
Tel: +385 1 600 2350; Fax: +385 1 600 2431
e-mail: ivandunder@gmail.com

ABSTRACT

CroSS, i.e. Croatian Speech Synthesizer is a text-to-speech synthesizer based on formant synthesis. Capable of producing Croatian speech from corresponding text input, CroSS aims for easier communication and accessibility for people with voice disorders, language impairments, reading disabilities and for Computer-assisted language learning. This paper discusses implemented features and design, but also emphasizes speech synthesis difficulties for Croatian language.

1 INTRODUCTION

Speech synthesis is the artificial production of human speech while text-to-speech synthesis represents the process of generating artificial speech based on corresponding text input (Aida-Zade, Ardil and Sharifova, 2010).
Applications of such systems are significant and widespread. Speech synthesis can be used for learning new languages or embedded in a vast range of devices. Especially useful for people with speech and language disorders, text-to-speech systems allow them to communicate and therefore integrate into everyday life.
Speech synthesis systems today exist for widely spoken languages with continuous research to improve quality of produced speech while for less spoken languages they are less developed. Only a few text-to-speech systems were developed for Croatian, but the lack of their user-friendliness and high degree of complexity resulted in creating a new tool – CroSS, i.e. **Cro**atian **S**peech **S**ynthesizer.
It is based on formant synthesis and besides being an assistive technology tool CroSS tends to be applied outside the disability market.

2 FORMANT SPEECH SYNTHESIS PARADIGM

Formant speech synthesis is based on the rules which describe the resonant frequencies of the vocal tract (Pobar, Martinčić-Ipšić, Ipšić, 2008). This speech synthesis paradigm approximates the frequency characteristic of human speech with several frequency-domain peaks, called formants, which play an important role in the human perception of phonemes. Formants represent the energy in speech signal spectra and are concentrated in certain frequency bands. They are caused by resonances in the vocal tract, and the frequencies and bandwidths of these resonances depend on the shape of the vocal tract (Dutoit, 1997). Such resonances, in conjunction with the voiced and unvoiced excitation signals define the particular sound being produced and allow humans to distinguish between the various possible speech sounds. Formant synthesis does not use prerecorded human speech samples at runtime. Instead, the speech output is created using an acoustic model where parameters such as fundamental frequency (F0) and voicing are varied over time to create a waveform of artificial speech. This is called Source-filter model of speech production, where speech is modelled by parameters of the filter model (Styger and Keller, 1994). It is set to formant frequencies of the human vocal tract corresponding to the desired sound. Formant synthesizers usually produce artificial and robotic sounding utterances, since it is difficult to estimate the vocal tract model and necessary parameters with a small number of formants. This is also because the synthesizer is not able to produce antiresonance characteristics (Taylor, 2009) with appropriate data to control them. Generally, the first three formants (F1, F2 and F3) can be identified without much difficulty, but the higher formants are not always as easily discerned. It should be possible to improve the speech quality with a large number of resonances. However, analyzing and controlling the resonance parameters for achieving various types of articulation and coarticulation becomes very complicated. In general, the synthetic speech sounds smooth since the variation of the formant frequencies is also driven by rules, which are determined using physical constraints.

3 TECHNICAL SPECIFICATION OF CROSS

CroSS is a Microsoft Windows desktop application written in C++. It was built using Microsoft Visual Studio 2012 and

requires Visual C++ Redistributable for Visual Studio 2012 Update 1 and Microsoft .NET Framework 4 or higher to be run. It has been successfully tested on Microsoft Windows 8 (x64) and Microsoft Windows 7 (x64). CroSS installer weights less than 2.7 MB and installs CroSS 1.1. alpha and all necessary resources. CroSS is founded on eSpeak speech engine, which is a compact open source formant synthesizer and allows Croatian language to be provided in a small size (Duddington, 2006). The synthesized speech is clear and can be used at high speeds, but it is not as natural as larger synthesizers which are based on human speech recordings.

3.1 Graphical user interface of CroSS

The most important purposes of the Graphical user inter interface (GUI) is on the one hand to facilitate production of synthesized speech for Croatian language and to display distinct information, and on the other hand to ease speech manipulation.

The intuitive interface consists of text fields and simple buttons, which makes CroSS easy to use and accessible to people with disabilities or people interested in Computer-assisted language learning. CroSS is divided into two main parts: (A) and (B), both containing one text field (see Figure 1). Part (A) enables users to load already existing text into CroSS and to synthesize it. Part (B) allows users to create new content by typing text.

Button (1) will import already existing text and show it in the upper text field, button (2) will synthesize textual input and generate sound hearable on loudspeakers at the rate of 175 words per minute. Button (3) will open textual input in text editor and that can be useful to users looking for more features (e.g. searching, stripping embedded font type and style codes from formatted text, logging, character encoding etc.). Button (4) will save the speech output to a file in WAV format (1 channel, 22050 Hz), rather than producing speech on loudspeakers, while button (5) will open the directory containing the generated WAV file. Button (6) will save the newly created content from lower text field to a new text file in UTF-8 format. Group box (7) contains buttons for producing, saving and showing International Phonetic Alphabet (IPA) transcription of the textual input. Button (8) will increase pause between words. The two buttons, see (9), will increase and decrease output volume. Group box (10) contains three buttons: for indicating words which begin with capital letters using a click sound, for naming punctuation characters when they are encountered in the text and for whispering textual input. Bottommost buttons, see (11), will pop up dialog boxes showing information about author and application.

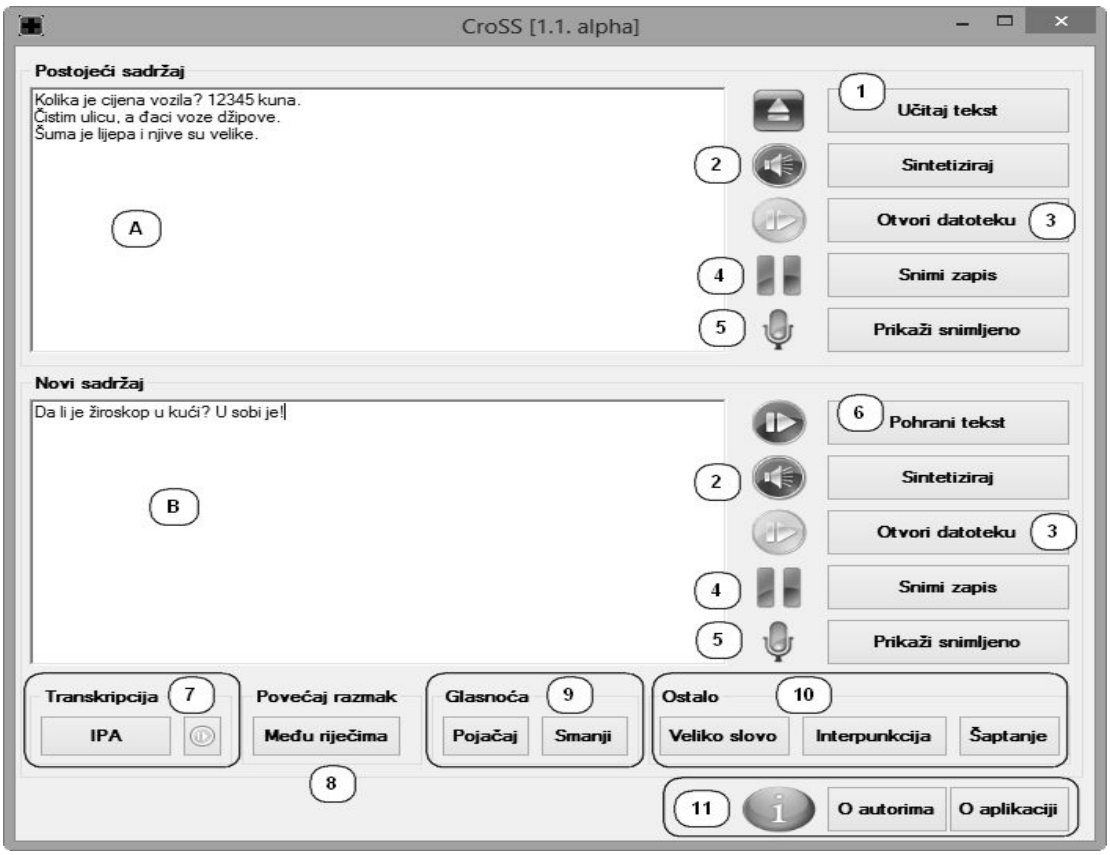


Figure 1: Overview of the Graphical user interface of CroSS.

3.2 Input preprocessing for speech synthesis

The process of synthesizing speech faces a lot of problems. One big issue is the need for input preprocessing and preparing text for speech synthesis, as the input is rarely structured, clean or unambiguous enough for this to happen directly (Reichel and Pfitzinger, 2006). CroSS requires manual preprocessing of textual input, thus this can be time-consuming (see Table 1).

Word classes	**Example**
Abbreviations	Dr. Marko: Doktor Marko Eng. "Doctor Marko"
	km: kilometar Eng. "kilometer"
	itd.: i tako dalje Eng. "etc."
Acronyms	Tk: Topografska karta Eng. "topographic map"
Cardinal numbers	12:52h: 12 sati i 52 minute Eng. "eight minutes to one"
Dates	2013.: dvijetisućetrinaeste Eng. "2013"
Decimal numbers	1,5: 1 i pol Eng. "one and a half"
Fractions	¾: tri četvrtine Eng. "three quarters"
Nominal numbers	PB 159: PB 1 5 9 Eng. "ZIP code 159"
Ordinal numbers	2.: drugi Eng. "2nd"
Roman numerals	I. svj. rat: Prvi svjetski rat Eng. "Word War I"
Special symbols	23.4€: 23 eura i 4 centa Eng. "23 euros and 4 cents"
	5^3: pet na treću Eng. "5 to the third power"
	b@d.com: b et d točka kom Eng. "b at d dot com"

Table 1: Types of preprocessing tasks and corresponding examples

In this stage the input text and punctuation marks are analyzed. E.g. handling ambiguous punctuation marks: full stops indicate the end of sentences (not spoken and no sound generated), but on the other hand, periods often appear in abbreviations or internet-related terms (spoken as "točka", Eng. "dot"). Other problems are how to pronounce digit strings, acronyms, mathematical and special symbols. Consequently, words need to be separated by spaces, while numbers, symbols, abbreviations, acronyms and other word classes are transformed into pronounceable and orthographic segments, i.e. full-textual form (Sasirekha and Chandra, 2012). Those transformations are highly language and context dependent, due to the fact that word classes are pronounced differently in different situations.

3.3 Output of CroSS

In a text-to-speech system like CroSS, the input is text and the output is synthesized speech. Each character is always pronounced following formant synthesis letter-to-sound rules, which will transfer graphemes to phonemes (Benoit, 1995).

CroSS considers punctuation characters in a sentence to produce appropriate prosody, such as pause at the comma, or a rising intonation on interrogative sentence. The goal of the implemented prosody feature is to create parameters for synthesis that will give the most natural output for a given sentence. These parameters include volume, pitch, pauses, speed and rhythm. In CroSS, volume and pauses between words can be adjusted manually. CroSS is able to produce phonetic transcription (IPA) of textual input, which can be very useful for linguists or in the process of Computer-assisted language learning. Additionally, CroSS can pronounce the following punctuation characters: , ("zarez", Eng. "comma") . ("točka", Eng. "full stop") ; ("točka zarez", Eng. "semicolon") ! ("uskličnik", Eng. "exclamation mark") ? ("upitnik", Eng. "question mark"). It is also possible to signalize capital letters using a click sound. An audio effect for whispering textual input is also implemented. Dealing with acronyms or abbreviations is in form of simply spelling letters or pronouncing it as a word, e.g. "ACL" is read /ˈatsˌəlˌə/ and "gdin" (Eng. "Mr.") is read /gdˈin/.

There is a slight difference in the phonetic transcription between pronouncing numbers written using numerical characters and numbers written textually. E.g. "598" is pronounced /pˈɛtstˈodˌɛvɛdˌɛsɛtˈosæm/, while "petsto deveset osam" (Eng. "five hundred ninety-eight) is pronounced /pˈɛtstodˌɛvɛdˌɛsɛtˌosæm/, i.e. syllables are being stressed differently.

In terms of naturalness, eSpeak still requires improvement in the stress placement on words (Azis et al., 2011). Decimal numbers are pronounced correctly; e.g. "5,98" is pronounced "pet zarez devedeset osam" (Eng. "five comma ninety-eight"). CroSS is also able to utter roman numbers, e.g. "III" for "3" is correctly synthesized as "rimsko tri" (Eng. "roman three"). CroSS automatically vocalizes numbers up to 99.999.999.999.999 (≈100 trillion).

4 FURTHER RESEARCH, DEVELOPMENT AND PLANNED IMPROVEMENTS

Evaluation is essential for further research and development. In order to assess adequacy and quality of the implemented speech synthesis system, experiments for testing usability, phonetic and semantic intelligibility in form of Mean opinion score test (MOS), Diagnostic rhyme test (DRT) and Semantically unpredictable sentences test (SUS) are to be conducted. To obtain the evaluator's view of the quality of the synthesized speech Mean opinion score test needs to be performed for a series of domains. Human listeners rate comprehensibility and correctness of pronunciation, appropriateness and suitability, intelligibility and naturalness of synthesized speech using Likert scale. Diagnostic rhyme test is appropriate for testing confusable phones, while

Semantically unpredictable sentences test evaluates sentences that are syntactically valid, but semantically meaningless. According to experimental results, parameters of CroSS are to be fine-tuned and optimized. Moreover, the identification of weak points might contribute to quality improvement, especially in specific domains. Waveforms, spectrograms and formants of synthesized speech need to be inspected and compared with natural, i.e. human speech. In order to deal with heteronyms in CroSS an input module for entering IPA transcription is planned, while for disambiguating homographs and homophones the possibilities of implementing Part-of-speech (POS) tagging will be investigated. In that case, the pronunciation can be annotated within a dictionary, and so long as the word parsing is correct, the right pronunciation will be chosen. Furthermore, CroSS for Linux operating system and a website for posting news, updates and downloads are planned as well.

5 CONCLUSION

Resonances are produced in the vocal tract while a human speaks. These resonances, known as formants produce peaks in the energy spectrum of the speech wave. Formant synthesis method synthesizes speech by attempting to imitate the time-varying formant frequencies of human speech. CroSS uses eSpeak to synthesize speech and is easy to learn, remember and operate. It has been utilized to provide easier means of communication for people with disabilities, but can also be applied in the process of Computer-assisted language learning. In this stage the interface of CroSS consists mainly of text fields and buttons. The convenient IPA transcription is also supported. This papers also aims to address problems for Croatian language that need to be further investigated and fixed in the text-to-speech synthesizer. In order to encourage further researches in this field, evaluation of CroSS is proposed.

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SEQUENCING AND NAVIGATION THROUGH LEARNING CONTENT

Gordana Rakić, Ljubomir Jerinić, Zoran Budimac, Mirjana Ivanović
Department for Mathematics and Informatics
Faculty of Sciences
University of Novi Sad
Trg Dositeja Obradovića 4, 21000 Novi Sad, Serbia
Tel: +381 21 4852877; fax: +381 21 6350458
e-mail: {goca, jerinic, zjb, mira}@dmi.uns.ac.rs

ABSTRACT

The aim of this paper is to describe a basic idea to introduce formal modeling in development and presentation of e-learning systems. By introducing formalism, reasoning on e-learning systems and processes through them can be more easily understood. In particular, we propose to use Harel's automata (statecharts) in modeling sequencing and navigation through learning content and learning process.

1 INTRODUCTION

Nowadays, e-learning play important role in educational market. Learning systems with confident management of learning contents and process bring additional value to the e-learning services. Formalization and pre-formalization in this area, that would provide more confidence in learning outcome, could assure additional quality to the learning process and results.

The design is drawn from the model OSOF [5, 7] where authors introduce full terminology and structure for the representation of different kind of information, which could be used in learning by the aims of computer, with the intention to introduce navigation trough that kind of information. Proposed approach is adapted to support SCORM standard but idea remains the same.

Most modern e-learning systems are based on the collection of various kind of information that needs to be accepted by the student, the presentation of this information on the computer, and the methods of their use by students. This approach assumes that the teaching material is presented as the mathematical structure of the graph. However, learning is primarily managed process by teachers who decide whether a material is adopted or not, as well as how to help the student when certain problems occur in the acquirement of content. Therefore, any information that a student needs to pass (overcome) has a beginning, and under certain conditions, the student moves on to the next. Therefore, the mathematical aspects of the structure of a series of information that a student needs to pass (overcome) has to be in a form of finite automata, in our case modified *Harel's automata*.

In this paper we propose formal modeling of learning content and process. In Section 2 the brief overview of course management systems is provided. E-learning terminology recommended by SCORM standard for e-learning interoperability is provided in section 3, while statecharts and their usage in formal modeling are introduced in section 4. Idea for statechart modeling of e-learning content and process is described in section 5. Related work is described in section 6, while conclusion and future work are given in section 7.

2 COURSE MANAGEMENT SYSTEMS

Course organization is an important aspect in educational process. Digitalization and usage of electronic courses gives additional value to good course management.

There are numerous approaches to course management which can be divided in two basic categories: course management systems oriented to learning process and course management systems oriented to learning content.

Systems oriented to learning content are aimed to organization of learning material independently on its usage in learning process. Usually, for these purposes we use Course Repositories (CR) or Learning Content Management Systems (LCMS). The main difference between these two categories are that CR do not take care about creation of material, but only about storing and delivery of stored content.

Systems oriented to learning process as a goal have management of creating, storing, organizing, and using learning material in learning process. There are two categories of process oriented learning systems: Learning Management Systems (LMS) and Intelligent Tutoring Systems (ITS). ITS uses techniques of artificial intelligence to adapt learning process and content to learner and to provide learner with instructions and feedback during the learning process.

Intelligent or not, process oriented learning systems include learning strategies to provide adaptive learning. In this context by learning strategy we mean personalized approach to learner but with methodology, pedagogy and

psychology driven teaching rules. Therefore we could equally use the term "teaching strategy", but we will keep the "learning strategy" as a common phrase.. Adaptability gives to these systems dimension of reactivity.

3 SCORM

Sharable Content Object Reference Model (SCORM) [1] is a set of technical standards for e-learning interoperability. It is developed in year 2000 by US Department of Defense organization called Advanced Distributed Learning (ADL) [2] Nowadays SCORM is widely used to transfer courses across different LMS and LCMS. It contains needed standards, specifications and guidelines for describing the relationship of content objects, data models and protocols such that objects become sharable across the systems that meet this standard.

SCORM standard consists of the following three parts:

- Run-Time Environment (SCORM RTE) takes care about launching of the content by LMS and way the content communicates with the LMS.
- Content Aggregation Model (SCORM CAM) defines learning content and its organization. SCORM defines two levels of contents: a) asset and b) Sharable Content Object (SCO). Asset is any piece of digital information (text, image, sound, etc.), while SCO is a collection of one or more assets that represent a single launchable learning resource. SCO is a smallest unit of information. (it can communicate with LMS by utilization of SCORM RTE.
- Sequencing and Navigation (SCORM SN) allows the course maker to govern how the learner is allowed to navigate between SCOs. It is based on hierarchy tree of activities represented by items. Item can be either asset or SCO if item is leaf in the tree. Otherwise it is called cluster and contains child activities. The rules for order in which user will be passing through the units (SCO) is realized by sequencing. Navigation provides possibility for learner to follow specific flow through the contents. This term is used for process of movement through provided contents. By usage of different sequencing and navigations we can introduce learning strategies.

4 STATECHARTS IN FORMAL MODELING

Modeling plays important role in software development, especially when we are dealing with reactive systems. It provides problem abstractions and structure for problem solving, enables complexity management and experimentation in order to explore multiple solutions and to select the most appropriate one. Modeling helps in reduction of time-to-market for business problem solutions and development costs, but also in managing the risk of mistake. Formal modeling includes mathematical background as an additional value.

Visual problem representation provides better understandability of problem and its solution. Testability of some visual models is important feature in this direction. Therefore visual modeling is used to reveal possible gaps in software development.

Statecharts (or Harel's Automata) [2] provide all listed benefits. This is powerful technique for visual formal modeling which belongs to state based modeling approaches. Similarly to finite state automata, statechart model is usually runnable, and hence testable. Still, in comparison with finite state automata it offers some improvements, out of which we emphasize the following ones:

- multi-states and state hierarchy modeling,
- parallel states,
- time modeling.

Our plan is to use statechart to model adaptive learning system.

5 STATECHART MODEL FOR SEQUENCING AND NAVIGATION

If we observe learning system and its usage in learning process we can notice that at each moment single learner, and therefore from this perspective the whole system can be in the single state. This state is uniquely determinable. It is determined by current item. Item can be SCO or Asset (regular or assessment one). Asset is atomic, while SCO can consist of Assets. On the other hand, when system is stated in the certain item it is hierarchically uniquely stated in all higher levels of organization: topic, lesson, section, course and curriculum.

Navigation through the contents and the processes is based on events appeared in the process. We provide (Figure 1) only the basic idea for modeling of these events in the learning process described on low level. This idea could be propagated on higher levels with minimal modifications.

Let us observe Item. In the current lesson and in the current topic user can use single SCO that is defined as set of Assets. Therefore we define it recursively. SCO built by one Asset and other SCO. In theory this differs a bit from the SCORM definition of SCO, but in practice it fulfills the requirement.

Based on parameters affecting the event on entering the SCO system user enters to the Asset, Assessment Asset or to empty asset in which case we move to the exit point of the SCO. When we are on the exit point of the SCO we can come to one of the following situations:

- There is next content in current Item but learner did not pass assessment and system move learner back to the previous step (usually beginning of the Item dependently on strategy)

[1] Sharable Content Object Reference Model (SCORM) http://scorm.com/

[2] Advanced Distributed Learning (ADL)[2] http://www.adlnet.gov/

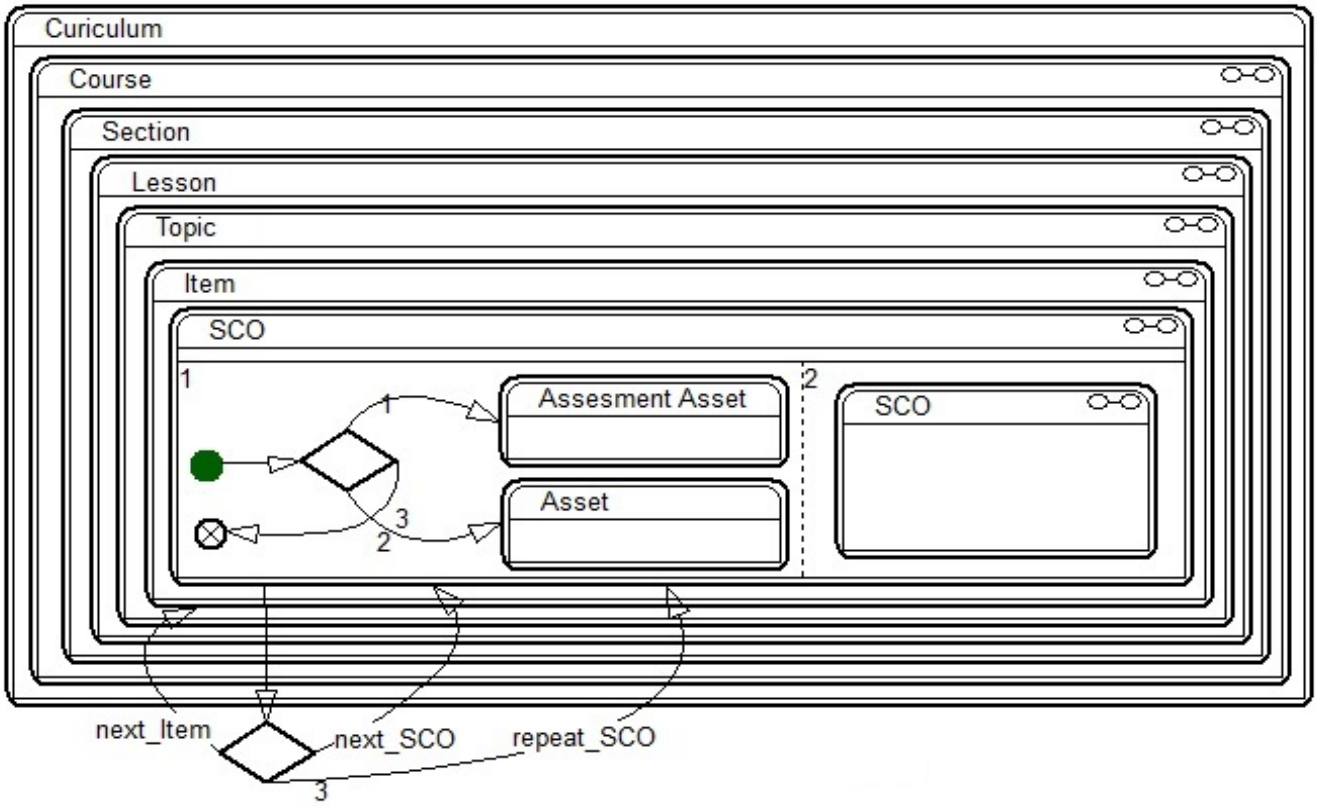


Figure 1. Statechart model for e-learning sequencing and navigation

- There exists next content in current Item and learner passed assessment and system move learner to the next content in the Item
- There is no next content in the Item and system moves the user to the next Item.

If we propagate these rules to the higher levels of the learning organization we will get full navigation through the curriculum.

Basic idea is to adapt conditions and events based on learning strategies.

6 RELATED WORK

Formal methods are commonly used in modeling critical properties of reactive systems. If we observe adaptive learning systems as a mission critical reactive system where the mission is successful fulfillment of learning goals, critical point is related to sequencing and navigation and the way for reaching the outcome. Sequencing and navigation are responsible to ensure learner to overtake all learning steps and to pass all needed tests. Formal modeling of sequencing should provide confidence in learning outcomes.

Formal modeling in adaptive sequencing and navigation should provide confidence of learning strategy. Authors of [1] provide good overview with future trends in sequencing modeling. In a frame of UML based sequencing, UML state diagrams, as a version of statecharts are used for visual representation of navigation rules and states. One model is also provided as an example, but without any relation to available standards in the field. In graph-based modeling finite state automata are considered as an appropriate technique. In our context, statecharts are used as an extension on finite state automata integrating both approaches, but additionally following the SCORM standard, which was not case in provided overview. Furthermore, the overview is concentrated only on sequencing while our goal is to integrate the sequencing and the navigation in the formal model.

Authors of [6] provide conceptual meta-model for the educational application. Even if their goal is similar to ours there exist some important differences. The most important one is that authors of proposed paper provide the meta-model as a guidelines or pattern for further conceptual development of educational applications. Our goal is to develop the formal model of concrete learning system.

In [4] we can find model-based approach but only to SCORM sequencing oriented to modeling content organization, while our goal is to include also the navigation and to model the process.

Finally, authors of [3] take into consideration the learning process, but again the goal is to model learning content organization, not the learning process which is goal of our efforts.

7 CONCLUSION AND FUTURE WORK

This paper describes a brief idea for formal modeling of learning content and learning process by statecharts. The goal is to use formal model in order to meet dependability of learning systems.

By formally modeling learning contents as an automaton, we get the possibility to represent personalized learning as function P that would be applied to existing automaton, giving

a new, personalized (or otherwise changed) one. Those functions could be also composed in

different ways, thus providing different pedagogical flavors.

Described idea for modeling of the navigation is demonstrated on the lowest level of sequencing, and possibility for propagation to the higher levels is described.

Still there are many open questions for investigation. All details are to be modeled and model is to be tested.

In this observation situations of following more then one course in the same curriculum in parallel, or even following more then one curriculums in parallel are not considered.

The real future work is to add dynamics to the model, by involving intelligent techniques for realtime generation of events and conditions for switching the states based on learning strategy and previous activities and results of the learner.

ACKNOWLEDGMENT

The work descried in this paper was partially supported by the Serbian Ministry of Education, Science and Technological Development through project "Intelligent Techniques and Their Integration into Wide-Spectrum Decision Support," no. OI174023.

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METRICS-BASED RECOMMENDATION SYSTEM FOR SOFTWARE ENGINEERING

Marko Gašparič[1], Andrea Janes[2], Marjan Heričko[1], Giancarlo Succi[2]

[1]Faculty of Electrical Engineering and Computer Science, University of Maribor
Smetanova ulica 17, 2000 Maribor, Slovenia
e-mail: {marko.gasparic, marjan.hericko}@uni-mb.si

[2]Faculty of Computer Science, Free University of Bozen - Bolzano
Dominikanerplatz 3 - piazza Domenicani, 3,
I - 39100 Bozen-Bolzano, Italy
e-mail: {andrea.janes, giancarlo.succi}@unibz.it

ABSTRACT

Previous research has shown that it is beneficial if developers study their work activities, e.g. the costs and outcome of activities. We have developed a prototype that is an Eclipse plugin and visualizes an overall team effort spent per source code artifact, source code metrics, and recommendations for source code improvements.

To evaluate the prototype, we conducted nine interviews. Interviews revealed that users found the functionalities of our system useful and were also interested in getting more information, particularly about the amount of effort per developer. Additionally, interviews revealed that developers were willing to execute a non-repetitive task to use the system, while they were not willing to leave the development environment to obtain the same information and recommendations.

1 INTRODUCTION

A developer rarely has enough knowledge to execute a task by himself. Some of his information needs are easily satisfied, but the majority is deferred [1]. To obtain the necessary knowledge, developers consult different sources of information, such as co-workers, project documentation, books, manuals, or computerized information systems [2].

Tools that help select the best item according to the user's expectations are ubiquitous, i.e. search engines, e-commerce recommendation systems, etc. Lately the recommendation systems have become an important instrument in software engineering as well [3].

Software developers have to deal with a large amount of information related to the project and the complex technologies they use in order to achieve maximum performance and high productivity [4]. Even though many tools are being developed by the software engineering community, solutions from other fields will also start solving individual competence problems [5].

The definition of a recommendation system for software engineering (hereafter: RSSE) conceived by Robillard et al. [6] and used by the RSSE community is:

"A recommendation system for software engineering is a software application that provides information items estimated to be valuable for a software engineering task in a given context."

Modern techniques for improving software quality, programmer productivity, and the economics of software project development are focused on the collection and analysis of empirical software project data [7]. Humphrey [8] showed that if developers study their own activities, the outcome of their activities, and the cost of their activities, that they improve their estimating and planning skills and reduce the number of defects in their work. However, the effective collection and application of empirical project data is hindered by the barriers surrounding the cost, quality, and utility of empirical project data [7].

Different research groups have started working on automatic means of collecting empirical project data. At our research center, we have developed a non-invasive software development process measurement framework.

Not all measurement activities can be automated. The main difference between manual measurements and non-invasive measurements is that non-invasive measurements do not require the training of collaborators on how to precisely and accurately collect data, that forms do not have to be filled out at all, and that the correctness of the filled-out forms need not be checked. But some recurring costs persist: the results' analysis, the results' distribution, and the verification that the collected data is correct, accurate, and precise. Because the collection and analysis of the metrics take time and cost money, we want to avoid the costs that occur due to the collection and analysis of the metrics that are not used.

According to Fenton and Pfleeger [9], we can collect the following metrics if we analyze a software development process:

- Process metrics – describing activities performed during software development,
- Product metrics – describing an output of the activities, e.g. source code, documentation,
- Resource metrics – describing an input of the activities, e.g. human effort.

Measurement framework developed at our research center collects all three kinds of metrics. However, it is designed for project managers, who, according to our experience, use a different set of values and are interested in different aspects of development than the software developers. We developed the RSSE prototype that leverages collected metrics by the existing measurement framework and presents them to developers. We believe that this will ease the use of the product and process metrics, especially from the programmer's perspective.

Boehm noted in 2003 that: "Much of current software engineering practice and research is done in a value-neutral setting, in which every requirement, use case, object, and defect is treated as equally important." Previously, when software decisions did not have a major impact on the overall project success, the value-neutral approach worked sufficiently well, but today, and increasingly in the future, software has a major influence on most systems' cost, schedule, and value, which means that value-neutral software decisions can seriously degrade project outcomes [10]. According to our experience, this claim is still partially correct – software developers are more concerned with the technical perfection of the source code than with the clients' needs, deadlines, team's internal requirements, and the *necessary* quality of the product, etc. With the new RSSE, we tend to support value-based software engineering [10].

We wanted to develop a system that would be well accepted by software developers. According to the Technology Acceptance Model [11], perceived usefulness and perceived ease of use determine usage behavior. Based on this theoretical background, the visualization of the product and process metrics is useful. We have evaluated the perceived usefulness and perceived ease of use of the RSSE prototype with the conduction of semi-structured interviews.

2 NEW RECOMMENDATION SYSTEM FOR SOFTWARE ENGINEERING

We built a RSSE prototype that shows context relevant information and recommendations[1] for developers during their programming tasks.

The overall system consists of several nodes:

- Measurement framework modules (task specific nodes: database, measurement framework core, measurement probes, data-manipulation plugins, visualization plugins, etc.) – all the input data is retrieved from the measurement framework,
- Eclipse plugin – it visualizes information and recommendations that the measurement framework provides.

The overall architecture is distributed. The Eclipse plugin is weakly coupled with the measurement framework and the framework can be replaced with any other measurement system that is accessible through the representational state transfer (REST) interface.

We decided that the tool should not demand any repetitive effort from the developer. For the representation of information and recommendations we used lists, tables, and charts. Currently, the prototype only supports the Java programming language. Figure 1 illustrates the supported use cases.

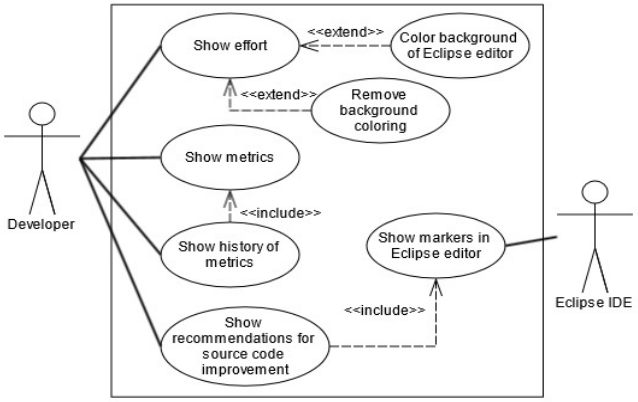


Figure 1: *UML use case diagram of the RSSE prototype.*

The RSSE shows all the product metrics collected by the measurement framework[2]. Additionally, it shows the changes of product metric values over time, i.e. the history of a certain metric.

Another functional requirement related to product quality was a visualization of recommendations for source code improvements. The measurement framework runs external tools that generate recommendations. At the moment, it leverages FindBugs, PMD, Jlint, Splint, and Cppcheck.

With the RSSE prototype we can visualize one resource metric collected and analyzed by the measurement framework: the total effort spent per source code artifact (class or method) by the team. When an effort table is opened, the Eclipse plugin also colors the background of the artifacts in an editor. The coloring is based on the relative amount of effort (a high effort is colored red, a low effort is colored blue, and an average effort is colored green).

For the RSSE prototype we tried to fulfill four non-functional requirements: modifiability, performance, usability, and scalability. We describe them in Table 1.

3 EVALUATION OF THE PROTOTYPE

3.1 Research methodology

[1] All visualizations are related to the actual developer's context, i.e. the data related to the opened file and the source code artifacts defined in it are shown at the artifact level. No other data is shown.

[2] The measurement framework calculates coupling between objects, cyclomatic complexity, the depth of the inheritance tree, fan in, fan out, lack of cohesion of methods, lack of cohesion of methods (Henderson-Sellers), lines of code, logical lines of code, number of children, response for a class, and weighted methods per class metrics.

Observation, interviews, and questionnaires are often used for qualitative case studies [13]. Interviews are targeted (i.e. the focus is directly on a case study topic) and insightful (providing perceived causal inferences) [14]. We decided to conduct an evaluation of the tool and to collect opinions, ideas, and critiques about it, through semi-structured interviews.

We selected nine participants that are different according to experiences and according to the tasks that they are usually appointed to. They are all studying or working at the Faculty of Computer Science at the Free University of Bolzano.

To each participant we presented screenshots of the prototype and explained the functionalities. Participants were allowed to make comments during the presentation and we asked questions if they started to talk about an interesting topic. After the presentation we spoke with them about the ease of use of the system and about the usefulness of the existing features for their development tasks, how they would change existing views, and which functionalities they would add to the tool. We also asked them which development environment they use and why, if they would use the RSSE if it would slow down the development environment (in this specific case: if a plugin would slow down Eclipse IDE), if they were willing to wait a minute or two after they made a request, and if they were willing to leave the development environment to obtain the same information, i.e. if they would still use it if the RSSE would not be a plugin, but a standalone application.

To get additional information related to previous questions and to get new ideas for the RSSE functionalities, we asked every participant at the end of the interview: “What would a RSSE look like if you developed it?”

3.2 Results and analysis

Two thirds of participants assessed the RSSE as simple to use. This could also be due to the popularity of Eclipse among them, since we tried to imitate the behavior of standard Eclipse features. However, two participants that do not use Eclipse found the RSSE simple to use as well.

During the interviews we explicitly asked participants if they would appreciate the filtering of recommendations, since we already planned to implement it in the next version of the prototype. The participants were less enthusiastic about this feature than we expected and some suggested different solutions, i.e. the ordering of recommendations.

The RSSE has to become more customizable. In particular, the selection of metrics visualized in the metrics view has to be supported. We find it interesting that even if some interviewees did not find the metrics useful for them, they thought that they would be useful for other developers.

Interviewees also wanted to get information about the efforts per developer, either by all team members, of the last one who worked on an artifact, or a personal effort.

Two participants were distracted by a color scheme used for the background coloring. They suggested we use a semaphore color scheme. Interestingly, they both did extensive research on the human understanding of colors, which is why we considered their opinion to be reliable. However, it remains to be found out what a *good* effort is, and what a *bad* effort is.

We always explained why the connection setup between the project in the workspace and the project in the measurement framework is needed. It is an example of a non-repetitive task. From the responses of the participants we can

Requirement	Definition	How the architectural design addresses system quality requirements.
Modifiability	Adding new functionalities does not require the modification of existing functionalities.	Processing of events is decoupled. Analysis of the raw data is done on the server site. If a new type of analysis is needed it has to be implemented in the new plugin and installed in the measurement framework.
Performance I	The same data does not have to be transmitted from the measurement framework to the Eclipse plugin more than once.	The Eclipse plugin keeps the data obtained from the measurement framework in memory.
Performance II	RSSE activities that start automatically should not stop the development environment. The processing of the developer's request should not hamper the execution of his tasks.	Only fast executable processes are started automatically. Currently, an automatic analysis is performed when a file is opened and recommendations are visualized. A lazy analysis is performed when the user requests an effort or a metrics view. JavaScript Object Notation (JSON) files are used in the REST communication. Used JSON files do not contain redundant data. In that way the size of the messages is kept small and communication is faster.
Usability	The system is intuitive. Developers learn how to use it in a short time.	The system leverages Eclipse functionalities and imitates standard Eclipse behavior.

Requirement	Definition	How the architectural design addresses system quality requirements.
Scalability	No big effort is needed to increase the processing power of the measurement framework.	Processing historical data is the most time consuming task. Data is saved in the distributed database[3], which means that the processing power can be increased with additional nodes.

Table 1: *Non-functional requirements*.

conclude that they are willing to make an additional small effort, if it is non-repetitive. A repetitive additional effort would be leaving the development environment to obtain recommendations and information. If our RSSE would be a standalone application, participants would not use it.
We expected that developers were not willing to use the RSSE if it slowed down their development environment. Interviews also showed that users were not expecting to wait after they make a request and that they want to continue working while they are waiting. That makes performance one of the most important requirements of the RSSE.

3.2 Validity threats

Interviews are exposed to response bias and reflexivity (i.e. the interviewee says what an interviewer wants to hear), bias due to poorly constructed questions, and inaccuracies due to poor recall [14].
Questions were defined by one researcher and reviewed by another. The sequence of questions was not fixed, but adopted based on the interviewee's comments. In that way we tried to lower the potential bias due to poorly constructed questions and tried to lower the reflexivity effect and response bias, by also constantly encouraging interviewees to recommend improvements.
We do not believe that our research was subject to inaccuracies due to poor recall, since none of the questions were related to past events.

4 CONCLUSIONS AND FUTURE WORK

Our prototype enabled the visualization of resource and product metrics within a development environment. The RSSE does not explicitly visualize process metrics, in the sense that it would recognize the development task, e.g., debugging. We are studying this field and we plan to implement this functionality in the future.
Since metrics and recommendations are visualized in the development environment and in the relevant context, the Eclipse plugin is more user friendly than a standalone tool would be. Our prediction was proven by the interviewees, since most of them would not use our RSSE if it was a standalone application.
Interviews showed that the perceived ease of use of the prototype was already high, but with the implementation of the suggested modifications we plan to increase it even more. Interviewees found the information and recommendations visualized by the RSSE prototype useful and would also like to see other kinds of information.
The evaluation was not sufficient to claim that the new RSSE has a positive acceptance level according to the Technology Acceptance Model [11], but we believe it is a promising instrument, at least in the context of value-based software engineering [10].

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COMPARISON OF SERVICE INTERFACE EVOLUTION MANAGEMENT APPROACHES

Mitja Gradišnik, Marjan Heričko
Institute of Informatics
Faculty of Electrical Engineering and Computer Science
Smetanova 17, 2000 Maribor, Slovenia
Tel: +386 2 2207000; fax: +386 2 2207272
e-mail: {mitja.gradisnik, marjan.hericko}@uni-mb.si

ABSTRACT

In this paper we aim to explore ways of overcoming interoperability issues between services that can arise due to the evolution of a service during its lifecycle. We will present two approaches used to solve the mentioned problem: service adaption and service versioning. We will also provide a brief overview of both approaches and provide a solidified comparison of approaches from different points of view, including from the point of view of the development process, system architecture and service consumers.

1 INTRODUCTION

Service-oriented architecture (SOA) is an architectural style for building enterprise solutions that promotes effectiveness, alignment with business needs and the flexibility of adjusting to changes in business strategies. With the intention of pursuing these objectives, SOA is based on a set of technologies and standards, such as SOAP [15] and WSDL [16], which are necessary for achieving interoperability and platform independence [15].

The standardized way of describing service interfaces or transmitting messages between services solves many interoperability related issues, but still some aspects of service interoperability are left unsolved. One of them refers to service interaction issues that arise due to the evolution of services over time. To service consumers, service evolution is reflected in changes in service interfaces and business protocols.

The service as a fundamental building block of systems based on SOA is constantly developing and evolving in order to stay aligned with changing business needs. During the life cycle of a service, capabilities can be added to the service, optimized or adjusted to current requirements. If they are no longer necessary, they can be retired and removed from a service. Updated service capabilities usually cause changes in service implementation. According to their influence on the service, the changes can be categorized into three main groups [15]:

- **Implementation changes:** this group of changes is not visible on the outside of a service. The service interface is not altered, therefore service consumers are not affected.
- **Compatible interface changes:** in this case, the changes in service implementation reflects on the service interface, but in a way that service consumers can continue using the service.
- **Incompatible service changes**: in this case, a service interface is changed in a way that hinders existing consumers.

Ideally, the evolution of a service would keep its service interface unchanged. For instance, the first version of a service interface can be frozen for further changes [4]. This would avoid interoperability issues with existing consumers, but in many cases (especially over longer periods of time) potentially disruptive service interface changes are inevitable.

In cases where the service interface changes, and incompatibly alter the service interface, the aim should be to minimize any effect on existing clients while still offering the possibility of benefiting from service enhancements [15]. This suggests that the introduction of changes should be smooth and transparent for existing service consumers. Therefore, maintaining service interoperability when a service is evolving undependably is an important and challenging problem [3], especially in cases when service updates cannot be coordinated with updates on the client side. This is usually commonly the case when services and their consumers are managed by a different team or different companies.

In general, there are two approaches to overcoming the issues that arise due to the evolutionary changes in services. The first approach proposes the establishment of service versioning, which establishes the parallel existence of multiple versions of a specific service. Every time a service interface is incompatible changed, a new service is added to offer enhanced service capabilities. Previous versions of a service are kept to ensure backward compatibility. The second approach proposes the development of an extra layer of services that mediate interactions and resolve issues among incompatible components.

The business aspects of evolutionary service changes, such as discontinued service or limited capabilities due to business decisions, are not a subject of discussion for this paper.

The concept of service versioning is presented in detail in Section 2-. The approach with service adaption is further

presented in Section 3. In Section 4 we will compare the discussed approaches from different points of view and present the results of the research. The paper is concluded with a summary of the main points of the compared approaches in Section 5.

2 SERVICE VERSIONING

The first available approach to dealing with interoperability issues that stem from evolutionary service changes is service versioning. Technologies used to implement systems based on SOA do not explicitly provide capabilities for service versioning. For instance, WSDL does not provide an explicit support for versions [13]. Service versioning is neither fully supported by current service registries [9], such as the UDDI registry [12]. These registries use a flat service model that does not consider service variants, or multiple versions of the same base service [9]. Therefore, service versioning inside the SOA ecosystem can be a challenging task.

Versioning assumes the simultaneous existence of multiple (different) implementations of a given resource, with every implementation distinguishable and individually addressable [8]. In practice, to overcome the described obstacles, a company may have to keep several versions of the same service operating at once [11]. Each version is an autonomous service in a service-oriented ecosystem, and consequently all service versions are managed independently from other service versions. Managing a separate instance of a service endpoint for each service version increases the number of service endpoints, making them difficult to manage and govern [13].

Changes that only affect the inner implementation of a service, such as bug fixes or code optimization, do not require a separately addressable service version in most cases. Incorrectly implemented functionalities could be an example of such an exception. All other types of changes usually require a new service version.

Versioning management offers service consumers different options to overcome interoperability issues due to changes in the service interface or protocols.

If changes are compatible with existing consumers there are few possibilities for overcoming the changed conditions. Service clients have the option of staying with an existing version service or can use the newer service with the old interface [15]. To be able to use the enhanced functionality of a new service, the client should switch to a new service interface.

In the case of an incompatible service interface or protocol changes the client only has two options. They can continue using the old version of a service using the old service interface or they can switch to a new service with enhanced capabilities using a new service interface [15].

3 SERVICE ADAPTION

An alternative approach to keeping several versions of a service for different clients is the development of service adapters. Service adaption refers to the process of generating a service (the adapter) that mediates the interactions among services (or service and client) with different interfaces and protocols, so that interoperability can occur [11]. In practice, the service adaption introduces an extra layer of services that mediate interaction between services (and consumers) with the aim of overcoming the service interface or protocol mismatches. Service mismatches are caused by incompatible service protocols, which are message exchange sequences between services. The service adapter can remedy incompatible service protocols by offering the interface mapping that overcomes the mismatching of two incompatible service exchange sequences [11].

For the most part a service interface is altered more than just once, therefore for each change of a service interface or protocol service, an adapter is required. The changes in the service interface or protocol can be handled by one or multiple adapters. To avoid complexity stemming from managing multiple adapters on the same service, a chain of adapters can be used [4]. A chain of adapters is a simple design technique that keeps clients compatible with all incompatible updates of service. Each time a service interface is incompatibly changed, one link in the chain is added so that each link in the chain represents a version of the service during its lifecycle. The described approach can ensure the undisturbed adaption to changes in the service interface, but only in cases where the client interacts with the service through adapters.

The simplest way to implement a service adapter is to implement it via stand-alone services, which are placed between the adapted service and its consumers. the problem with this approach is that the service adapter must be placed between the service and its consumer during the development time, regardless of the actual need for adaption during the time of implementation. All subsequent attempts to insert a service adapter between the service and consumer will not be transparent for the service consumer.

To avoid the problem described above, and especially in dealing with an additional service layer in the form of a pass through services, service-oriented middleware can be enhanced with the capabilities of the service adaption. In this case, service middleware is responsible for intercepting messages sent from service consumers, detecting potential incompatibilities in the message version and applying the required service adapter, if necessary.

4 COMPARISON OF SERVICE VERSIONING AND SERVICE ADAPTION

Both approaches, service versioning and service adaption, appear to be an effective way of overcoming interaction

issues raised because of the evolutionary changes of services. Although both presented approaches are keen to solve the same problem, there are many significant differences between them that must be considered by developers before the approach is adapted in a service-oriented environment.

Through our exploratory research we identified some of the key differences in the addressed approaches and classified them in groups based on common characteristics. We can view the differences in the compared approaches from various points of view. On that basis we divided the characteristic based on the perspective of:

- **Architecture of solutions** – the service evolution management approach can have a direct impact on a service-based solution, for instance, in the manner of the performance degradation.
- **Development process of solutions** – the approach of the service change management can be chosen based on the rapidness and complexity of the development process of service-based solutions.
- **Service clients** – the impact on existing clients should also be precisely considered. The changes necessary for service evolution should be transparent for existing service clients.

The main differences of both compared approaches are presented in Table 1.

Perspective of an architecture		
approach to the problem	**service adaption**	**new version of a service**
solution	adaption logic	duplicated service with enhanced capabilities
impact on performance	possible performance degradation	performance not affected
impact on service management	additional layer of services	multiple endpoints of the same service
Perspective of the development process		
service mismatch resolution	manually, (semi-)automated	manually
Perspective of service clients		
benefits for service clients	service changes are transparent for clients	transparent service change management

Table 1: Comparison of service adaption and service versioning

4.1 Perspective of the architecture

To overcome mismatches between services and clients, caused by changes in service interface and protocols, both approaches introduce additional services. In the case that service versioning is used, the service interface and protocol evolution is handled by adding new versions. Each version of service is autonomous and should be independently managed and governed. It is important to ensure that all common changes in service implementation, for instance bug fixes, are properly applied to all versions, especially when the versions are created via code duplication.

In comparison with service versioning, the service adaption avoids challenges caused by service duplication. Each adapter attached to a service contains only capabilities needed to bridge differences between two versions of a service. Because services are constantly evolving over time, there are more adapters needed to preserve interoperability with a variety of clients bounded with different versions of a service.

Adapters attached to a service prolong the path that a message sent from the client has to take to be processed. In every link of the chain of adapters, the message is transformed to a newer version of a service. Therefore, the potential performance degradation occasioned by a long chain of adapters may be a cause of concern [4]. From the viewpoint of a service-based system there are two performance metrics that should be considered when applying service adapters [4]: **Service latency**, **Scalability**.

On the other hand, service versioning does not affect a system's performance metrics the way service adaption does, because clients are bounded directly to a service.

4.2 Perspective of the development process

From the perspective of the software development process it is crucial that resolving incurred interoperability issues is not time consuming and does not require extensive human intervention. Therefore, if interoperability problems can be solved automatically, an organization can save a substantial amount of money on maintenance [3].

The service versioning approach requires re-design, re-testing and deployment of an added service version, which requires the full attention of a development team. On the other hand, in the domain of service adaption, there are approaches for the automatic service adapter generation for software models and service protocols [11]. The service adaption can be enhanced with the capabilities of self-adapting software systems, which can make the process of the service adaption able to respond to interoperability issues dynamically and autonomously [12].

The process of an automatic (or semi-automatic) service adaption is based on the analysis of a service interface and message exchange protocols, a result of which is that generated mapping solves the interaction issue between incompatible services and consumers. There are a few different approaches to remedy interoperability issues by the semi-automated generation of service adapters. For instance, the adapter can be generated by templates that contain a solution for resolving detected mismatches. Automatized service adaption strategies can be grounded in semantic technologies [13,17]. Based on existing ontologies, which describe the non-functional requirements of services, semantic-based service adaption is usually used to remedy service mismatches related to the quality of a service.

Fully automated generation of service adapters is harder to achieve. For example, semantic changes in a service

interface is hard to detect by just analyzing the service interface or message exchange protocols. These kinds of mismatches must be resolved by a development team.

4.3 Perspective of service clients

From the perspective of service consumers the service management should ensure that the disruption to clients caused by evolutionary service change is as minimal as possible. Service consumers prefer to follow their own maintenance cycle with controlled transitions to a newer versions of services. Any unexpected repairs that are required due to broken interactions caused by changes in service interfaces or protocols interrupt their continuous operation and increase their costs.

The service adaption particularly provides a strong mechanism that ensures a high level transparency of service interface changes. The messages sent from service consumers are handed over to adapters, which are responsible for transforming messages in the form compatible to a service. In this way, a variety of possible mismatches can be covered, which guarantee a high degree of mismatch transparency.

A guiding principle of service-oriented architecture is that a service consumer should be able to use a service without concern or interest in the implementation details. Despite efforts towards the increased transparency of service interface changes, it is unrealistic to expect that implementation changes are of no interest [8]. Small inner implementation changes can also affect service consumers if they are not managed properly. For example, for service consumers it can be devastating if the returned values suddenly start to show different patterns compared to expectations from past experiences. Even a changed order of inquiry results returned from the service can affect service consumers if consumers rely on that particular order. Therefore, it is crucial for consumers to have a transparent overview over the implementation changes of a service.

The approach with automated service adaption, based only on a service interface change analysis, can be vulnerable for missing service modifications that cause a change in the service behaving pattern, which can affect service consumers. Service versioning, which is fully in the control of a development team, can be more resistant to such inconsistencies.

5 CONCLUSION

The approaches of solving interoperability issues caused by service interface evolution have been addressed in many studies, the majority of them related to service versioning [8,9,14,18] and service adoption [1,4,5,6,11]. In our research, we aimed to compare both approaches from the perspective of architecture, the development process and clients and identified potential weakness that must be considered before the chosen approach is applied in a service-oriented environment.

Our research showed that service adoption brings benefits in terms of automation and the speed of the development process but there are also drawbacks that must be considered. Particularly, a lack of change transparency can be problematic if the service adoption is applied in critical environments. On the other hand, service versioning requires a higher level of development team intervention, but it makes change management more transparent and traceable.

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WHAT IMPACTS THE ACCEPTANCE OF MOBILE SERVICES – PRELIMINARY STUDY

Boris Ovčjak, Gregor Polančič, Marjan Heričko
Institute of Informatics
Faculty of Electrical Engineering and Computer Science
Smetanova 17, 2000 Maribor, Slovenia
Tel: +386 2 2207000; fax: +386 2 2207272
e-mail: {boris.ovcjak, gregor.polancic, marjan.hericko}@uni-mb.si

ABSTRACT

In this preliminary analysis we aim to explore factors that influence the acceptance of mobile services and the correlations between them. The acceptance in this study mainly refers to the Technology Acceptance Model (TAM) although the researches using other models could be found. Analysis was aimed at the mobile services in general and it could stand as a basis for the more specific services acceptance research.

1 INTRODUCTION

Mobile technologies and services are creating a wide area of business opportunities. They are enabled via mass use of different communication technologies and mobile devices. The main power of mobile devices are mobile applications, which deliver various services, enhancing user flexibility, mobility and efficiency within business and life domains. There are many definitions of mobile services (MS) [1][2][3][4][5][6]. Our study is based on the definition that defines MS as content and transction services that are accessed and/or delivered via a mobile handheld device (PDA, mobile, cellular or smart phone, GPS, etc) based on the interaction/transaction between an organization and a customer [7].MS development is growing with the advancement of mobile technologies, therefore the mobile telecommunications industry assumes that MS constitute a massive source of potential revenue growth [5].

The acceptance of technology innovations is important for purchasing and use of new products and the same stands for MS. There are many studies and researches that are trying to find factors, that can influence the acceptance of MS. These researches are often relying on the acceptance models like Technology Acceptance Model (TAM), Theory of Planned Behaviour (TPB), Theory of Reasoned Action (TRA), Unified Theory of Acceptance and Use of Technology (UTAUT) and similar. This study mainly referred to the TAM model, an information systems theory that models how users come to accept and use a technology. It indicates that perceived ease of use (PEOU) and perceived usefulness (PU) are the two main beliefs that determine one's intention to use technology [8]. On this basis the goal of this research is the identification of factors that could influence the acceptance of MS and finding the correlations between them.

2 RESEARCH

In the scope of the study we wanted to find factors that are influencing MS acceptance. Because this is a preliminary study, we decided to include only the most relevant articles. For the study we selected the following keywords: TAM, Technology Acceptance Model, Acceptance, Adoption, Mobile Applications, Mobile and Mobile services. Selected keywords were used to form the following search string:

(TAM or Technology Acceptance Model or Acceptance or Adoption) AND (Mobile Applications or Mobile or Mobile Services)

Our study was based on articles that were found in electronic databases such as ScienceDirect, Springerlink and Scopus. With all databases we used structurally and semantically uniform search string, although we had to adapt to the search string syntax requirements of each database search engine. After the initial results we excluded the articles that focused on specific MS since we focused only on the MS in general. We also wanted to include only the most relevant researches, therefore we included only those that incorporated at least one of the acceptance models and provided the empirical validation of the results. The list of selected articles will be presented in the following section.

3 RESULTS

The following section presents the results of literature review. In the scope of this study we choose 11 relevant articles, presented in table 1. Each article was presented with an unique identifier, intended for easier referencing.

Table 1: *Chosen articles*

Ref	*Authors*	*Year*	*Acceptance Model*	*Research subject*
[1]	Zarmpou et al.	**2012**	TAM	Mobile services
[2]	Deng et al.	**2008**	TAM	Mobile services
[9]	Mallat et al.	**2009**	TAM and DOI	Mobile ticketing (mobile commerce)
[10]	Verkasalo et al.	**2010**	TAM	Mobile services
[11]	Leong et al.	**2013**	Model consisting of integrated constructs from TAM, extended TAM, TRA, TPB, DOI and Bandura's theory in predicting acceptance of ME	Mobile entertainment
[3]	Sun et al.	**2010**	TAM	Mobile services
[12]	Hao et al.	**2009**	Integrated TAM from TPB and TAM	Mobile services
[4]	Gao et al.	**2011**	Mobile service acceptance model – extension of TAM	Mobile services
[5]	Rao et al.	**2007**	Conceptual acceptance model of MS – extension of TAM	Mobile services
[13]	Huiying et al.	**2010**	TAM	Mobile services
[6]	Karaiskos et al.	**2009**	TPB	Mobile services

As seen in table 1 we selected articles that focused on MS acceptance research. In this study we wanted to incorporate the acceptance of MS in general in order to include a wider aspect of the definition. It was important that the research incorporated at least one of the previously mentioned acceptance models. The list of literature shows that the majority of the researches explore acceptance with TAM model, derive from it or use it together with the rest to compose a more integrated model. There was also an article that used the Theory of Planned Behaviour model. On the model basis we could look for factors that influence the acceptance of mobile services in general.

4 FACTORS IMPACTING ACCEPTANCE OF MS

Our study results provided many factors that influence the acceptance of MS. Factors directly or indirectly impact the acceptance of MS. They include elements from TAM (PU, PEOU, Att, BI, AU), extended TAM (SN, PE), UTAUT (SI, FC, Gen, Age), TPB, TRA models and other external factors provided by authors.

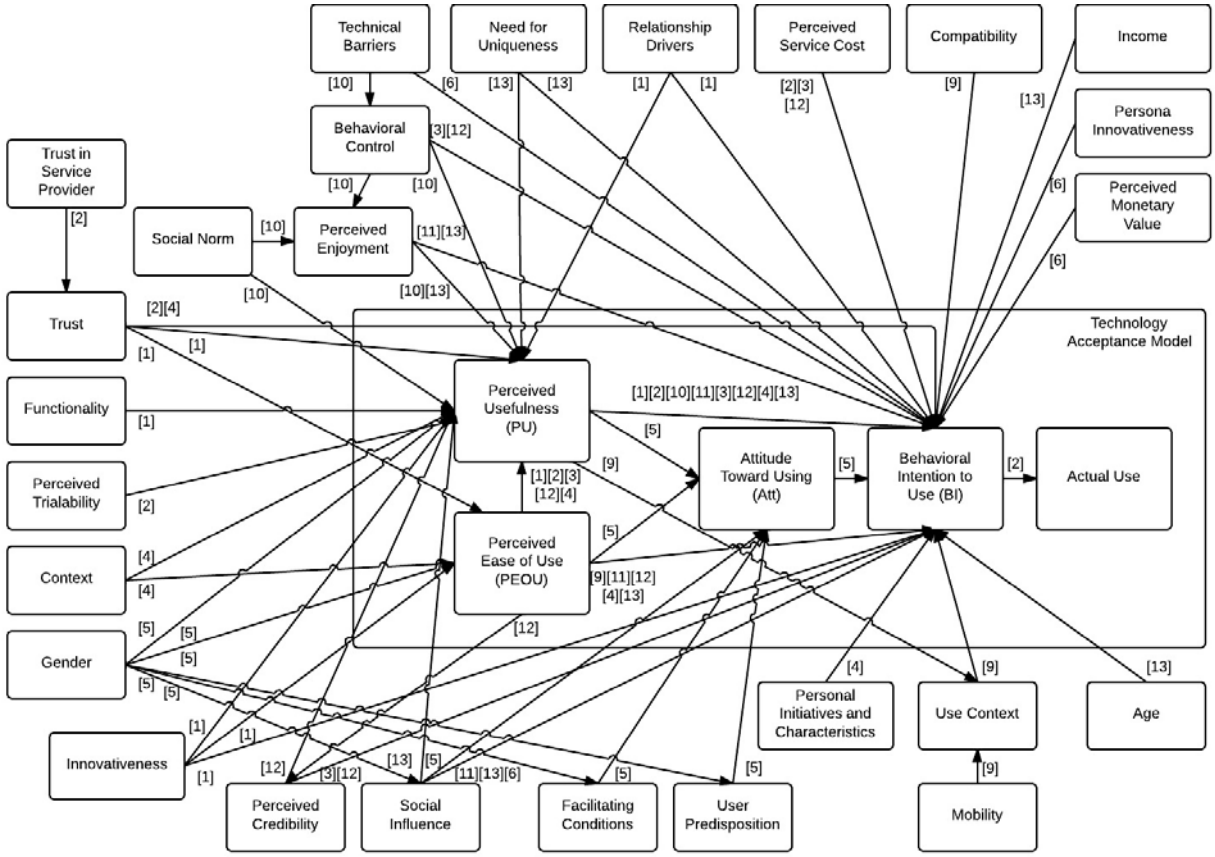
The main goal of our study was finding the factors that could influence the acceptance of MS. In addition we also wanted to see how these factors correlate with one another. The results with description of found factors are displayed in the following table.

Table 2: *Factors impacting the acceptance of MS*

Factor	*Description*	*Dependant variables*
Perceived Usefulness (PU)	"The degree to which a person believes that using m-services would enhance his or her job performance" [8]	Att [5], BI/IU [1][2][10] [11][3][12][4][13], UC [9]
Perceived Ease of Use (PEOU)	"The degree to which a person believes that using m-services would be free of effort" [8]	PU[1][2][3][12][4], Att [5], BI/IU [9][11][12][4][13], PC [12]
Attitude (Att)	Individual's positive or negative feeling about performing the target behaviour [14]	BI/IU [5]
Behavioural Intention (BI)	"A person's subjective probability that he or she will perform some m-services" [14]	AS [2]
Actual Subscr./Use (AU)	Actual use of the system	/
Trust (Tru)	Security in mobile payments; Confidentiality of personal data; Trustworthiness in the result of the m-services; Integrity of the terms of use of m-services [1]	PU [1], PEOU [1], BI/IU [2][4]
Innovativeness (INN)	"The willingness of an individual to try out any new information technology" [15]	PU [1], PEOU [1], BI/IU [1]
Relationship Drivers (RD)	Time and location personalization of the m-services; The services' adaptation to the consumers' profile; The consumers' dynamic permission option [1]	PU [1], BI/IU [1]
Functionality (Func)	Transaction speed (response time), Connection to the network speed; Interface comprehensibility; Infrastructure availability [1]	PU [1]
Perceived Trialability (PT)	"The degree to which an innovation may be experimented with before adoption" [16]	PU [2]
Perceived Service Cost, Perceived Cost, (PSC)	The possible expenses of using MS, equipment's costs, access cost and transaction fee [17]	BI/IU [2][3][12]
Trust in Service Provide (TSP)	Refers to consumers' perception of a mobile SP as credible and generally trustful [2]	Tru [2]
Compatibility (Comp)	Persons' ability to link the new technology with previous use experience, values and preferences [9]	BI/IU [9]
Use Context (UC)	Construct representing the conditions that users meet when they use mobile services In different places and time. [9]	BI/IU [9]
Mobility (Mob)	Benefits of time and place, service access and use. [9]	UC [9]
Technical Barriers (TB)	Lack of reliable and accessible mobile technologies; Lack of facilitating conditions mainly supplied by the service provider; Lack of technical support and trailing in using mobile systems [10]	BI/IU [6], BC [10]
Behavioural Control (BC)	"An individual's perceived ease of difficulty of performing the particular behaviour" [18]	PU [10], BI/IU [3][12], PE [10]
Perceived Enjoyment (PE)	"The extent to which the activity of using the computer is perceived to be enjoyable in its own right, apart from any performance consequences that may be anticipated" [19]	PU [10][13], BI/IU [11][13]

Social Norm, Subjective Norm (SN)	Person's perception that most people who are important to him think he should or should not perform the behaviour in question [20]	PU [10], PE [10]
Social Influence (SI)	The degree to which an individual perceives that important others believe he or she should use the new system [20]	PU [13], Att[5], BI/IU [11][13][6]
Perceived Credibility (PC)	the extent to which a person believes that using m-service will be free of security and privacy threats [3]	PU [12], BI/IU [3][12]
Personal Initiatives and Characteristics (PIC)	The user's willingness to experiment with new services. [4]	BI/IU [4]
Context (Cont)	Any information that can be used to characterize the situation of entities (i.e., a person, place, or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves. [4]	PU [4], PEOU[4]
User Predisposition (UP)	Collection of a number of factors including the individual's prior knowledge and experience of existing mobile services, compatibility, behavioural control, image, personal innovativeness, and perceived enjoyment [5]	Att [5]
Facilitating Conditions (FC)	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system [20]	Att [5]
Gender (Gen)	Users' gender	PU[5],PEOU[5],SI[5],UP[5],FC [5
Need for Uniqueness (NU)	"an individual's pursuit of differentness relative to others that is achieved through the acquisition, utilization, and disposition of consumer goods for the purpose of developing and enhancing one's personal and social identity" [21]	PU [13], BI/IU [13]
Age (Age)	Age of user	BI/IU [13]
Income (In)	Income of user	BI/IU [13]
Personal Innovativeness (PI)	"the willingness of an individual to try out any new information technology" [6]	BI/IU [6]
Perceived Monetary Value (PMV)	The amount of value an item or a service has in relation to it were sold for cash to a willing buyer [22]	BI/IU [6]

As it is seen from the table 2 the Technology Acceptance Model is confirmed by the majority of selected studies, as there is proven significance between TAM factors. Beside factors included in base TAM model it can also be observed that there are many other factors that could influence the acceptance of MS even though our study only referred to the limited number of articles. The research showed that in majority of cases the factors had a positive influence. We only found one case of negative impact, where the Technical Barriers negatively influenced the Behavioral Control. The aggregation of correlations between factors can be seen in the picture 1.



Picture 1: *Aggregation of correlations between factors*

4 CONCLUSION

Mobile services (MS) are becoming increasingly present in the field of telecommunication technologies. It is also predicted that MS will constitute a great source of potential revenue growth. As a result, a lot of authors are researching the factors influencing the acceptance of MS. In the scope of our study we have shown that majority of articles explored the acceptance with TAM model, derived from it or used it together with the rest with the goal to compose a more integrated acceptance model. Only in one case we found that the author derived from the TPB model (Theory of Planned Behaviour).

In most cases, significance was proven in the relation between existing factors of the TAM model (PU, PEOU, BI, AS), which confirms the relevance of the mentioned model in the field of MS. In addition to these, we can also see the influence of additional factors that may be found in the table 2. Nevertheless, it is worth noting that there could be even more relevant factors found, since our research only based on a number of more relevant articles.

It is important to note that this study is limited by the number of articles chosen in the field. For more accurate results of the research, a more complete analysis should be made. Our study also included only the literature, which focused on the acceptance of MS in the broad spectrum and therefore did not include studies in acceptance of the specific categories of MS.

The field leaves open many possibilities for further research. Given the factors that influence the acceptance of MS services we could investigate which model of acceptance would be most appropriate for the research in this field. A more in depth research could also be made for each of the MScategories.

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USE OF SEMANTIC TECHNOLOGIES TO IMPROVE HUMAN WELFARE

Viktor Taneski
University of Maribor, Faculty of Electrical Engineering and Computer Science
Smetanova ul. 17, 2000 Maribor, Slovenia
Tel: +386 1 4773419; fax: +386 1 4251038
e-mail: viktor.taneski@uni-mb.si

ABSTRACT

The Semantic Web is a very important initiative that is currently attracting significant interest while also influencing the future of the World Wide Web. Tim Berners-Lee's vision of a more flexible, integrated, automated and self-adapting Web, which provides a richer and more interactive experience for users, is what inspired the Semantic Web initiative.

We present a prototype solution called the WeatherHealthcast warning system, which uses Semantic technologies to help weather-sensitive people to easily withstand changes in weather - the Weather Healthcast warning system. The system takes into account many parameters, such as humidity, barometric pressure and temperature, and additional weather conditions, such as rain or thunderstorms, which are known to affect human welfare. The health forecast is made on the basis of a semantic analysis and the use of a reasoning tool, called Pellet. In this way, we can make as accurate a health forecast as possible, which, on the other hand depends on the input data for the changes in weather, as well as data about the user (age, gender, etc.)

In this paper, the architecture of the Weather Healthcast system is outlined, as well as the reasoning model, its ontology and a web application.

1 INTRODUCTION

We face drastic weather changes every day. Every second person complains about things like headaches and tiredness. Scientists have discovered that varying weather conditions can affect various ailments, such as headaches, migraines or even basic discomfort [2].

Some people react well to changes in weather, but others do not. This is because our bodies respond differently to weather changes, depending on age, sex and general health. These reactions are related to our endocrine system (a system of glands), which regulates the creation of hormones in the body and is sensitive to the effects of pain, stress and weather [1]. Weather-sensitive people react with varying intensity to changes in weather such as air pressure, temperature and humidity. Moreover, these changes can also worsen the symptoms of an existing ailment [2]. Therefore, some questions arise, namely:

What can we do about weather sensitivity? How can we improve the life of weather-sensitive people?

The Weather Healthcast system offers answers to these questions. The idea is to build a system that allows users to quickly obtain relevant information about how weather will affect their welfare in the next 24 hours. The system warns users that suffer from migraines, asthma, arthritis, diabetes or a heart condition and are also very sensitive to weather changes. The goal is to make life easier for weather-sensitive people by warning them about the effects that weather changes may have on their welfare, so that they can properly prepare for it.

The Weather Healthcast system is designed as a Web application that would be accessible to everyone, regardless of their location and time. The system's architecture is presented in Section 2. Section 3 describes the system's ontology and the problems that we faced when designing the ontology, while Section 4 describes the Web application itself. Section 5 refers to related work, and Section 6 concludes the paper.

2 WEATHER HEALTHCAST ARCHITECTURE

The Weather Healthcast system architecture is designed on three levels, as depicted in Figure 1.

The first level is the user interface, which defines the different modules that provide an effective interaction between the user and the business logic. Each module represents a certain functionality of our application, which provides efficient handling and control of data.

The second layer in Figure 1, the business logic layer, separates business logic from other layers (data and user layer), thereby allowing for system flexibility. The business logic is presented with different modules for processing and exchanging data (weather data, user data, data about medication), processing ontologies, reasoning, querying etc., as well as with methods by which the data layer is accessed.

The third level constitutes the database, which contains the ontology, and "Hibernate" libraries, which provides simplified, easier access to the database and the ontology.

2.1 The Data Model

The interaction between users and our system is provided by a Web application, which allows more users to simultaneously and independently access its services. In doing so, users can read data, as well as update.

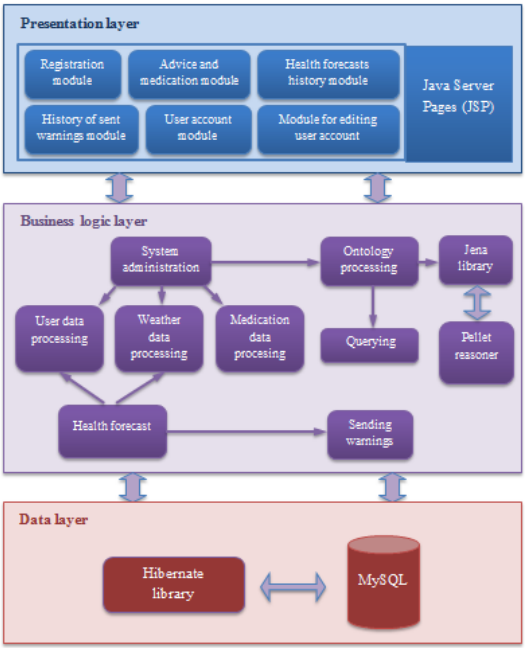


Figure 1: *System architecture.*

For this purpose, instead of exporting the ontology into an OWL (Web Ontology Language) document, we exported the ontology into a database, using SDB [3]. SDB is a component of the Jena framework, which provides APIs (Application Programming Interface) for managing and storing an ontology in a database. SDS supports different types of databases: Oracle 10g, Microsoft SQL Server 2005, DB2 9, PostgreSQL, MySQL and others. For the purposes of our system, we used MySQL due to its high level of performance, reliability and ease of use.

The ontology, including classes and their instances, and data with simple data type, is stored in the MySQL database scheme *weatherhealthcast*.

The table *nodes* contains data from all RDF (Resource Description Framework) nodes. Sources are given with their URI (Uniform Resource Identifier) address, simple data with their values. While data type is given as an XML schema data type. The table *prefixes* contains namespaces, which are defined in the OWL document, before being exported in the MySQL database using SDB.

All statements (RDF triples), which are written in the OWL document can be found in the *triples* table. The values in this table correspond to the identifiers in the *nodes* table. The user authentication data and user data necessary for obtaining weather forecasts are stored in a table named *user*. For security reasons, passwords are stored in a hashed form created by an unidirectional hashing function SHA-256 [4].

The *Healthcastalert* table contains information about previously sent warnings to each user, namely the date when the alert was sent and which ailment the warning refers to.

For mapping Java classes into database tables, we used Hibernate [5]. Hibernate is an ORM (Object Relational Mapping) mechanism, which provides a framework for mapping a object-oriented model into a traditional relational database and vice versa - the information contained in a relational database is converted into Java objects. It generates SQL calls and thus enables the user to very easily process the results and also allows for the portability of applications on all supported SQL databases.

2.2 Business Logic Layer

For ontology components, we used the Jena library [6]. Jena provides an interface (API) for reading and exporting data into an RDF graph. The graph is presented as an abstract "model." The model can contain data from different sources (file, database, URL or a combination thereof). Jena also provides SPARQL querying and, unlike other similar frameworks, Jena also supports OWL syntax and the serialization of RDF graphs in a database.

Our system requires reasoning ability. Providing services that enable reasoning is essential for the proper functioning of the system. In addition, reasoning is necessary if we want the system to determine how the weather will affect the user's welfare. To ensure this, SWRL (Semantic Web Rule Language) rules are provided, which are explained in Section 3.

A health forecast is made on the basis of a semantic analysis and the use of a reasoning tool, called Pellet [7], which is easily included in the Jena framework. We use Pellet primarily because it is a complete and capable OWL-DL (DL stands for Description Logics) reasoner with very good performance and many unique features. It is an open-source Java implementation that provides programmatic access through Jena.

To obtain weather information, our system uses the WeatherBug weather service [8]. WeatherBug is a an Earth Networks trademark, which manages and operates with the largest global weather network. It combines data from multiple sources, such as the National Weather Service and the World Meteorological Organization, and allows users to access the largest network of professional weather stations in the U.S. and more than 35,000 locations worldwide. The API provided by WeatherBug is simple and easy to use. Before you can use the WeatherBug API, it is necessary to obtain a code that is later used as a personal key to access the API and WeatherBug data. To retrieve weather information, an HTTP request is made, which contains the *cityCode*, the *UnitType* (US or metric units) and the *OutputType* (RSS or plain XML document). The HTTP request then returns an XML document, which contains information about the weather changes. The document is further processed (parsed) by the Weather Healthcast system, in order to obtain necessary information about weather changes. The component for processing the medical data allows the user to obtain information for a specific

medicine that the system recommends as medicine in order to reduce the symptoms of the ailment. The DBpedia API [9] is used to obtain this data. DBpedia is a community that allows the extraction of structured data from Wikipedia, which is available on the Web in RDF format. The DBpedia database serves as a set of open linked data online, so that users can demand data from Wikipedia and also link this data with other data sets. In order to retrieve data from DBpedia, DBpedia provides a SPARQL endpoint for SPARQL querying. The querying can be achieved by using the Jena library, as Jena also provides querying for some remote services.

In this way, we can make our health forecast as accurate as possible, which, it should be noted, also depends on the input data for weather changes, as well as data about the user (age, gender, etc.).

3 WEATHER HEALTHCAST ONTOLOGY

To model the system ontology we used the Protégé ontology editor, which is a free open-source platform and can be used to construct a domain model and knowledge-based applications with ontologies [10]. Protégé ontologies can be exported into various formats, such as RDF, RDFS, OWL and XML Schema.

The ontology is the basis of our system and therefore needs to be well planned. The first ontology that we designed is faulty, since a variety of ailments are represented as different classes, or subclasses of the Disease class. Such an ontology would be useful if there were more types of one disease and if each different type would represent one instance of a specific disease (for example, in this case, diabetes type 1 and diabetes type 2 are instances of the Diabetes class).

After discovering that this ontology was not very useful for our system, we used a slightly different approach, namely: every affliction was presented as an instance of the Disease class, instead of as a subclass. With this approach, the ontology was made a little more flexible. If there was ever a need to add some other disease into the system's prediction, everything that should be done is to create a new instance of the Disease class with the necessary data and define the corresponding SWRL rules. Then the reasoner will take the newly added disease and SWRL rules into account.

We fill the ontology with only a few concrete resources and data, due to the dynamicity of the ontology (the data in the ontology changes all the time). Data is only stored in the ontology if a user is registered in the system. The weather class contains only two instances that are always updated (instances containing information about the weather forecast for the next two days).

As previously mentioned, the Pellet reasoner is used in order to take into account the SWRL rules that are encoded. We use the Protégé ontology editor to write these SWRL rules as part of the created ontology.

SWRL is a rule language, based on the OWL description logic. It allows the user to write rules that can be expressed using OWL concepts and provides powerful deductive reasoning skills. SWRL extends OWL notation with the definition of logical axioms (statements) that must be fulfilled in a given interpretation. An SWRL rule is composed of a *body* and *head*, which are logical implications in the form of *antecedent* => *consequent* or *body* => *head* [11]. The SWRL rule can be interpreted as a statement in which, if the conditions specified in the body hold, the conditions specified in the head must also hold.

The system's ontology is shown in Figure 2. The ontology actually contains quite a number of properties and relations, but this is a simplified graph and displays only the most important concepts in the ontology.

4 WEB APPLICATION

The Web application was developed in JSP (Java Server Pages) and runs on the Apache Tomcat 6.0 web server.

The user must first register if they want to receive regular alerts about how the weather will change over the next 24 hours and how these changes might affect their well-being. For this purpose, the user must first complete the registration form with the required information: username, password, e-mail, name, country, city, gender, age, and information about the particular ailment they want to receive warnings about. The country and city are obviously necessary in order to gather information about weather forecasts. At a prescheduled time, the system will check if it is necessary to warn any users about weather changes and will send an email that contains a warning, appropriate advice, and suggested medicine.

The Web application can also be used by unregistered users (the user wants to check how the weather will affect their health in the next 24 hours but does not always want to receive notices). All the user has to do is to complete the appropriate form with the necessary information (country, city, gender, age and information about the disease for which they want to receive alerts). Then the system displays the appropriate health forecast.

Each warning also contains a link that leads the user to a page where suitable advice and a description of the proposed medicine are presented. If there are no warnings for the following days, the system displays the weather forecast for the next two days, thus allowing the users to decide on whether to take certain actions to protect themselves against the influence of the weather.

5 RELATED WORK

The most related work to our solution is the MediClim system [12]. It is a health warning system that provides weather health alerts via e-mail, warning people in advance of weather conditions that can trigger some health problems. MediClim is the result of research conducted by Dr. John Bart, a medical practitioner in Toronto, and meteorologist Denis Bourque. It was carried out in the early 1980s, focusing on human biometeorology and weather health. They developed an index that would map specific weather conditions that may trigger migraines, asthma,

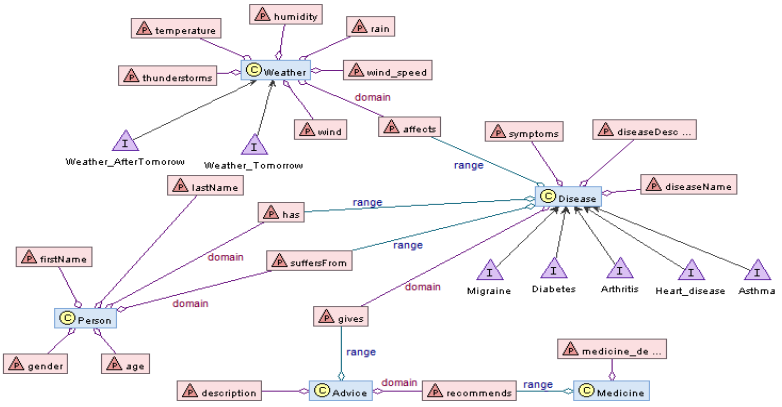


Figure 2: *Weather Healthcast ontology.*

arthritis, diabetes or heart disease problems.

The MediClim system uses an algorithm that identifies the days that the weather will affect specific afflictions and, similarly to our system, warns subscribers via e-mail that their health condition may be triggered.

To the best of our knowledge, the MediClim system, unlike our Weather Healthcast system, in not based on semantic technologies. Also, the user must be registered in order to be able to receive these warnings via email.

This has been improved in our Weather Healthcast system by allowing the user to receive instant information about the weather forecast, if the user does not want to be registered in our system (i.e. one-time use).

As we can see, our solution is a more sophisticated approach based on semantic technologies. It has its own ontology and uses the Pellet reasoner, for providing as accurate a health forecast as possible. This provides us with the opportunity to show how semantic technologies can be employed in a useful way (in this case to help weather-sensitive people feel better).

6 CONCLUSION

On a practical, prototype example, we have shown the use of semantic technologies, with the aim of improving the lives of people sensitive to weather changes. The result is a solution that shows how semantic technologies can be used in order to improve human life. Our solution is still in a prototypical phase and requires further improvements before completion. Since our system stores some personal data about users and their health, it is necessary to provide better protection for personal data. Although our system provides data security through a username and password (passwords are stored in the database in hashed form), the main difficulty is still in the data transfer. For this purpose, we can use a well-known algorithm, RSA [13], which is an algorithm for public-key encryption.

Our next step would be to test the system on a particular group of people, in order to prove that our solution is helpful and that we have achieved our goal. We could use semantic technologies to provide easier access to correct and useful health data over the internet, which would highly improve the lives of patients and ordinary Internet users. We believe that the idea presented in this paper is a step in this direction.

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USING THE PERSONA CONCEPT IN SOFTWARE DEVELOPMENT

Iztok Hafner
University of Maribor
Faculty of Electrical Engineering and Computer Science
Smetanova ulica 17, 2000 Maribor, Slovenia
Tel: +386 2 2207000; fax: +386 2 2207272
e-mail: iztok.hafner@uni-mb.si

ABSTRACT

This paper presents a literature review of using Personas in software development. Personas are fictional characters which are created to represent all of the different user types in targeted user groups. Personas are very useful in considering goals, desires and limitations of users which will use the software we are developing.
It was also demonstrated that Personas can be used on a wide variety of software development models and are elastic enough to be adjusted to fit every type of project in which they have the ability to significantly improve user understanding.

1 INTRODUCTION

One of key steps in requirements stage of software development is correctly identifying user roles (actors). Because these actors are indeed actual users which will use our software daily, it is essential we identify them properly, so we can begin to understand their behaviors and desires. One of biggest weaknesses of using actors is the fact that actors are mostly defined too general and can flex to fit in our desires as developers. This kind of flexing of course isn't what we want, as we want to make our software flexible to satisfy our user, not the other way around.
In this paper we will present the process of systematic literature review done on topic of Personas in software development. In the first chapter we will take a look at what Personas are. Next chapter will present steps of planning and executing of this literature review. In chapter four, we'll take a look at ways that Personas are used in software development. In the last chapter we'll be comparing some ideas of Personas use that were presented and look at possibilities of future research on this topic.

2 PERSONAS OVERVIEW

Personas are in general a replacement of "classic" actor in requirements stage of software development process. They are not representatives of a user role, but are a more concrete user of our software. Personas are archetypical representation of future user [1] which means, that every persona is an instance of an actor.

The advantages of using Personas in software development process are [5]:

- Personas make assumptions and knowledge, of our users, explicit. This makes it easier to communicate about what exactly our users want within our development group.
- Personas make it easier to focus on the adaptiveness of our software to suit individual user. This allows the designer to facilitate the decision-making aspects of the future system.
- Personas raise interest and empathy for end-users. Planning and development group can connect with the end users in a way that using traditional user data doesn't allow.

For every Persona, defined in requirements stage, it is recommended to define at least [1]:

- Name, surname, life and work habits.
- One sentence that individually defines this Persona.
- Key attributes, which present Personas expectations from our software.
- Tasks, which Persona performs regularly.
- Tools and resources, which Persona uses regularly.

3 PLANNING AND EXECUTING LITERATURE REVIEW

The goal of this literature review was to gain broad insight about Personas in the development of IT solutions and to figure out the latest trends and research on the use of Personas in software development.
The actual search phrase we used to search for articles is "*(persona? NOT personal) AND (software OR application) AND (develop* OR identif*)*". This search phrase includes searching for the word Personas and excluding word personal. It is also trying to find articles that are connected with words software and development. Search itself was conducted in libraries stated below::

- IEEE Xplore (*www.ieeexplore.ieee.org*)
- ScienceDirect, Elsevier (*www.sciencedirect.com*)
- Web of Science (*www.webofknowledge.com*)
- ProQuest Computing (*search.proquest.com/computing*)
- SpringerLink (*link.springer.com*)

3.1 Article exclusion criteria

We defined a basic set of criteria, which all of articles needed to satisfy in order to be included in this literature review. Here is a full list of criteria:

- *Does this article correspond to defined category?* – Categories which were recognized as viable include "Computer Science", "Information Technology", "Software development" and all of their subcategories.
- *Is this article written in English language?* – All articles must be in English language in order to be considered.
- *Do we have "full text" access to article?* – We needed full text access to be able to include them.
- *Is this article of correct type?* – We would use only articles that were published in scientific journals, published on conferences, books or book chapter.
- *Does this article suit our research topic, based on quick title and abstract preview?* – We firstly focused on its title and abstract. If it was immediately clear that an article is within our topic, then we would include it.
- *Does this article suit our research topic, based on full text review?* – If we weren't sure article suits our topic based on quick preview, we looked in its full text.

3.2 Article exclusion process

After executing defined search phrase in each of stated libraries, we got a total of 5.616 article hits.

Figure 1 shows how we, using defined exclusion criteria, excluded all irrelevant articles. Along every activity line on Figure 1 (in parentheses), there is a number that represents how many articles met each of defined criteria. We found, that total 7 articles were relevant to our topic of using Personas in software development.

4 ARTICLE REVIEW

4.1 Extension of the Personas technique for the requirements stage

Articles [4, 7] propose a way to extend Personas technique to make it easier to systematically integrate in existing "classic" requirements stage of software development process.

The article authors argue that all HCI (Human-Computer Interaction) techniques (including Personas) share the same two basic weaknesses [4, 7]:

1. They haven't got fully defined and accurate procedure that would guide software engineer to successfully integrate it software development process.
2. They haven't got fully defined products, which each of identification steps produces.

Proposed solution includes the extension of basic Personas technique activities, defined by Cooper in [2, 5].

They're proposing an extension of next activities [4, 7]:

- *Activity 1, State Hypotheses* – Adding sub activity *Hold Ethnographic Interviews*, in which we should interview potential users to find out their motivations and behaviors.
- *Activity 2, Identify Behavioral Variables* – Adding sub activity *Synthesize Interview Responses* in which we synthesize the responses of all interviews, before actually conducting rest of activity 2 tasks.
- *Activity 3, Identify Ranges of Behavioral Variable Values* – Authors are proposing addition of sub activity *Identify Ranges of Behavioral Variable* Values in which we should identify range of possible values for each of behavioral variables. This sub activity should be executed before other sub activities in activity 3.
- *Activity 8, Designate Persona Types* – Addition of sub activity *Enrich the System with Secondary Personas*. In this activity we should what secondary Persona needs are likely to enrich the system.
- *Activity 10, Implement and Evaluate Prototypes* – Authors are also proposing addition of this activity which isn't added in classic Persona creation process. In this activity we should create and validate Persona mock-ups.

Marcengo, Guercio and Rapp in paper [9] describe PayPal's decision and integrating process for Personas. They used their experience to create next guidelines [9]:

- Start with well-defined goals and a team that covers multiple areas.

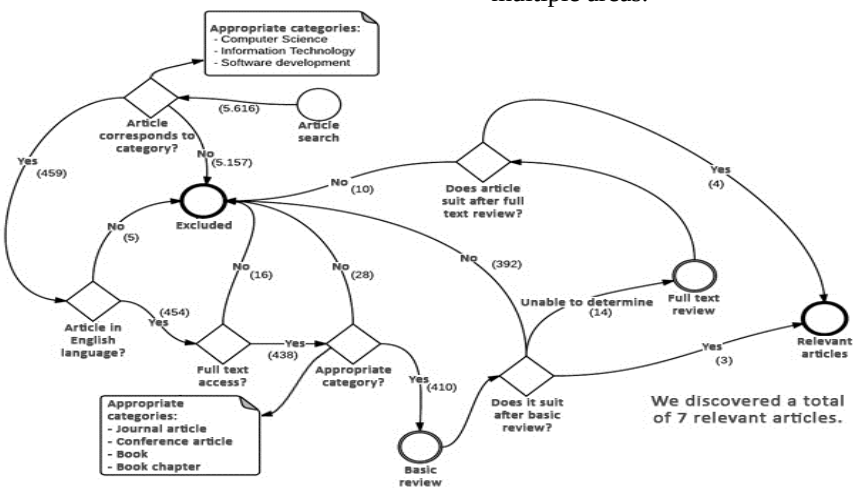


Figure 1: *UML Activity diagram – Visualization of article exclusion process (number of articles in parentheses).*

- Aggregate data from previous user researches, before starting to develop Personas.
- Start with domain and user data, which were already collected in previous user researches.
- When assigning important attributes to Personas, use big white boards on which then write important attributes. Then use Post-It stickers to define values to said attributes, so you can easily move them around.
- Don't start with specified number of Personas. Let clustering specify the number of relevant Personas.
- Create documents that describe personas [9]:
  - Brochure – One sided document.
  - Foundation Document – Word document with full Persona details.
  - Poster – Big posters to decorate hallways.
  - Presentation – PowerPoint presentation of Personas.
  - Intranet site for Personas.
- Have "beta" version of Personas and create "success case studies", before showing them to larger audience.

Their main goal of using Personas was to achieve internal consistency. Also, Personas which had more attention from developers were the one that represented higher business values [9].

4.2 Trait List Persona

Kurosu [6] proposes a new type of Persona as a replacement for classic Persona, called Trait List Persona. Trait List Persona is built from predefined user traits which were obtained through classic user research. This should shorten the time and lower the cost to make Persona [6].

With the use of sHEM method, Kurosu assessed both classic Persona and Trait List Persona, and finally compared both of them, which yielded following results [6]:

- *Inspection time* – Classic Persona had shorter inspection time, because it was easier for developers to resonate with classic type. Trait List Persona was more challenging to understand because after developers read each trait, they had to change their thought state to be able to resonate with this type of Persona.
- *Contents of Inspection* – Classic Persona has wider use case, because its description makes the Persona come to life. Kurosu thinks this result is natural, because only most important traits are included in Persona definition.
- *Coverage of Diversity* – Trait List Persona covered wider array of traits and problems with which end users might have to deal with.

Kurosus final thoughts are that combination of both Personas in a real world software development project would yield better results than use of any of these two types individually.

4.3 Personas in Agile Software Development (ASD)

Haikara [8] proposes a way to naturally extend agile software development (ASD) process with Personas. User interaction design differs in different ASD models [8]:

- *Extreme Programming (XP)* – Customers are represented by users and their opinions are taken into account during requirements stage and release.
- *Feature-Driven Development* – Well formatted user documentation and large web-based help system are a part of user engineering.
- *Crystal Methodologies* – Explicit interaction design process is defined.

Kurosu integrated Personas with Mobile-D process, which is based on ASD XP. Integration process and necessary steps are shown on Figure 2.

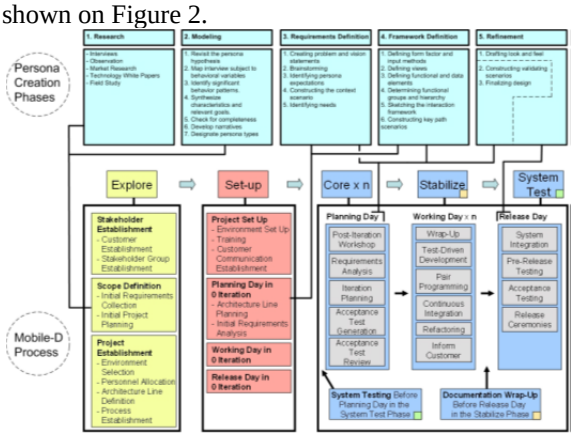


Figure 2: *Persona integration with Mobile-D process* [9].

In article [11] Broschinsky and Baker describe process and challenges of Personas integration in LANDesk Software. They're using XP style of ASD and were always struggling to fulfill "customer on-site" demand of XP, as they are a big company and their customer is not always known upfront. Human Factors department suggested and implemented the use of Personas to fill that hole [11].

4.4 Using Personas for functionality identification

Rosenberg, Stephens and Collins-Cope [3] describe a way to use Personas in conjunction with ICONIX process for a more focused product. Specifically they're proposing use of Personas for software functionality identification, and not only user interaction design. For this ICONIX process is extended in three ways [3]:

- *Interaction design* – Key step in interaction design is identification of potential users: Personas.
- *Personas* – Personas use for functionality identification.
- *Interaction Scenarios* – Interaction scenarios are similar to UML use-case diagrams, but include more information, specifically users' goals for using our software.

Proposed technique includes creation of multiple UML use-case diagrams for each Persona-to-software interaction. This can then serve as a basis on which functionality identification is conducted. Rosenberg, Stephens and Collins-Cope state that this technique is used best when adopted early in development process, because it tends to define basic software requirements [3].

4.5 Personas Layering

Article [10] proposes a very interesting way to reduce time and cost to produce relevant Personas for projects with similar user domain within one company. It's called Personas Layering and its basic idea is that we create [10]:

- *"basic" Persona (reusable)* – It consists of two main items:
  - A core base of persona, which defines central elements common to the whole set of Personas.
  - An internal layer, fundamental and durable, that defines socio-demographic characteristics and Personas daily routine and life goals.
- *external layer (specific)* – A context layer which is modular and interchangeable. It's an extension of the internal layer based on the Persona usage context.

Personas are partly done once and partly upgraded for specific project. The whole Personas Layering framework is shown on Figure 3 [10].

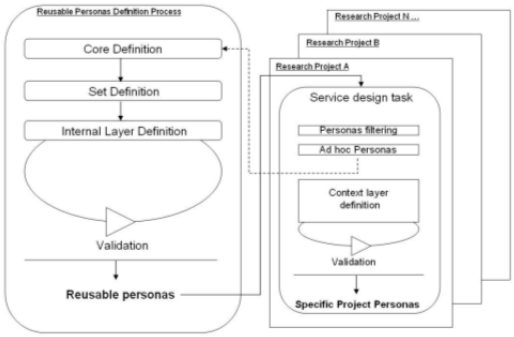


Figure 3: *Personas Layering framework* [10].

5 CONCLUSION

As mentioned articles point out, there are a number of researchers that try to adjust and extend Personas to make them easier to integrate into different stages of development process [4], and also in different company internal structures, most notably ASD [8, 11]. Because ASD is deemed as modern and very powerful way to develop, we think Personas are a perfect candidate to make ASD work even better.

Some interesting articles propose new types or subtypes of Personas. Articles that propose such types are [6] where author proposes Trait List Persona, and article [10], where authors propose Persona Layering as a cost effective way to use Personas.

Persona author Alan Cooper predicted the use of Personas to help designers develop better user focused user interfaces, but some articles propose other ways to user Personas. In book chapter [3] authors propose a way to use Personas for basic and main functionality identification. Using Personas to identify needed functionality to satisfy your customer seems a very interesting way to make your product more user goal focused.

Article [9] describes a more extensive process of integrating Personas in a well formed company PayPal.

Possibility of future research could very well be in a form of integration of some proposed Persona types in a real scenario. Interesting research would also present additional comparison of Trait List Persona and "classic" Persona on a real project. Also a comparison of "classic" functionality definition and Persona functionality identification would definitely yield very interesting results.

After conducting this literature review it has come clear, that properly used Personas can significantly help designers and developers in many ways while developing new software.

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Zbornik 16. mednarodne multikonference
INFORMACIJSKA DRUŽBA – IS 2013

Proceedings of the 16th International Multiconference
INFORMATION SOCIETY – IS 2013

Kognitivna znanost

Cognitive Science

Uredili / Edited by

Urban Kordeš, Matjaž Gams, Olga Markič

http://is.ijs.si

10. in 11. oktober 2013 / October 10th and 11th, 2013
Ljubljana, Slovenia

PREFACE

INTERNATIONAL CONFERENCE OF COGNITIVE SCIENCE

The papers presented at the Cognitive science conference speak for themselves when it comes to scientific quality and especially interdisciplinary approach. Over 25 participants from four different countries greatly contribute to diversity, a wide spectrum of topics of the study of the mind.

We are happy to welcome two invited contributors and keynote speakers. The first one is dr. Ronald Sladky, one of the first graduates of the Middle European joint masters in cognitive science, who is now a renowned neuroscientist at the Medical university of Vienna. His paper presents various approaches to the research of social anxiety disorder, the topic which has been his point of research interest for a longer period of time now. Our second invited guest is dr. Samo Kreft, professor at Faculty of Pharmacy, University of Ljubljana. This time he is presenting an overview of the placebo research – a fascinating phenomenon that is gaining momentum within cognitive science in recent years.

Contributions include interesting phenomenological research, covering methodological questions as well as very concrete experiential areas such as dreams and food related thoughts. Not unrelated, next group reports on attempts of scientific understanding of consciousness. The core of the conference topics consists of papers presenting neuroimaging, neuroscientific studies, social learning and mind-body-environment integration, all these rounded up with a critical philosophical reflection. The proceedings also include contributions from the field of psychology, anthropology, linguistics and art to round up a truly colorful palette of contemporary cognitive science.

This year, we have decided to give a chance also to younger presenters. The new era of scientific research shows great demand for interdisciplinarity and we believe that young blood means a great potential for collaboration, not only among various disciplines, but also among different generations of researchers, as it opens a fresh new look to the old ideas and methods.

Urban Kordeš, Matjaž Gams, Zala Kurinčič, Katarina Marjanovič, Toma Strle

P3 TOPOGRAPHY IN DIFFERENT SENSORY MODALITIES: TESTING THE COMMON PATHWAY HYPOTHESIS OF P3 GENERATION

Daniel Attia, Jurij Dreo, Zvezdan Pirtosek
Department of Cognitive Science
e-mail: daniel_attia@outlook.com

ABSTRACT

The P3 wave is an event-related potential (ERP) component with a latency of 250-500ms. It is considered to be an endogenous potential independent from physical attributes of a stimulus, reflecting attentional, evaluative, categorization and memory processes in response to the stimulus. Specifically, P3 might reflect comparison of the existing neural presentation of the environment with the sensory input and updating in the case of a mismatch [1]. If P3 is indeed independent of the stimulus, that should be reflected in a stable P3 topology across different stimulus modalities [2]. To test this hypothesis 20 healthy subjects completed two sessions of an oddball task using visual and auditory stimuli while 128 channel EEG signal and fMRI signal were acquired on two separate occasions. This is the first study that employs high-resolution EEG while directly comparing P3 topographies obtained in two different stimulus modalities. As such it has the potential to provide a better understanding of the basics of the neural P3 generation. As one of the most often used ERP components, detailed understanding of the P3 generation could provide valuable information both for future study designs and interpretation of results in both basic and clinical research.

1 INTRODUCTION

The first P3 potential[1] was measured already in 1964 by Chapman and Bragdon [3]. It has its largest peak between 250 and 500ms, but can vary depending on the stimulus modality, task conditions, age, gender and many other factors (Fig.1). It is considered to be an endogenous potential, independent of the physical attributes of a certain stimulus. In contrast, a person's reaction seems to be a crucial factor for the generation of the P3 potential, reflecting attentional, evaluative, categorization and memory processes.

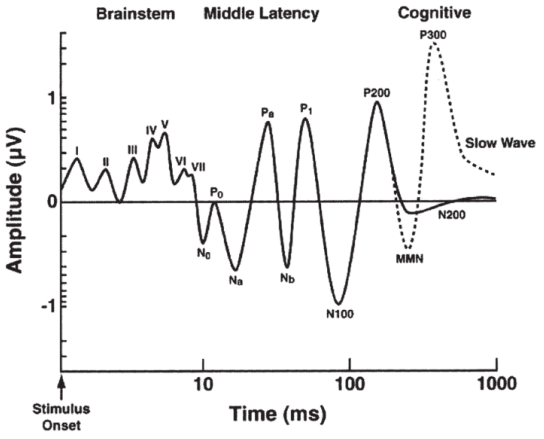


Fig.1: This picture shows evoked potentials and event-related potentials after auditory stimulus presentation. Copyright Cahn and Polich 2006 [4].“

Different theories about the meaning of the P3 have been established, though the most common one is the context updating theory (Fig.2).

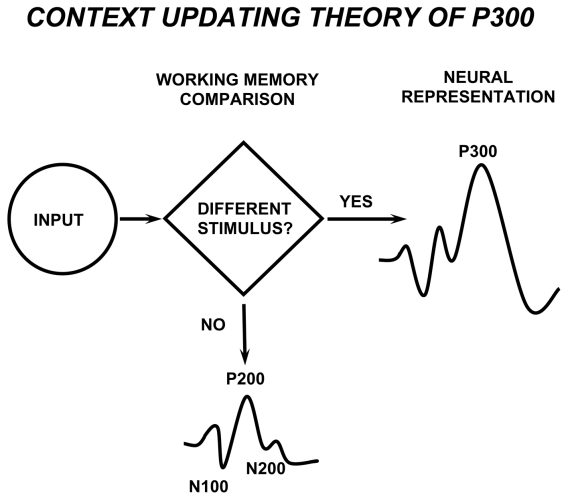


Fig. 2 depicting the context updating theory of P3:
After initial sensory processing, an attention-driven comparison in the takes place, comparing and evaluating the stimulus with the actual neural representation of the previous event, stored in the working memory. If the stimulus is evaluated as the same as the previous, the neural model of the stimulus environment remains the same, leading only to sensory evoked potentials (N100, P200, N200). However, if the incoming stimulus is not the same, the neural representation of the stimulus environment gets updated, once the person pays allocates attentional resources to it, reflected

[1] As it was measured at this time with a maximum peak of 300ms after stimulus onset, it was referred to as P300. Due to different latencies, we prefer the term P3, reflecting the third positive voltage deflection of the ERP component

in the P3
Source: Polich 2003 [1]

After initial sensory processing, the new incoming stimulus is compared with the previous neural representation of the stimulus environment, stored in the working memory. If the stimulus stays the same, only sensory evoked potentials (N100, P200, N200) are generated. However, if the simtulus is different, the stored neural representation of the stimulus environment gets updated, reflected in the generation of the P3 potential.

1.1 P3a and P3b

It has been shown that presented stimuli, when ignored by the subject, lead to smaller amplitude or even to a lack of a P300 response. Researchers found out, that subjects who where instructed to ignore the target tone, still exhibited a P300 signal. This led to the assumption that the P300 consists of subcomponents. In a study of Squires et al. [5] P300 signals between subjects who paid active attention to the stimuli and conditions where they paid no attention at all have been compared. The results showed that that the two P300 potentials differed in latency and scalp topography. In the conditions, where subjects ignored the rare tones, a positive-going potential, which occurred between 220ms and 280ms was generated. This component was termed P3a in contrast to the positive-going potential that occurred when subjects paid attention to the infrequent tones and occurred between 310ms and 380ms, termed P3b. The P3a has its maximum amplitude over frontal-central electrode sites and a latency bet 220-280 ms [6]. It is associated with attention-related brain as well as the processing of novelty and can be observed during orienting and involuntary shifts to changes in the environment [1]. The P3b has its maximum over temporal-parietal electrode sites, is associated with attention and seems to be related to memory processing. In contrast to the P3b, the P3a habituates with repeated presentations [7].

2 PRESENT STUDY

Even though the P3 potential is an already well-studied ERP component, the exact generation and distribution of it remain unclear yet. It has been found to have a maximal distribution over the frontal central areas, as well as the temporal parietal areas. If the P3 is indeed endogenous and independent of different sensory modalities [2], this should be reflected in a stable topography.
A lot of research has been done with the P3, but this is the first study we are aware of, investigating the topographical correlations of different sensory modalities, using a dense array of electrodes as well as fMRI. In our study, we target the question of the generation and distribution of the P3 potential over the scalp, as well as for its topographical correlations in different sensory modalities, testing 20 healthy participants, using EEG and fMRI for measurements. As one of the most often used ERP components, a detailed understanding of the basics of the neural P3 generation could have valuable impact for future study designs and interpretation of results in both basic and clinical research.

2.1 Participants

Participants of our study were invited to two separate sessions of recordings. In the first recording session, consisting of fMRI measurements, 31 healthy subjects participated. Out of these, we finally used 20 subjects to participate in the second recording session, consisting of EEG measurements.

2.2 Recording conditions/Methods

2.2.1 fMRI

Subjects were recorded in a 3 Tesla fMRI scanner (Philips) using high-resolution T1w and T2w images, SE-FieldMap images for BOLD distortion correction and 3mm isometric TR 2.5 EPI BOLD images. The Participants were asked to keep their head still at all the times and to keep their eyes focused on a cross fixation on a screen.

2.2.2 EEG

The EEG data were recorded in a sound proof and electrically shielded room. Subjects were asked to sit still and to avoid movements related to EEG artifacts as much as possible. They were also instructed to keep their eyes focused on a cross fixation on the screen during all time. EEG was recorded with a 128-channel digital amplifier using active Ag/AgCl electrodes attached to a flexible cap (BrainAmp, ActiCap, BrainProducts GmbH). Data was sampled at 5000 Hz (0,016-250Hz analog filters), and then downsampled to 500 Hz. Electrodes were arranged according to the 5/10 system with 6 additional facial electrodes.

3 ODDBALL PARADIGM

In experimental settings, the P300 event-related potential is usually obtained by a stimulus discrimination task, which can be obtained across modalities. In the oddball paradigm, two types of stimuli are presented randomly with different probabilities of their occurrence. If we take the auditory oddball as an example, a frequent standard tone can occur 80% of the time, while in the other 20% a target tone occurs. The subject has to discriminate the target from the standard stimulus. The detection can be registered by a button press, mental counting or simply by paying attention.
In our study, we used a modified version, namely a three-stimulus oddball paradigm. In addition to the frequent and rare target, another rare non-target stimulus is added, called distractor. The P300 component elicited by this oddball

exhibits a large, positive-going amplitude with a maximum over parietal and frontal-central electrode sites. (Fig. 3)

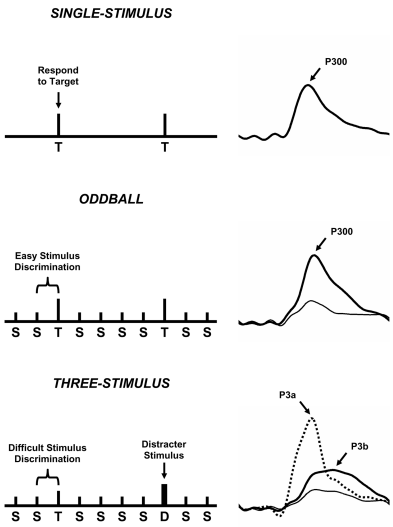


Fig. 3: The Oddball Paradigm. (Polich, Criado 2006) [8]

4 RESULTS

The data is still being analyzed. By the time the Conference will take place the ERP results will be presented.

3.1 Auditory Oddball

An active auditory three-stimulus oddball paradigm was applied to elicit the desired ERP responses. All stimuli were presented randomly and consisted of a frequent standard tone, a frequent tone with a higher pitch and a distractor tone in the form of white noise. The stimuli were presented using the E-Prime software package. For the fMRI the stimuli were presented over stereo headphones, while for the EEG we used frontally placed stereo speakers. A behavioral response task was integrated, subjects had to press a button, each time they detected the target tone.

3.2 Visual Oddball

Also for the visual paradigm we used a three stimulus oddball task. Consisting of three different types of gabor patches: A frequently occurring gabor patch, a rotated gabor patch which functioned as a target stimuli and a distractor, which again was differently rotated than the standard stimuli, as well as different in color.

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CAN EEG PROVIDE ADDITIONAL INFORMATION ABOUT LEARNING PROBLEMS

Comparison of spectral EEG analysis in young healthy adults with age matched adults after perinatal mild-moderate hypoxic-ischaemic encephalopathy (HIE) and learning problems

Tina Bregant[1], Špela Lesar[2], David Neubauer[1], Aleš Belič[3]

1) Department of Paediatric Neurology, University Children's Hospital, University Medical Centre Ljubljana, Slovenia
2) Middle European interdisciplinary master programme in Cognitive Science (MEi:CogSci), University Ljubljana, Slovenia
3) Faculty of Electrical Engineering, University Ljubljana, Slovenia

e-mail: tina.bregantdrmed@gmail.com

ABSTRACT

This paper presents a spectral EEG analysis which was in our experiment shown to provide additional information about learning problems in young adults after perinatal mild-moderate hypoxic-ischaemic encephalopathy (HIE).

We studied an inception cohort of 13 young adults with mild (69.2%) to moderate HIE (30.8%): 5 girls (38.5%), 8 (61.5%) boys, born with mean GA of 36.3 weeks (SD=±3.4) and mean BW of 2640g (SD=±807), now with mean age 22.1±0.7 years and compared them to a healthy group of students: 5 girls (50,0%), 5 (50,0%) boys, with the mean age 23.2±1.1 years.

Epilepsy evolved in 15, 4% adolescents with perinatal HIE. Spectral analysis of normal EEG showed a hyperbolic decline curve with peaks in frequency band of alpha spectrum (8-13 Hz), and a second frequency band peak of beta activity (most prominent in 17-23 Hz). Adolescents with HIE who had learning disorder showed less variability in the spectrum with a constant hyperbolic decline and low or absent alpha activity peaks while in group of healthy subjects, who were all successful students, 10 (100 %) had local maximum at mean 7.0 ± 1.0 Hz. Median value of spectrum rebound was 57%, with distribution of values ranging from 18% (25th percentile) to 162% (75th percentile) above minimum of alpha spectrum power density. Significant differences in alpha rhythm powers in EEG and its principal components were observed.

Learning disorder in HIE patients was associated with absent or attenuated alpha rhythms in otherwise normal EEG, suggesting that the absence of alpha peak predisposes for learning problems. Students with HIE and healthy students, who both reported school success, had very well defined alpha peak.

With additional testing we may provide a new method, spectral EEG analysis, to help us identify specific endophenotype of HIE with learning disorder.

1 INTRODUCTION

Electroencephalography is often used to diagnose and manage epilepsy. Occurrence of electrical distorsions in the brain impulses can be detected by EEG. EEG can be used to identify the type of epilepsy, triggering factors, help identify the area of damaged brain tissue that needs to be removed in epilepsy surgery, or to monitor the brain activity. An EEG can be used to determine whether a person has reversible brain damage that can be treated, or whether the damage is so severe that there is little or no brain function at all. This information can help to decide whether someone should be kept alive using a life-support machine. EEGs can also be used to investigate a number of other conditions that affect brain function including: head injury, brain tumour or abscess, encephalitis, brain haemorrhage, dementia, vertigo, sleep disorders.

EEG power captures some of the dynamics associated with the disruption of neural oscillations. Also, differences in power of resting EEG, particularly in frontal regions, have been functionally linked to cognitive functions. Variation in low alpha activity was shown to be related to individual differences in temperament [1]. Research data suggest that some neurodevelopmental disorders, e.g.: autism spectrum disorder (ASD), is a disorder of neural synchrony, which has its origins in the functional connections within and among regions of the brain [2, 3, 4, 5]. Studies using power spectra, a measure of oscillatory amplitude that contributes

to neural synchrony, have documented that adults with ASD have higher frontal and posterior theta and posterior beta power while they also have lower frontal and posterior alpha power [6]. It is unclear whether changes in neural oscillations represent an index of the disorder or are shared more broadly among both affected and unaffected individuals. We also do not know, whether there are changes which can be contributed to the developmental processes, however there are studies, suggesting that trajectories of EEG power represent important endophenotypes of ASD [7].

In children with mild-moderate hypoxic-ischaemic encephalopathy (HIE) learning disorder in the absence of overt neurological sequelae can be observed. Specific learning disorder is diagnosed by criteria defined by DSM-5 and ICD-10 and represents a single, overall diagnosis, incorporating deficits that impact academic achievements. As hypoxic-ischaemic injury outcome can be seen on a spectrum, ranging from normal to severe neurological impairment, and even perinatal death [8], we can see learning disorder as one of the possible outcomes, which is near the normal outcome; however it requires diagnostic accuracy and target care – intervention. Some specific endophenotypes were observed in our study of young adults with HIE, that were reported previously [9].

In this study, the purpose was to evaluate cortical electrical activity in young adults with perinatal HIE by spectral EEG analysis and compare it to the healthy, age matched controls who have no learning problems.

2 MATERIALS AND METHODS

We studied an inception cohort of 13 young adults with mild (69.2%) to moderate HIE (30.8%): 5 girls (38.5%), 8 (61.5%) boys, born with mean GA of 36.3±3.4 weeks and mean BW of 2640±807g, now mean age 22.1±0.7 years, compared to healthy students: 5 girls (50.0%), 5 (50.0%) boys, mean age 23.2±1.1 years.

HIE in the perinatal period was confirmed clinically by presence of abnormal CTG and/or meconium and/or Apgar scores less than 7 at 5 minutes and/or need for resuscitation and/or cord pH less than 7,2 and /or BE more than -15. HIE was graded by Sarnat and Sarnat criteria.

All participants were examined and interviewed, follow-up EEG after sleep deprivation was performed. EEG recording was performed with Nicolet One, version 5.7.1. with NicVue 2.9.1 reader. Standard international 10-20 anterofrontal system of electrode mountings was used. We used a set of recording conditions after whole night sleep deprivation using: eye movements and alpha blocking followed by eyes closed resting; eyes open resting; hyperventilation; and photic stimulation. Data were exported and further analysed. An average reference was used for the signals, and the signals were filtered with the 50Hz notch filter and band-pass filter between 0.1Hz and 70Hz.Gained data were exported and later analysed with prinicipal component analysis (PCA). From the beginning of measurement till the beginning of photic stimulation, segments of EEG signals were selected for spectral analysis to avoid mixing photic stimulation effects and normal activity of the occipital alpha generators. Numerical analysis was performed in Matlab 2009b (The mathworks inc., Natick, Massachusetts, USA).

3 RESULTS

In HIE group, epilepsy evolved in 15.4% adolescents: one had focal, the other had focal and generalized seizures. Both were excluded from further spectral EEG analysis.

Spectral analysis was done in all young adults with normal EEG: in 11 HIE adolescents (84.6%), and in all 10 (100%) healthy adolescents. Of HIE group, 8 (72.7%) had local maximum at mean 10.0±0.8 Hz, mean spectrum rebounds 82.3± 72.5, while in 3 (27.3%) local maxima were absent. All 3 had learning problems. Learning problems were present in 2, who had local maximum at 9 and 11 Hz, one having 3 and one 221 rebounds, which made their spectral analysis curve outlier. In healthy student group, 7 (70.0%) had local maximum at mean 11.3±1.7 Hz; mean spectrum rebounds 42.3± 40.7, while in 3 (30.0%) local maxima were very low. However, when the same segments, between the beginning of the measurements and photic stimulation, were taken, then alpha peak appeared in them, too. These were good students, with no learning problems.

Principal component analysis (PCA) showed two distinctive components. The first component, located symetrically occipitally, comprised 50% of the total EEG variability and increased during stroboscopic light stimulation. Its eigenvector is oriented from frontal to occipital electrodes, suggesting that it originates in the occipital region. The assumption is backed up by the fact that the significance of the first component raises up to 80% during photic (light) stimulation. The second component, located over the motor area, either symetrically or lateralized, comprised 15% of the total EEG variability and increased during hyperventilation. The third component was demonstrated, but it was not relevant clinically since it was recognized as an eye movement artifact.

Spectral analysis of raw EEG signals showed no significant pattern. The spectral power density showed the usual high power-density values for low frequency signals and approximately exponential decay toward higher frequencies for all subjects. However, spectral analysis of the prinicipal component divided our patients into two group. Rebound of the spectrum in the alpha range was observed in some while in the others, no visible local maximum in the alpha range

was observed. The absence of the "alpha peak" was observed in HIE adolescents with learning disorder.

	Alpha peak present	Alpha peak absent
Learning disorder present	0/10	0/10
Learning disorder absent	10/10	0/10

Figure 1: *Local maximum in the alpha range in healthy students (total No. =10).*

	Alpha peak present	Alpha peak absent
Learning disorder present	2/11*	3/11
Learning disorder absent	6/11	0/11

*Two young adults with HIE had their local maximum at 9 and 11 Hz, with spectrum rebound 221 and 3, which made their spectral analysis curve different from those, who had alpha peak present and no learning disorder.

Figure 2: *Local maximum in the alpha range in young adults with perinatal HIE (total No. =11).*

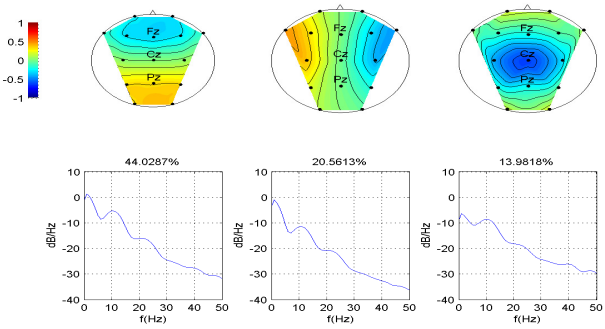


Figure 3a: *Spectral analysis of normal EEGs of an adolescent with no learning problems* showed a hyperbolic decline curve with peaks in frequency band of alpha spectrum (8-13 Hz), and a second frequency band peak of beta activity (most prominent in 17-23 Hz). (Adolescent No. 3)

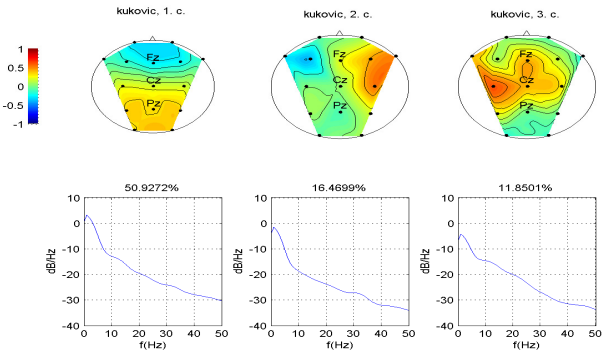


Figure 3b: *Spectral analysis of normal EEGs but in adolescents with HIE who had learning disorder* showed less variability in the spectrum with a constant hyperbolic decline and low or absent alpha activity peaks. (Patient No. 4)

4 DISCUSSION

In 15% HIE adolescents we observed epilepsy, which confirmed that HIE is still one of the major causes of neonatal epilepsy that can persist into adulthood.

Most interesting result of our study is a correlation between charateristics of the power spectrum of the first principal component and learning disorder. As the first component is so clearly located above the occipital area, its signal can be interpreted as the signal at the source of the visual area. Its spectral analysis would indicate the frequency transmission/generation properties of the underlying network. As lower frequencies are associated with wide-area network synchronisations, we can speculate that in people with learning disorder the long-range connectivity of the occipital area was disturbed in a manner that prevents wide-area synchronisation. Hence, alpha rhythms are disturbed, which is clealry seen from the results presented in Figures. One can speculate that the observed alpha rhythms which originate from the occipital area might have a role in organising and storing the collected data into a long-term memory during resting. The disturbance of the rhythms would thus cause learning problems. Only the patient No.5 and No. 7 do not fit the pattern, however, their spectrum is an outlier as well, as it has amost twice the amplitude of the rebound in alpha range than all the rest, and it also has a strong rebound in beta range, suggesting some other reasons that prevent successful learning.

Interestingly, the identified pattern is only visible when principal components are analysed while the analysis of the raw EEG signals shows no such pattern, regardless of the choice of the source electrode. PCA takes into account whole EEG recording at once, therefore, it provides more detailed insight into processes of the most active brain areas, especially, because the conductivity specifics of the head and its geometry can spread the signal from its origin over the whole head.

5 CONCLUSIONS

We confirmed that even mild HIE can have a long-term impact on child development, including epilepsy. However, with spectral EEG analysis, we could define an endophenotype of HIE that has a healthy appearance, with no motor impairment but has specific learning disorder.

This experiment shows, that presence of local maximum in the alpha spectrum is observed in young people, who are successful in school, be healthy or after perinatal insult, suggesting that local maximum in the alpha spectrum is associated with school success.

As we do not currently have a cheap, quick test for learning problems, EEG spectral analysis would provide it. However, more data are needed to confirm that spectral analysis EEG could identify learning problems at a high rate without a lot of false positives or negatives.

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EMERGENCE OF COMPLEX BEHAVIOUR IN SWARMS OF MOBILE AGENTS

Jelena Ćosić Lesičar, Josip Stepanić, Josip Kasać
University of Zagreb – Faculty of Mechanical Engineering and Naval Architecture
I. Lučića 1, HR – 10 000 Zagreb, Croatia
Tel: +385 1 6168592; fax: +386 1 6168466
e-mails: jelena.cosic.lesicar@fsb.hr, josip.j.stepanic@fsb.hr, josip.kasac@fsb.hr

ABSTRACT

In many practical situations, it is more efficient to conduct a given task by the swarm – a particular type of group of autonomous, mobile unmanned agents than by one agent or by humans. In order that the probability of successfull task conduction be acceptably large, often the software governing agents' behaviours needs to be structured in a particular way. In that way, the communication among agents as well as their processing of thereby collected information, needs to be properly structured. In this paper we analyse how the characteristics of the conducted task and its context are related to the principles underlying agents' software realisation, in particular their information processing functions. The emphasis is put onto how one can ground such functions into distributed, wirellesly connected low-capability agen hardwares.

1 INTRODUCTION

In many circumstances, tasks to be conducted in a given environment are dangerous or in other ways inappropriate for humans. Therefore, they are conducted by automatic, or autonomous systems. For example, searches and rescue missions, reconnaisances for tactical operations etc. are conducted by unmanned vehicles, either teleoperated or autonomous. Further in the text we will use the notion of agents for all vehicles and other types of entities that can perform some task partially autonomously, and will concentrate on them. Formally, group of agents can be a software complex, realised in silico, yet with the previous statement they are excluded from considerations in this paper.

Moreover, there is clear difference in using one, solitary agent or a group of agents. Advantages of using a solitary agent is that it is rather easily steered. However, there are advantages of using a group of agents: the group can perform a task if one or several group members become nonfunctional, the group can consist of simpler thus also a cheaper agents, in complex environments a group has larger probability to avoid obstacles if task to be conducted involves path detection, etc.

A particular type of group is called a swarm, resembling biological swarms. Synthetic swarm systems (to be differentiated from biological swarms) are then typically composed of agents that, at the individual level, have relatively limited task-solving abilities and limited knowledge about their environment [1, 2].

Despite the rich set of understood and controllable swarm system characteristics, currently in practice the simpler steering is a crucial advantage for using a single agent.

A lot of researches has been conducted in order to develop robust and flexible software which would enable the group of mobile agents to function autonomously, yet efficiently and reliably in a large set of diverse environments, rather uncharacterised, changing in time.

The bottleneck of broader use of autonomous groups of agents was recognised as a lack of a software with which a controller of a group's member is programmed and which fullfils necessary requirements [3]. The main requirement in that context is the possibility to combine available information and derive additionaly useful information from it, using relativelly simple procedures, if not rudimentary procedures.

Useful software must implement seemingly contradictoral requirements: on the one hand it has to enable the agent to function in unstructured environments, and on the other hand it governs the selectivity, discirminability and other localised requirements that agents need in order to perform a specific task. Presently, it is assumed that complex processing software, e.g. one which attributes to the agents, at least in some amount, the cognitive function, could significantly improve level of the software applicability in the context of autonomous agent groups.

In this paper we analyse the characteristic functioning of collective task conduction by autonomous agents and analyse in which parts one could expect significant improvement in future after collective cognitive level of agent groups is raised.

In section two we present characteristic phases of task conduction collectively by autonomous group of agents. The description will be somewhat reduced compared to the most general case because not all tasks for which autonomous agents are used reached the same level of maturity on the one hand. Section three contains discussion regarding prospectivness of some of these segments from the point of view of rising the cognitive level involved in their processing. Section four summarises and concludes the paper.

2 CHARACTERISTIC PHASES OF COLLECTIVE TASK CONDUCTION

Researches related to autonomous groups of agents cover underwater autonomous vehicles, unmanned ground vehicles, unmanned aerial vehicles, unmanned space vehicles. Designed groups are either homogeneous, thus consisting of only one type of agents e.g. group of mobile robots foraging for some objects in a given terrain, or heterogeneous. Heterogeneity range from differences in processing capabiilities (e.g. group of mobile robot in which some robots are group leaders and other their followers) of agents having identical hardwares to physically different agents (e.g. group of unmanned aerial vehicles representing aerial support to convoy of unmanned ground vehicles).

In order to be somewhat specific, in further text we concentrate on group of mobile robots, identical both in the hardware and in the software, that has to transport collectivelly a heavy load. That is probably the most researched, canonical problem, in the field of collective work of group of agents. Heaviness of the load means that a single agent cannot move the load. Instead, group of robots should combine their work in order to move the load and continue to push it.

Work of a typical group consists of several phases [4]:

- **search** for the object with its identification,
- **recruitment** of sufficient number of agents,
- **pushing the object** by coordinated efforts of agents with possible repositioning, realignment and self-assemblying.

While search and recruitment phases can be performed in a non-coordinated way, governed usually by a single agent, the pushing of the heavy object is by its definition collective action conducted by constant coordination of all involved agents [4].

Biological inspiration in designing the group of agents is constantly present, with ants serving as a the prevalent source of information how living species characterised with rather low procesing cpabilities develop, maintain and utilise cooperative work in a given class of environments. Along with ants, other groups of social insects provide the researchers with useful insights into developing the cooperation.

Time scales, on which mentioned processes are realised, span rather different scales. In this paper the duration of a particular process or of some of its phases is of secondary importance. Because of that, we will not determine or compare time scales of discussed processes.

3 COLLECTIVE INFORMATION PROCESSING

While in previous sections the group of agents was introduced based on their rather manifest prospectivness, it is in order to tackle in more details differences between the software characteristics of the single agent and of the agents in a group. The reason for that is that software for a single agent is self-contained, completed and (by line of previous development) the prevalent form of software design with the significant experience gathered.

If a task is subdivided between group members, a redundancy is achieved so failures in one or several agents do not bring about automatically failure of the complete mission. That is major advantage of this approach. Each member of the group collects data from environment and exchanges it with other members. That, furthermore, brings about the possibility that there is a unique software to be installed in each and every agent within a group. Certainly, that makes installation and maintenance easier. However, because of that, in order that different agents work efficiently in their different local environments during different parts of task conduction, that software should include the rather significant adaptivity characteristics, in that it includes dynamic and temporary development of functions which introduces mutual differences among agents' performances. In other words, the software should include constant checks and procedures for transforming some agents into leaders, or into followers, etc. depending on the assumed need.

As a rule, small part of internal memory is used for exchange of data and the rest is used for motion control and individual sensing.

Software for autonomous action of a group of mobile agents (e.g. robots or UAVs) is not yet developed because there is no sufficient level of understand the essence of collective performance which can be effectively formalized and operationalized. This is a general phenomenon for distributed agent systems such as UAVs [5], group of mobile robots or stationary robots connected with unique process.

However, the following characteristics are universally present in the basis of their underlying software [3]:

- **rudimentariness**,
- **openness** regarding number of group elements,
- **closeness** regarding information exchange.

Regarding the code rudimentariness, the software must have as few as possible commands of simpler character and overall as short as possible code.

Regarding openness, the software must enable the group to preserve functionality even if one or more agents are missing. On the other hand, openness of the software to the number of elements allows adding new elements which ultimately increases probability of successful task realization and that extends the duration of the group action if requested. The openness means that the group is scalable, i.e. its performances change quantitatively but not qualitatively with changes in the number of the agents.

The closeness regarding information exchange, puts demand on the software in the sense that if the element in a given time interval does not receive data from other elements of the system it can continue to conduct its subtasks. Otherwise, malfuncioning in a single agent would during time propagate to block the whole group or at least its significant part.

The influence of environment is seemingly missing in requirements for software. But since the environment is rather unstructured, moreover dynamic, its influence is profound, and imposes two characteristics of the software for agents: robustness and adaptivity, which we thereby encounter again from the other point of view. It is assumed that all these characteristics are manifest in agents behaviour, thus as a collective phenomena.

Installation of the software in agents means that processes, to be performed by the group during task conduction, should be paralelised. Currently prospective candidates for software are extensively looked for as based upon evolutionary algorithms [6].

In groups of agents, the design of which is aligned with biological examples, each agent is characterised with a rudimentary processing capabilities. All collective actions of such a group are attributed with the notion of emergence. In that sense, collective task conduction is a collection of emergent phenomena. As an example, cooperation is a rather important emergent phenomena within a group of agents.

Setting the focus of the group performance onto complex information processing means that, in fact, we assume that the group has some cognitive abilities. A cognitive system is a continuously active complex adaptive system autonomously exploring and reacting to the environment with the capability to "survive" [7]. A cognitive system should be able to operate in a wide range of environmental conditions, performing tasks of different kinds. A rudimentary cognitive system does not need to be efficient, instead the performance boosting specialized algorithms can always be added afterwards [7]. Since a cognitive system is not necessarily intelligent [7], we do not consider the notion of (artificial) intelligence explicitly.

4 SUMMARY AND CONCLUSIONS

Distributed, autonomous groups of mobile agents are being developed regarding their potential in conducting a variety of tasks. However, characteristics of their controllers are not sufficiently developed and are seen as bottlenecks for reaching the level of efficient, robust, adapted groups.

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THE INFLUENCE OF ANXIETY, GENERAL SELF-EFFICACY AND MOTIVATIONAL SYSTEMS ON COGNITIVE SELF-EVALUATION AND PERFORMANCE DURING THE ANTI-V TASK

Rado Gorjup[(1)], *Paolo Bernardis*[(2,3)], *Michele Grassi*[(2)], *Walter Gerbino*[(2,3)]
[(1)] Faculty of Education, University of Primorska, Slovenia
[(2)] Department of Life Sciences, Psychology Unit, University of Trieste, Italy
[(3)] B.R.A.I.N. Centre for Neuroscience, University of Trieste, Italy

ABSTRACT

Attention and performance are influenced by trait and state anxiety through top-down and bottom-up regulation in terms of expectations and stimulus relevance. In the present study we examined the relationships between anxiety, general self-efficacy and motivational systems in a sample of 195 university students.

In line with previous research high positive correlations were found between the behavioral inhibition system (BIS anxiety) and trait-state anxiety (STAI) scores. Subjective measures of optimism (GSE, LOT-R) showed high correlations between them and with the behavioral activation system (BAS reward, drive, fun). Negative correlations were found also between subjective measures of optimism and STAI scores (in particular, with trait anxiety).

Then, we randomly selected 54 subjects out of the previous sample to participate in the ANTI-V task, after completing the CFQ and ARS-2 questionnaires as measures of cognitive self-evaluation and performance expectation. CFQ was positively correlated with trait anxiety. More importantly, strong positive correlations were found between CFQ and the BIS general motivational system, as well as between CFQ and ARS-2 state anxiety scores. High negative correlations were found between CFQ and GSE scores. We also found a positive correlation between some CFQ subscales and performance in the ANTI-V task.

Key words: anxiety, cognitive self-evaluation, attention-vigilance performance, ANTI-V task, Signal Detection Theory

1 INTRODUCTION

The present study explores the influence of some psychological traits and characteristics (anxiety, general self-efficacy, motivational systems) on cognitive self-evaluation and performance during the ANTI-V task. Personality researchers traditionally distinguish trait and state anxiety, which in some way can be explained by a lack of control (Lazarus, 1991). In recent years a lot of research attempted to explain the relationship between anxiety and attention. Many theoretical models have been empirically verified from the perspectives of cognitive and affective neuroscience (Phelps, 2006). Anxiety perceived from the cognitive perspective is highly related to hyper-vigilance (Eysenck, 1997).

Although it is clear that anxiety modulates attentional biases, this process is still poorly understood. Since attention is not unitary, but rather depends on a set of structurally and functionally independent networks interacting in a complex way (Posner & Peterson, 1997; Posner et al., 2007), the question arises whether attentional biases overlap with other more or less stable traits and psychological characteristics.

Therefore, we run an experiment in which all attention networks (alerting, orienting, executive control) were measured independently and, at the same time, Signal Detection Theory (SDT) indices of vigilance were objectively measured as well. We also evaluated the correlation between state anxiety, several personality measures and cognitive self-evaluation on performance in the ANTI-V task. The ANTI-V task (Roca et al., 2011) was chosen as the best available tool to study the influence of anxiety and other psychological characteristics on attention networks and vigilance.

2 METHOD

2.1 Participants

We invited 195 university students (age range: 19-31 years) to participate in the first part of the study and complete the self-evaluation questionnaires. Two weeks later 54 subjects were randomly selected from the above sample to perform the ANTI-V task. They completed the CFQ and the ARS-2 just before the execution of the ANTI-V task.

2.2 Questionnaires

State-Trait Anxiety Inventory (STAI)

The STAI consists of 40 items measuring both state and trait anxiety (Spielberger et al., 1970). The Italian version was used (Sanavio et al., 1997). Cronbach's alpha: .89 for trait anxiety and .91 for state anxiety.

Behavioral motivational systems (BIS/BAS)

Gray (1981, 1987) defined personality traits in terms of individual differences in two basic brain-motivational systems: behavioral inhibition system (BIS) and behavioral activation system (BAS). Based on the assumption of independence of BIS/BAS systems, Carver and White (1994) developed a questionnaire on BIS anxiety, and BAS reward, drive and fun seeking. Cronbach's alpha for the whole BIS/BAS scales: .79.

General Self-Efficacy (GSE)

General self-efficacy is a uni-dimensional construct referring to personal optimism that one's actions are responsible for successful performance in any task (Schwarzer & Jerusalem, 1999). The Italian version of GSE scale was adopted (Sibilia et al., 1995). Cronbach's alpha for the whole 10-item scale: .87.

Life orientation test (LOT-R)

The LOT-R 10-item scale measures optimism and pessimism along a bipolar dimension (Carver et al., 2010). Cronbach's alpha: .87.

Cognitive Failures Questionnaire (CFQ)

It is a 25-item scale measuring one's awareness of absentmindedness, memory failures, space-orientation failures. Participants are asked to indicate on a 5 point Likert scale (0= never, 4= always) how often in the last six months they experienced the error described by the question (e.g., "Do you bump into people?"). Broadbent et al. (1982) confirmed the relationship between anxiety and CFQ. The Italian version (Mecacci et al., 2004) was used. Cronbach's alpha: .79.

Anxiety Rating Scale (ARS-2)

The original ARS, based on the multi-dimensional anxiety theory (Martens et al., 1990), was developed by Cox et al. (1999). The revised ARS-2 was developed as a short version, made of three subscales based upon a single statement - rating scale format (cognitive state anxiety, somatic state anxiety, self confidence) and a 7-point Likert scale from 1 (not at all) to 7 (intensely so). The three original aggregate statements were translated into Italian. Cronbach's alpha: .85.

2.3 ANTI-Vigilance task (ANTI-V)

The ANTI-V task (Roca et al., 2011) was used to obtain a direct measure of vigilance in addition to the usual attention network scores (alerting, orienting, executive control). Instructions presented the task as a game. A row of five cars was presented to participants above or below the fixation point, superimposed on one of two parking lines in the background road. Participants pressed the left or right button ("c" for the leftward and "m" for the rightward direction of the central car). The row of cars was presented for 200 ms, but responses were allowed up to 2000 ms.

To analyze the functioning of the executive control network, in half (congruent) trials the flanker cars pointed in the same direction as the target car whereas in the other half (incongruent) trials the flanker cars pointed in the opposite direction. To manipulate the orienting factor, a 50-ms visual cue (an asterisk) was presented for 100 ms before the row of cars, either in the same (valid cue) or in the opposite location (invalid cue). In one third of trials there was no asterisk. Alerting was manipulated by the presence/absence of a 50-ms warning auditory signal presented 500-ms before the target car. To obtain a direct measure of vigilance, the ANTI-V dual-task paradigm required participants to detect infrequent stimuli (central car displaced to the left or right), to inhibit the response to the main task ("c" vs. "m" buttons), and to press the spacebar. The ANTI-V task included five 64-trial blocks. The first block contained training trials with a visual feedback and a final pause. The other four blocks contained experimental trials with no possibility to stop until the end of block.

3 DATA ANALYSIS AND RESULTS

3.1 Correlations

As predicted by the hypothesis that the behavioral inhibition system is motivated by anxiety, high positive correlations were found between BIS and STAI trait anxiety scores: $r(193)= .47$, $p< .01$. Subjective measures of optimism (GSE and LOT-R) were strongly correlated: $r= .54$, $p< .01$. The GSE measure correlated with BAS fun ($r= .27$, $p< .01$) and with BAS drive ($r= .34$, $p< .01$). Negative

correlations were found between subjective measures of optimism and STAI scores, between trait anxiety and GSE (r= -.55, p< .01). CFQ and STAI trait anxiety scores were positively correlated, with more anxious subjects reporting a higher frequency of cognitive failures: $r(52)$= .35, p< .01. More importantly, strong positive correlations were found between CFQ and BIS scales (r= .54, p< .01), as well as between CFQ and ARS-2 state anxiety scores on all three aggregate statements (CFQ - cognitive state anxiety, r= .44; CFQ - somatic state anxiety, r= .42; CFQ - self confidence, r= .41; all p< .01). A negative correlation was found between CFQ and GSE scores, r= -.41, p< .01).

No correlation was found between CFQ scores and d' for left/right discrimination (the primary ANTI-V task) while a positive correlation emerged between the Memory and Distractibility CFQ subscales and the vigilance score (i.e., the d' difference in valid vs. invalid trials, referred to spacebar pressing). Our results suggest that the amount of reported failures in memory and attention domains is a good predictor of performance in a complex task that requires the participant to suppress a routinary response.

Analysis of Variance (ANOVA)

The expected pattern of RTs was found for both left/right discrimination and vigilance tasks (Roca et al., 2011). No significant differences were found for the distribution of d' in the left/right discrimination task.

4 CONCLUSIONS

Our results are consistent with evidence that CFQ and trait anxiety are positively correlated (Mecacci et al., 2004). We confirmed that anxiety modulates attention (Mathews & MacLeod, 2005) and in particular the executive control network (Bishop, 2009). Reported failures in memory and distractibility areas predicted a significant proportion of variance in vigilance performance, measured as the increment due to cue validity. However our results are in line with the work of Roche et al. (2005), who performed an event related potential (ERP) analysis and found that high vs. low CFQ participants performed similarly, but showed a different pattern of electrophysiological responses; i.e., individuals aware of their cognitive failures (high CFQ scores) might put more attentional effort then those with low CFQ scores in order to obtain the same performance result. Other directional hypotheses should be explored: vigilance performance should be (a) worse in participants with high scores on anxiety (trait anxiety, BIS anxiety, and ARS-2) and (b) more effective in participants with better scores on optimism (GSE and LOT-R).

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KOGNITIVNA ZNANOST KOT SPODBUDA ZA RAZISKOVANJE DOŽIVLJANJA

PREGLED PRISTOPOV

Urban Kordeš
Univerza v Ljubljani, Pedagoška fakulteta
Kardeljeva pl. 16, Ljubljana
urban.kordes@pef.uni-lj.si

POVZETEK

Empirično raziskovanje doživljanja je dobilo v zadnjih letih dokaj pomembno vlogo v okviru raziskovanj kognitivne znanosti. V članku pregledam najbolj pogoste metode pridobivanja doživljajskih podatkov. Empirične pristope poskušam kritično ovrednotiti in odgovoriti na nekatere epistemološke probleme, ki so značilni za tovrstno raziskovanje.

Ključne besede: doživljanje, empirična fenomenologija, prvoosebno raziskovanje

1 UVOD[1]

Empirično raziskovanje doživljanja, je področje, ki se ga je znanost nekajkrat lotila (najbolj zagnano v sklopu projekta t.i. nemškega introspekcionizma v začetku dvajsetega stoletja) in, zaradi očitnih težav z objektivizacijo subjektivnega, prav tolikokrat opustila. Najnovejši poskus prihaja iz logov kognitivne znanosti – interdisciplinarnega sklopa raziskovanj duševnosti. Zanimivo je, da je ravno vzpon objektivnih (tretjeosebnih) raziskav kognicije vzpodbudil ponovno oživitev raziskav neposrednega živega (prvoosebnega) človekovega izkustva. Ravno nevroznanstveniki, katerih naloga naj bi bila raziskovanje nevrofizioloških korelatov doživljanja, začenjajo ugotavljati, da ni problematična samo tretjeosebna stran, ampak da slabo poznamo tudi prvoosebno. Ta ugotovitev hitro pripelje do spoznanja, da pridobivanje zanesljivih podatkov o doživljanju ni preprosto. Ni dovolj samo vprašati, niti ni dovolj pripraviti dobrega vprašalnika.

Potrebo po resnem, znanstveno podprtem preučevanju doživljanja je že v sedemdesetih letih prejšnjega stoletja nakazal kibernetik von Foerster [1], veliko bolj sistematično in natančno pa se je področju posvetil njegov varovanec, biolog Varela. Prelomnemu članku, ki je uvedel pojem nevrofenomenologije [2, 3] je sledil zbornik *The View from Within* [4]. Od začetka devetdesetih do danes je empirično raziskovanje doživljanja, kljub mnogim kritikam in nasprotovanjem, dobilo svoje mesto v sklopu kognitivne znanosti. O tem morda najbolje priča razdelitev področij raziskovanja duševnosti, kot jo na svojih predavanjih zariše en najbolj znanih kognitivnih nevroznanstvenikov Damasio [5]: »dogodki« v možganih (fiziologija), vedenje in doživljanje.

Dejstvo, da je prvoosebno raziskovanje dobilo svoje mesto na zemljevidu pristopov kognitivne znanosti še ne pomeni, da so Varelove ideje zacvetele na način kot ga je začrtal pri snovanju nevrofenomenološkega projekta. Področje razmišljanja in praktičnega udejanjanja tovrstnega raziskovanja je še v povojih. Zelo daleč je do Varelove vizije enakovrednih področji prvoosebnega in tretjeosebnega raziskovanja, ki bi – vsak s svoje strani epistemološkega prepada – gradili korpus znanja. V zadnjih letih se je razvila pisana paleta poskusov pridobivanja in osmišljanja podatkov o doživljanju. Kljub temu pa je zaenkrat raziskovanje doživljanja bolj nekakšen pripomoček tretjeosebnim raziskavam; pripomoček, ki ga je treba uporabiti samo v nuji in katerega rezultate je treba vedno preveriti z drugimi metodami. Ta metodološka nesamostojnost področja je v veliki meri posledica epistemoloških problemov, ki prežijo v ozadju in se jih raziskovalci večinoma izognemo. Zaradi vsega tega zaenkrat področje preveva občutek, da zaenkrat še ni privedlo do prav posebej novih spoznanj o duševnosti.

2 ZEMLJEVID PRISTOPOV

V nadaljevanju bom pregledal nekaj najpomembnejših sodobnih pristopov in poskusil pokazati kako se njihovi zagovorniki spoprijemajo s problemi, ki jih s sabo prinaša poskus objektivnega raziskovanja subjektivnosti.

Pristop »preprosto vprašaj« (kvantitativne raziskave)
Najpogostejši način spoprijemanja z epistemološko-metodološkimi problemi prvoosebnega raziskovanja v okviru kognitivne znanosti je, da ta vprašanja ignoriramo.

Leta 1972 je Heinz von Foerster na pol za šalo, na pol zares zapisal svoj tako imenovani "prvi teorem": "Globlji kot je problem, ki ga ignoriramo, večja je verjetnost za slavo in uspeh.« [1] Kakorkoli že zgleda trditev posmehljiva in cinična, drži. Kognitivna nevroznanost (pred njo pa seveda vse naravoslovne vede) dosega svoj skokovit napredek izključno zahvaljujoč temu, da se je odpovedala spraševanju o osnovah fenomena, ki ga raziskuje, torej o tem kaj je zavest, kaj doživljanje in kakšen je odnos med

[1] V besedilu se naslanjam na daljšo razpravo z naslovom "Negotova pot: od izkustva do empiričnega podatka", ki bo objavljena v eni od prihodnjih številk Analize.

doživljajskim in telesnim. Podobno velja za velik del kvantitativnih študij doživljanja. Kot rečeno, gleda zaenkrat večina kognitivne znanosti na raziskovanje doživljanja kot na pridobivanje manjkajočih podatkov za raziskovanje fiziološke podlage duševnosti. Torej kot na nekakšno stransko pomoč. Na srečo za zadovoljitev teh potreb ni treba gledati pregloboko.

Tovrstne raziskave uporabljajo psihološke metode. Pri pridobivanju doživljajskih podatkov se večinoma zanašajo na vprašalnike, ki udeležencem ponujajo izbiro med vnaprej določenimi možnosti ali pa skale, kjer morajo udeleženci izbrati stopnjo intenzitete določene doživljajske modalnosti (na primer: »Koliko ste srečni? – Obkrožite številko med 1 in 10!«). Seveda je na področju raziskovanja izkustva veliko težje zagotavljati zanesljivost zbiranja podatkov – navsezadnje je področje, ki ga raziskujemo ravno subjektivnost. Kljub temu je takšen način raziskovanja v zadnjih letih zacvetel. Dober primer so raziskave, povezane z mirovno možgansko aktivnostjo (torej s tem kaj počnejo možgani, ko niso zaposleni s kakšno konkretno nalogo). Na doživljajskem nivoju se s to aktivnostjo povezuje tako imenovano tavanje misli (»mind wandering«), pri raziskovanju katerega se uporabljajo zgoraj omenjene metode. Vprašalniški tipi raziskav se na področju kvantitativne empirične fenomenologije navadno izvajajo v obliki vzorčenja izkustva – udeležence se ob izbranih trenutkih (navadno naključno izbranih) zaprosi, da odgovorijo na vprašanja [6, 7].

Tako dobljeni podatki o doživljanju dobro dopolnjujejo nevrofiziološke študije. Odgovarjajo na vprašanja o pogostnosti določenih doživljajskih kategorij, njihovi intenziteti in o povezavah (vnaprej izbranih) kategorij z (izbranimi) konteksti. Ne omogočajo pa preverjanja ustreznosti izbranih možnosti. Tovrstno raziskovanje je torej utemeljeno na predpostavki, da tako ali tako poznamo strukturo doživljajske pokrajine – naloga prvoosebne znanosti je ugotavljanje kvantitativnih podrobnosti. Težava je v tem, da vsi raziskovalci, ki se nekoliko bolj poglobijo v opazovanje doživljanja [4, 8] ugotovijo, da so naše intuitivne predpostavke o tem področju v veliki meri zgrešene. Paradoksno se znova in znova pokaže, da udeleženci ne poznajo (ne poznamo) svojega doživljanja (enako seveda velja za raziskovalce). Pristop, ki ga nekateri imenujejo »preprosto vprašaj« (»just ask«) ni veljaven. Kot je zaslutil Varela [2] in je kasneje empirično pokazal Hurlburt [9, 10], je potrebno sistematično in vztrajno urjenje v opazovanju doživljajske pokrajine. Raziskave, ki predpostavljajo, da udeleženci poznajo svoje doživljanje in je dovolj, da ga po njem preprosto vprašamo praviloma torej ne pokažejo ničesar drugega kot naše predstave o tem kakšna naj bi bila doživljajska pokrajina. Enako velja za filozofske argumente, ki temeljijo na »očitnih« doživljajskih primerih.

Dialoške kvalitativne metode

Doživljanje - področje, ki nam je najbolj intimno blizu, je kot kaže hkrati najbolj zakrito. Kako to? Naša pozornost je skoraj povsem nevajena usmerjanja na »kako?« doživljanja na račun stalnega ubadanja (zanimanja, kreiranja, manipuliranja) z vsebino doživljanja (»kaj?«). Kot v kinu, kjer je merilo dobre predstave to, da se publika lahko povsem vživi v predvajano zgodbo in čimbolj pozabi na platno, projekcijsko napravo itd., nas tudi naša vsakodnevna bivanjska naravnanost vleče v popolno vživljanje in identifikacijo z »zgodbo« oziroma tako imenovano resničnost (v vsakodnevnem pomenu te besede). Husserlov pojem *naravna naravnanost* se zdi zelo ustrezen za opis te bistvene in izjemno močne poteze naše duševnosti.

Vso pozornost smo vajeni usmerjati v rezultate procesa urejanja, interpretiranja, pojasnjevanja, kategoriziranja in osmišljanja doživljanja. Nič pa v proces sam. Ugotovitev, da slabo poznamo svoje neposredno izkustvo [4] lahko preoblikujemo v metodološko smernico za raziskovanje doživljanja: naravno naravnanost je potrebno postaviti v »oklepaj«. Ker se pri tem upiramo navadi oziroma naravni naravnanosti, je za opazovanje doživljanja potrebna sistematična, vztrajna vaja.

Hitro lahko opazimo, da ugotovitve o naravi doživljanja in metodološke smernice za pridobivanje podatkov o doživljanju zelo spominjajo na osnovne pojme Husserlove fenomenologije: naravna naravnanost, epoche in fenomenološka redukcija. Kljub aluzijam na Husserlovo terminologijo, pa je treba spomniti, da gre pri empiričnem raziskovanju doživljanja za bolj ohlapno in širšo uporabo pojmov kot si jo je zamislil avtor fenomenologije. Ne zgrešimo veliko, če gledamo na veščino opazovanja doživljanja kot na veščino upiranja naravni naravnanosti oziroma postavljanja njenih učinkov v oklepaj. Poleg tega se zdi *fenomenološka redukcija* primerno ime za takšno početje [11]. Kot rečeno, pa je takšna uporaba pojmov širša kot si jo je zamislil Husserl. Pomen fenomenološke redukcije, kot praktične introspekcijske metode je dvojna. Njen prvi aspekt postavljanje predpostavk, interpretacij itd. v oklepaj, torej opazovanje doživljanja »kot se kaže«. Da pa lahko to dosežemo je pomemben še en aspekt: obrat pozornosti k strukturi doživljanja, razgledovanje po področju, ki smo ga ves čas zanemarjali – po platnu in projekcijskem mehanizmu. Na primer: namesto, da smo pozorni na vsebino misli, se ozremo na to *kako* mislimo. Si tiho govorimo, vidimo slike, morda samo vemo vsebino, brez doživljajske simbolne reprezentacije? Morda je za empirično nabiranje prvoosebnih podatkov drugi aspekt še pomembnejši.

Na teh metodoloških temeljih je zrasla večina sodobnih šol empiričnega raziskovanja doživljanja. Vse imajo skupnih nekaj osnovnih metodoloških smernic.

- »Preprosto vprašaj« načelo ne deluje. Za raziskovanje doživljanja je potrebno vztrajna vaja v veščini introspekcije. Zaradi tega mora biti raziskovanje iterativno.
- Večina metod je dialoških. To pomeni, da zgoraj omenjeno iterativnost dosežemo s ponavljanjem intervjujev z udeleženci.

Ostale metodološke smernice so prekopirane iz Husserlove fenomenologije:

- Osredotočenje na fenomene (stvari kot se kažejo v našem izkustvu) in postavljanje običajnih privzetkov o stvareh v oklepaje. Redukcija opazovanega na fenomene kot tisto edino, kar je dano v izkustvu in gotovo.
- Iskanje kar se da podrobnih opisov doživljanja in odrekanje razlagam. Urjenje v opisovanju doživljanja (in v spraševanju po takih opisih), ne da bi ga kakorkoli klasificirali, umeščali v teoretske okvire, pojasnjevali ipd. K temu spada tudi odpoved ocenjevanja »realnosti« opaženih fenomenov.

Nekoliko podrobneje bom predstavil dve, verjetno najbolj razširjeni, metodološki šoli empirične fenomenologije: deskriptivno vzorčenje izkustva in eksplikativni intervju. Razlika med omenjenima smerema je v odnosu do retrospekcije. Kot smo ugotovili v prejšnjem poglavju je raziskovanje doživljanja (z izjemo čuječnega opazovanja doživljanja tu-in-zdaj) v bistvu raziskovanje *spomina* na preteklo doživljanje. Spomin je pri fenomenološkem raziskovanju temeljni medij, ki omogoča dostop do raziskovalnega polja. Nobenega dvoma ni, da spomin ni ravno idealen vmesnik, zaradi tega je eno od bistvenih vprašanj do katerega se mora opredeliti vsak pristop, kako se najbolj natančno približati živemu izkustvu. Kako ohraniti pretekle uvide čim bolj nedotaknjeno?

Šoli empiričnega fenomenološkega raziskovanja, ki ju bom omenil se ločita ravno po svojem odnosu do problema »čistosti« spomina. Razlika je v tem, da ena poskuša zmanjšati retrospekcijo na minimum, druga pa poskuša izuriti spraševalca v dialoški spretnosti »čiščenja« konstruktov, ki jih prinese s sabo spomin.

V Parizu se je okrog fenomenologa, psihologa in psihoterapevta Vermerscha izoblikovala metodološka smer, katere najbolj znana predstavnica je Varelova asistentka Claire Petitmengin. Raziskovalci te smeri so izoblikovali dialoško metodo znano kot eksplikativni intervju[2] [12], katere glavna značilnost je poskus izpiliti umetnost spraševanja do te mere, da bi se lahko približala tudi spominom, ki niso čisto sveži in jih odrešila konstruktov, ki so se nabrali v vmesnem času. Takšno »čiščenje« (ki je seveda iterativen proces) je kot kaže možno in mnogokrat zelo uspešno. Zanimive so na primer raziskave Petitmenginove s področja doživljanja sebstva [13] ali pa nekoliko starejše delo s področja tako imenovanih predzavestnih stanj [14]. Petitmenginova je bila tudi del skupine, ki je po Varelovi smrti nadaljevala delo na področju nevrofenomenologije, vendar so to skupino ukinili, ker udeleženi nevrologi niso videli v fenomenološkem delu dovolj pomembnega prispevka. Koncept eksplikativnega intervjuja se je v zadnjih letih zelo »prijel«. Različne izpeljanke tega pristopa se uporabljajo za raziskovanje doživljajskih vzorcev, torej ponavljajočih elementov doživljajske pokrajine. Primer sta porajanje misli [14] ali raziskovanje doživljajskega aspekta intuicije [15].

Drugače se problema loteva Hurlburt, utemeljitelj tehnike deskriptivnega vzorčenja izkustva - DVI [8]. DVI lahko primerjamo z geološkim sondiranjem tal: na naključnih mestih vzamemo vzorce, ki jih potem v laboratoriju prečistimo in analiziramo. Analogno, pri DVI v naključno izbranih trenutkih sondiramo (vzorčimo) izkustvo. Sondiranje je v praksi izvedeno tako, da raziskovalni subjekt s sabo nosi napravico, ki nežno zazvoni ob naključno izbranih trenutkih. Subjekt poskuša "zamrzniti" doživljanje tik pred piskom. Za razliko od preprostega odgovarjanja na vprašanja o doživljanju (kot pri prej omenjenem kvantitativnem vzorčenju izkustva) gre tukaj za proste opise doživljanja – v priročno beležko, v zadnjem času pa še pogosteje na mobilno napravo. Kot pri vseh metodah tudi ta temelji na ponavljanju in na intervjuju. Ne kasneje kot štiriindvajset ur po sondiranju, se udeleženec sreča z raziskovalcem, ki poskuša skozi pogovor o vzorcih dobiti čim bolj jasne podatke o doživljanju. Naloga raziskovalca je, da odpre prostor za natančno opazovanje zbranih izkustev. Za razliko od eksplikativnega intervjuja, Hultburtova tehnika ni usmerjena v čiščenje retrospekcijskih konstruktov. Njena moč je v velikem številu zbranih vzorcev in zmanjšanju posledic retrospekcije na minimum. Hurlburt uči, da je treba takoj odstopiti od pogovora o izbranem vzorcu, če dobi spraševalec občutek, da je udeleženec prešel od raziskovanja spomina k premlevanju ali konstrukciji. Glavni del urjenja v tej tehniki je namenjen veščini »odprtega« spraševanja in prepoznavanju ter izogibanju pojasnjevanja [9]. Rezultat DVI je nekakšen zemljevid udeležencève doživljajske pokrajine. Tehnika je stara že skoraj štirideset let in je verjetno najbolj razširjena in najbolj metodološka varianta sodobnega provoosebnega raziskovanja. V tem času so raziskovalci pridobili ogromno količino podatkov o doživljanju, tako da jim je uspelo sestaviti nekakšno enciklopedijo osnovnih doživljajskih elementov (t.i. »codebook«).

Kot vidimo, sta oba koncepta raziskovanja doživljanja komplementarna. Pristopi, kot je DVI, so uporabni za »risanje« zemljevida vsakodnevnega izkustva, eksplikativne dialoške metode pa se lahko poglobijo v določen (izbran) aspekt. Sodobne empirične metode raziskovanja doživljanja so torej v veliki meri utemeljene na smernicah Husserlove fenomenološke redukcije, kljub temu pa raziskave ostajajo na nivoju zbiranja deskriptivnih podatkov – torej na nivoju, ki se mu je Husserl poskušal izogniti. Dejstvo je, da raziskave doživljanja v okviru kognitivne znanosti s Husserlom ne delijo visokih ambicij ejdetske znanosti. Ena izmed kritik DVI je, da ves čas pobira po površini doživljanja. Hurlburta takšne pripombe ne motijo [8] in jasno daje vedeti, da je ta nivo ravno tisto, kar v svojih raziskavah išče. Isti raziskovalec rad kritiko obrne v napad na »introspekcijo iz fotelja«[3] [11], torej na filozofske razprave, katerih argumenti ne temeljijo na sistematičnem urjenju introspekcije, ampak na »očitnih« spoznanjih o doživljanju.

[2] explicitation interview

[3] armchair introspection

Poglobljene prvoosebne raziskave

Kljub temu, da cilj večine prvoosebnih raziskav ni odgovarjanje na globlja spoznavnofilozofska vprašanja, pa nekateri vseeno merijo (merimo) višje. Varela [3] na primer že v naslovu nevrofenomenološkega članka odkriva svoje pričakovanje, da bi empirična fenomenologija pripeljala (ali vsaj pripomogla) k rešitivi »težkega probkema«, t.j. problema odnosa me duševnim in telesnim. Husserl je jasno prikazal paradoksne predpostavke na katerih gradi psihologija (v vlogi spoznavnoteoretske vede). Začarani krog med raziskovanjem duševnosti kot vzroka za racionalno argumentacijo in uporabo racionalne argumentacije kot orodja za raziskovanje duševnosti verjetno res zapira možnosti klasične empirije za razumevanje narave vrženosti v doživljanje. Na naravoslovni način lahko raziskujemo lastnosti našega bivanjskega stanja, ne pa njegovih temeljev. Po drugi strani je treba tudi priznati, da se Husserlovi upi po vzniku nove, primarne znanosti niso uresničili. Fenomenologija je postala cenjena filozofska usmeritev, ni pa ji uspelo pridobiti privilegiranega mesta na katerega je avtor upal.

Morda vseeno obstaja pot med Scilo naravoslovnega reduciranja in Karibdo sterilnega logičnega argumentiranja. Morda bi bilo treba vzeti resno Husserlova spoznavnoteoretska opozorila, po drugi strani pa Hurlburtove kritike introspekcije iz fotelja. Husserl je pokazal omejeno moč empiričnih rezultatov, vključenih v mrežo klasične psihološke znanosti (oziroma naravoslovne metode). Nikjer pa ni pokazal nemoči samega empiričnega raziskovanja. Po drugi strani sta Varela in Hurlburt jasno pokazala nemoč sklepanja o doživljanju brez utemeljitve v sistematičnem preverjanju. Vprašanje za prihodnje raziskave na tem področju je torej: ali je možno temeljito empirično raziskovanje doživljanja – tako temeljito, da bi privedlo do povsem novih spoznanj o duševnosti.

Menim, da je. Menim tudi, da je to vrsta raziskovanja, ki jo je imel Varela v mislih.

Viri

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PLACEBO – HEALING LIE THAT IS NOT A LIE

Samo Kreft
Department of Pharmaceutical biology
Faculty of pharmacy, University of Ljubljana
Aškerčeva 7, 1000 Ljubljana, Slovenia
Tel: +386 1 4769703
e-mail: samo.kreft@ffa.uni-lj.si

ABSTRACT

Placebo effect is an improvement of health status of the patient which is caused by the socio-psychological interaction between the patient and the therapeutic procedure. Only the presentation and perception of therapeutic procedure are important for socio-psychological interaction, placebo effect is therefore caused also by empty procedure (e.g. medicinal product without active ingredient). It can efficiently contribute to the patients' health, but nevertheless its use in practice is controversial. Prescribing a placebo is a lie that can undermine the relationship and trust between the therapist and the patient, even if this lie is in the best interest in the patient.

Lie is defined as "untrue statement with intent to deceive" (1) or "a false statement to a person or group made by another person or group who knows it is not the whole truth, intentionally" (2). Usually, somebody is hurt by the lie. But there is also a lie which can be of great benefit - we call it the placebo.

1 DEFINITION

Placebo is usually a **product** in a form of tablet, capsule or injection, which is presented to be a medicinal product, but actually it does not contain any pharmacologically (or immunologically or metabolically) active substance and it is made only from the starch and sugar, or injectable solution, of salty water. Placebo is, more generally, any "inert" medical **procedure**: application of placebo product, surgery with just cutting and sewing the skin, acupuncture without penetration through the skin. "Inert" procedure means a procedure which does not contain any **directly** physiologically, pharmacologically or physically active intervention. Nevertheless, placebo can have **indirect** physiological, pharmacological, physical and therapeutic activity, achieved trough the psychological activity due to the **presentation** by a person giving placebo and the **perception** by a person receiving placebo. The components of presentation that can influence the perception are for instance the colour, smell, shape of medicinal product, but also the verbal and non-verbal communication with doctors, pharmacists and nurses participating in the therapy. And of course patients previous experiences, expectations, preferences and believes are also influencing the perception.

2 METODS FOR STUDYING PLACEBO

Placebo effect is therefore an effect caused by presentation and perception of medicinal procedure and not by its physical or chemical content. Placebo effect is not only a result of the empty medicine placebo, but can be achieved also when using the proper pharmacologically active medicinal product (or other active therapeutic procedures). In these cases, the entire effect of the drug consists of two parts: a pharmaco-physiological effect caused by the active ingredient and placebo effect caused by presentation and perception.

To study placebo effect, we have to compare the treatment effect in two groups of patients, which differ in what was presented to them, but do not differ in what was actually given to them (they both received either active or both inactive treatment). The study has to be randomised, to obtain groups of equal patients that do not differ in age, disease severity, lifestyle or any other parameter.

In optimal study design, there are four groups of patients differing in what was presented to them, and also in what was actually given to them (Table 1).

		What is presented to the patient (What patient thinks he receives)	
		No active treatment	Active treatment
What is actually given to the patient	No active treatment	1. "spontaneous healing"	2. "empty (placebo) treatment"
	Active treatment	3. hidden application of treatment	4. open application of treatment

Table 1: *An optimal design of trial to study placebo effect includes four groups of patients differing in what was presented to them (that they received active or inactive treatment), and also in what was actually given to them (active or inactive treatment).*

Group 1: patents do not receive any therapy and any possible improvement in their disease is only a result of spontaneous healing. The patients in this group can also receive empty (placebo) treatment, which is openly presented to them as being empty.

Group 2: patents receive an empty medicine (placebo) but they are told that they are getting the real treatment. In the optimal study design, the treating physicians should also believe that he is giving these patients the real active treatment. In these patients, the placebo effect is added to the effect of spontaneous healing.

Group 3: patients receive the real treatment, which is hidden (e.g., drug added to food or to infusion). In these patients, the treatment success is only due to spontaneous healing and pharmacological effect, but not due to the placebo effect.

Group 4: patients receive the real treatment, and are informed about this. In addition to spontaneous healing and the placebo effect, the treatment success in this group is also due to the pharmacological effect of the active substance.

The placebo effect can be calculated as the difference in treatment success between groups 2 and 1 or between groups 4 and 3.

The pharmacological effect can be calculated as the difference in treatment success between groups 3 and 1 or between groups 4 and 2.

Due to ethical reasons and legislation on clinical experiments, all the participating patients must be informed about the trial design and give a consent to participate in the trial. The patient should of course not know in which group he will be, but he has to know, which groups will be included in the study and that there is a chance, that he will be in either of the groups. This unavoidable circumstance can already influence on the results.

Unfortunately, most researchers (and sponsors) are interested only in pharmaco- physiological effect, so they perform the studies with only groups 4 and 2. There are many thousands of such studies with different medicines and wide variety of diseases. Group 1 is added to the study occasionally as additional control, and this enables the calculation of placebo effect. There are about 200 studies of that type. Studies which include also group 3 (hidden application of therapy) are extremely rare (~10).

3 PRESENTATION INFLUENCES PLACEBO EFFECT

Several studies were performed, which investigated how individual aspects of presentation of the therapy to the patent influences the extent of placebo effect.

Interesting study was performed on sport performance in cyclists. A group of four cyclists had to ride a distance of 10 kilometres several times. Twice they did not receive any tablet. This was baseline measurement for control and the results were compared to the results of subsequent trials. In the following three trials, the riders got a blank tablet, but once they were informed that received placebo, once they were said that the tablet contains a low dose of caffeine and once they were said that the tablet contains a high dose of caffeine. When the riders knew that they received placebo, their result deteriorated by 1.5%. When they thought they were getting a lower dose of caffeine, the result improved by 1.3%. When they thought that they received the higher dose of caffeine, they improved the result by 3.1%. This is not a great improvement, but it is large enough that in the Olympics game it could improve one's rank from the 10th of the first place. Since the effect is achieved through the psychological effect and not through chemical or biological intervention, it is not prohibited by the anti-doping rules.

The following example shows how the placebo effect influenced by prejudice. In a group of 82 healthy volunteers, the pain sensation caused by electric shocks was assessed (Rebecca et al. 2008). First the pain sensation was measured without any medicine (for baseline comparison). Then all the volunteers were given a placebo, half of the participants were informed that the drug had a regular price of $2.50 per pill and half that the price had been discounted to $0.10 per pill. This was followed by retesting pain sensation by electric shock. In volunteers, who thought to receive expensive medicine, pain was reduced by 85 %, and in volunteers with thought to receive cheaper drug the pain reduction was 61 %.

One study compared the effect of placebo treatment, accompanied by a warm and empathic conversation, and the effect of placebo treatment, accompanied by a neutral, and cold, business-like, but not unfriendly conversation (Kelley et al, 2009). Patients with irritable bowel syndrome received placebo therapy (placebo acupuncture, with the needles that fold as a radio antenna and do not penetrate in the body). The effect of augmented therapy was twice as high as effect of neutral therapy. All patients were also analysed namely the psychological test. Psychological characteristics did not affect the success of the neutral treatment. Extroverted patients were particularly good responders to augmented placebo therapy. Significant differences were also observed between the four therapists. Every therapist performed augmented therapy in some patients, and neutral therapy in others. Although all therapists received same training on how to implement one and another type of therapy, the differences were huge. Some therapists are more and some less able to develop appropriate relations with patients.

Placebo effect is therefore greater if the patient believes and relies on the strength of the therapeutic effect. The more impressive the therapeutic procedure is, the higher placebo effect can be expected. According to this logic, it is obvious, that a surgery should have a great placebo effect. Studies with the placebo surgery (therefore such, in which the patient only cut through the skin and re- stitched, while the inside of the body is not interfered), are very rare due to ethical concerns. One study (Moseley et al. 2002 compared the efficacy of well-established arthroscopic surgery for osteoarthritis of the knee with the placebo (sham) surgery. Surprisingly, the efficiency of real and sham surgery was equal. The overall effect of the real operation, which was at

that time for several years routinely used, was only due to psychological effects. Surgical interference with the knee did not contribute to the effect.

4 INTERACTIONS BETWEEN PLACEBO AND ACTIVE THERAPY

When a study has an optimal design with all four groups of patients, the results enable calculation of placebo effect in two situations: 1) when placebo is achieved alone or 2) when it is achieved on top of pharmacological effect. Table 2 presents the data on average pain perceived in four groups of patients are from the study of Atlas et al. 2012. When placebo effect was achieved alone, it reduced the pain for 0.47 points on the scale. When it was achieved on top of the effect of remifentanil, it additionally reduced the pain only for 0.26 points (besides the reduction of 0.40 points achieved by the active substance). This effect (although in this case not statistically significant) is called negative interaction (antagonism). Despite this negative interaction, the pain is lowest, when the patients actually received the active ingredient, and they knew about this.

average pain		What was presented		Difference (placebo effect)
		No treatment	Remifentanil	
What was given	No treatment	4.10	3.64	0.47
	Remifentanil	3.70	3.44	0.26
Difference (pharmacological effect)		0.40	0.20	

Table 2: *An optimal design of trial enables the calculation of placebo effect when achieved alone or on top of pharmacological effect. The data on average pain perceived in four groups of patients are from Atlas et al. 2012.*

In some cases also a positive interaction (also called synergism) between placebo and active therapy can occur. Table 3 present the data from the study of Amanzio et al. 1999, where extreme positive interaction was observed. The active substance proglumide did not cause any analgesic effect (reduction of pain) when applied hidden. Its effect was only achieved when applied openly. Proglumide is per se not an analgetic drug. It only enhances the analgesia produced by opioid drugs or analgesia caused by placebo, where endogenic opioids are released.

average pain		What was presented		Difference (placebo effect)
		No treatment	Proglumide	
What was given	No treatment	-0,80	-2,00	1,20
	Proglumide	-0,80	-3,10	2,30
Difference (pharmacological effect)		0,00	1,10	

Table 3: *Placebo effect and pharmacological effect can be in positive interaction (synergism). The data on average pain perceived in four groups of patients are from Amanzio et al. 1999.*

5 THE USE OF PLACEBO IN CLINICAL PRACTIS

The use of placebo in clinical practice is controversial. Prescribing a placebo is a lie, that can undermine the relationship and trust between the therapist and the patient. On the other hand this lie is many times in the best interest in the patient.

The other difficulty for the physician is, that placebo tablets are not available, since the patients would soon found out, which tablets are empty. An anonymous web-based survey of physicians from Internal Medicine departments of 3 Chicago-area medical schools was (Sherman et al. 2008) found, that 45% physicians had used a placebo in clinical practice. Among treatments given were antibiotics for viral or other nonbacterial diagnoses (33%), vitamins (20%), ibuprofen (12%), subtherapeutic doses of medication (7%), herbal supplements (5%), saline infusions (3%), prepared placebo tablets (2%), and sugar or artificial sweetener pills (1%).

6 CONCLUSION

Placebo can efficiently contribute to the patients' health, but its use in practice is controversial. The optimal way to exploit the power of placebo would be to add it to every therapeutic procedure in a form of warm and empathic conversation and optimistic presentation of the therapy.

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HOW RESEARCHING DREAMS AFFECTS THE EXPERIENCE OF DREAMS

Alja Lah
Gabrje 93, 1356 Dobrova, Slovenia
Tel: +386 31 221 661
e-mail: aljalah@gmail.com

ABSTRACT

A phenomenological study was conducted for the purpose of exploring and describing the experience of what it is like to study one's own dreams. The focus was on people that start to pay attention to their dreams, and what changes might occur in their experience of dreams, and waking life.

1 INTRODUCTION

Hervey de Saint-Denis (1867, po Hobson, 1988) had already shown, via systematic self-observation, that it is possible for individuals to gain greater access to their own dreams simply by turning their attention to their own dream process. To elucidate dreaming, he believed we need to examine it directly. We also need to have in mind that we cannot examine dreams like an independent object that is separated from the person, because they apparently respond to observation. Friedman (2007) held a dream class where every week he'd have a talk on some dream theorist, and every week everyone in the group would share a dream from the previous week. He was struck by the way that what people dreamed from week to week was influenced by the dream theories being talked about. The group's dream imagery and content literally changed so that it fit the model of the theorist of the week. He supposed that it is this phenomenon that convinces any dream theorist he is on the right track. Jung expected to find archetypal images in dreams, and he found more and more. Freud, too, found what he was looking for, proving he was right. It shows how remembering and working with dreams is a project in which your dreams are active partners.

The primary purpose of this research was to explore how the content, experience, and relation to dreams change with increased attention to dreaming. We were also interested in how dream content is influenced by a person's theoretical concepts about dreams.

2 METHOD

In order to research dreaming directly, and to answer the research questions, a multiple (comparative) phenomenological case study was chosen. Phenomenology seemed the appropriate qualitative methodology as its derived findings provide an understanding of a phenomenon as seen through the eyes of those who have experienced it and identify the essence of human experience related to a certain phenomenon (Kordeš, 2009).

The research included eight participants, who had not studied dreams before or taken any particular interest in this matter. They started to explore their dreams by keeping dream diaries for four months. In the second half of this interval they were also actively involved in their dreams. Phenomenological dialogues were conducted once a week, attempting to describe the experiential world of the respondent. The focus was on experiencing the process of dreaming, and above all, on possible changes of participant's relation to dreams and dreaming. They also participated in discussions about dreams and dream theories. They were divided into three groups, according to the interpretational scheme presented to them. Three participants learned about Freud dream theory, three participants learned about Jung dream theory, and two only participated in general dream discussions.

Transcribed interviews were analysed according to the procedure of thematic content analysis of Glaser and Strauss (1967) as well as Flick (2006) with the use of computer software NVivo (2006). Dream content was analysed with the use of a list of Freudian and Jungian symbols, as well as typology of dreams by Busink and Kuiken (1996). Themes or meaning units related to the participant's lived experiences were identified. Final interpretations of analysis were formed according to the model of grounded theory of Glaser and Strauss (1967), which cannot be generalised without additional measures.

3 RESULTS

Changes have appeared on several levels. Among others were: difference in quantity of dreams, dream content, and relation to dreams between three periods: (a) before the study when the participants weren't paying attention to dreams; (b) the first two month of the study when they were only keeping a dream diary; (c) the last three months of the study when they were actively involved in their dreams. By paying more and more attention to their dreams and learning about certain dream theories, their dreams

responded in interesting ways, changed in frequency and content and also their relation to dreams has changed.

3.1 Types of dreams

In order to examine how paying attention to dreams affects dream content we used typology of dreams by Busink and Kuiken (1996). We compared the distribution of dream types between first and second phase of the research.

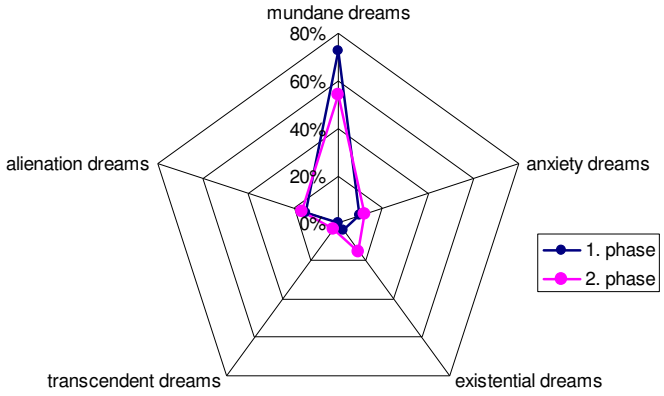


Figure 1: *Average distribution of dream types of all participants in 1. and 2. phase of research.*

In average participants had less mundane dreams in the second phase and more existential and transcendent dreams. Alienation and anxiety dreams were less frequent with some participant but more frequent with others so in average they stayed the same.

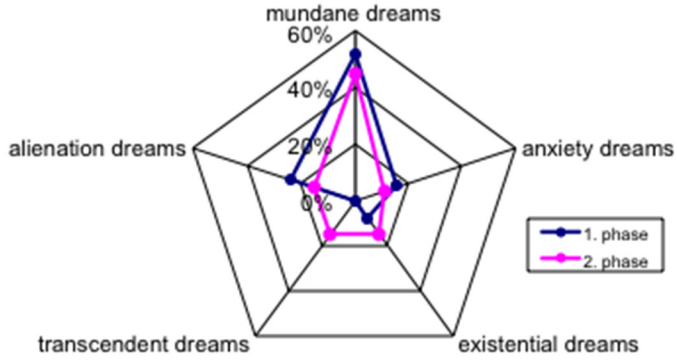


Figure 2: *Distribution of dream types of participant Ivan in 1. and 2. phase of research.*

In the above figure we can see how paying attention to dreams has changed types of dreams of participant Ivan. Mundane, anxiety and alienation dreams were less frequent in the second phase but transcendent and existential dreams were more frequent.

Previous research (Kuiken idr., 2006; Busink in Kuiken, 1996; Kuiken in Sikora, 1993) has shown that existential dreams are followed by reports of self-perceptual depth, existential disquietude, reconsideration of life's meaning (or emptiness), life's value (or insignificance), and so forth. Transcendent dreams are followed by reports of spiritual release, ineffable awe, self-renewal, and liberation from daily entanglements. Participants of this study reported of similar feelings and thoughts, which might point to a connection between changes in types of dreams and personal changes of participants. (This raises a question weather the dream content changed or did the participants change the way they made sense of dreams?)

General perception of dreams in the end of the study was that they hold great potential for self-research and creative problem solving. Participants have reported positive experiences when paying attention to dreams, saying they gained insights about themselves and their loved ones, their aspirations, ways of thinking and how they perceive the world around them. Dreams were also a reminder for thinking about certain things and made them change their perspective on some situations or problems in their lives. They had a direct effect on their waking lives. For example some participants made choices and actions according to what they dreamed. Some of them said they were going to continue working with their dreams because they enrich their everyday lives.

3.2 Relation to dreams

Before the study, when participants weren't paying attention to dreams, most of their relation to dreams was neutral or slightly positive. Some thought that dreams have meaning and some thought they don't. Some of them liked their dreams and some didn't because most of the time their dreams weren't pleasant. After the first phase of the study when they were only keeping a dream diary, all of the participants' relation to dreams stayed the same. Except two of them changed their feeling toward dreams; for them dreams lost their mysticism and magic. By really paying attention to their dreams day by day, they began to believe dreams were meaningless and boring. After the second phase of the study, when they were actively involved in their dreams, all of the participants were more enthusiastic about dreams. In fact dreams were a lot more important to them as they were before the study. It seem that for all of the participants the passive phase (only writing a dream journal) was drawing their attention to dreams but at the same time making them aware how unorganized and chaotic dreams were.

Most of the participants reported that they changed their relation to dreams in the second phase of the study when they were actively talking and learning about them. Dreams seem to be one of the most chaotic and unorganized things that we experience in our lives. Since we are used to make sense of the world around us, experiencing something

chaotic is rarely pleasant. When (in the second phase of the study) they were taught how to find meaning in their dreams and connect them to waking life, they started to change their relation to dreams and like them more. Some of them described that the interviewer was asking them the right kind of questions to make them interpret the dream content in a different, more meaningful way. This points at the importance of a co-researcher, who broadens awareness of the dreamers' experience. With his questions he helps a person "discover" fields of experiential world that he previously may not have been aware of or maybe just didn't know how to look in the right direction (Kordeš, 2009).

3.3 Concepts about dreams

In order to research how dream content is influenced by a person's theoretical concepts about them, participant were learning about different dream theories. We categorized dream elements from dream reports according to lists of dream symbols that were made beforehand. The use of Jung and Freud dream theory was only symbolic; it enabled us to detect how different concepts, which participants have about dreams, can affect their dreams. The results showed that dream content of participants that were learning about Freud dream theory changed in a different way than did the dream content of participants learning about Jung dream theory. The change was slight but consistent, whereas the change in the group of people not learning about any theory wasn't consistent. We can interpret this as confirmation that dreams do change according to expectations and theoretical concepts of the dreamer. Due to limited possibilities of generalization of the results, this interpretation must be seen as a grounded theory ("grounded theory," Glaser and Strauss, 1967).

4 CONCLUSIONS

The results of this study imply that there exists a two-way exchange between dreams and waking life. Dreams of our participants changed according to their expectations and theoretical concepts. Participants also reported changing their thoughts and actions according to their dreams. Paying attention to dreams changed the intensity and type of dreams, as well as dreamers' relation to dreams.

Our interviews revealed a deep-seated tendency to make sense of experiences (in this case dreams) and comprehend them (isn't persistent search for theoretical function of dreams also a part of that?). The purpose and phenomenological orientation of our research was not focused on answering the question of functionality. However our findings can maybe contribute to the understanding of what any study of dreams should take into account:

(a) A two-way exchange takes place between dreams and waking life, because of that it would probably make more sense to explore characteristics of this interaction prior to dream content.

(b) Researching dreams is a fine example of participative research. Until we discover a non-invasive neurological method that would allow third person "observation" of mental content, dreams can be researched only by interfering in them. Our study shows how active observation changes content, intensity, and frequency of dreams. Some methods of studying dreams (Domhoff, 1999; Hall, 1953; Kuiken in Miall, 2001) try to reduce the effect of observation to a minimum, nevertheless the question remains whether this type of research is able to reach the full spectrum of phenomena associated with dreams. Based on the findings of this study we can reliably say that they cannot.

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EYE MOVEMENT CORRELATES FOR COMPLEX SUBTRACTION IN HEALTHY ADOLESCENTS AND IN ADOLESCENTS WITH HYPOXIC-ISCHAEMIC ENCEPHALOPATHY

Tatjana Levstek[1], Tina Bregant[2], Anja Podlesek[3]
[1] University of Ljubljana, Slovenia
[2] Department of Pediatric Neurology, University Children's Hospital, University Medical Center Ljubljana, Slovenia
[3] Department of Psychology, Faculty of Arts, University of Ljubljana, Slovenia
e-mail: tanja.levstek@guest.arnes.si

ABSTRACT

With our research we tested the hypothesis, that healthy adolescents differ from adolescents with neonatal hypoxic-ischaemic encephalopathy in arithmetic processing. Arithmetic processing was inferred from analyzing eye movement correlates for complex subtraction. More specifically, participants subtracted two digit numbers with regard to the borrow problem and to the distance between the first and the second operand. The differences between groups were perceived in reaction times, in eye movements, and also in strategies of complex subtraction. The borrow problem affected the response accuracy in healthy group, while the adolescents with hypoxic-ischaemic encephalopathy did not perceive the difficulty of the tasks. As expected, participants with neonatal hypoxia were using more alternative strategies of subtraction, which were not based on the subtraction facts, recalled from the memory. The distance between operands however was shown to have no influence on subtraction.

1 INTRODUCTION

The human ability for arithmetic has a cognitive substrate with an anatomical-morphological correlate (Chochon et al., 1999; Dehaene, 1997; Dehaene et al., 2004). The intraparietal sulcus is activated in all number tasks, while the areas of precentral and prefrontal cortex are engaged in mental arithmetic; temporal cortex is important for memory recall of arithmetic facts. Little is known about the eye movements as a measure of mathematical thinking processes. A few studies have demonstrated the results of eye tracking data. Green et al. (2007) investigated eye movement correlates of younger and older adults' strategies for complex addition and they discovered that young adults more successfully distinguished between different strategies. Schneider et al. (2008) investigated eye movements during the number line estimation task. They suggested that both manual responses and eye movements show improvement in the number estimation with increasing grade level. Moreover, they suggested that the eye-tracking data are sensitive indicator of children's developing number sense. Levstek et al. (2012) were studying subtraction characteristics investigating eye movement correlates for complex subtraction of two digit numbers with/without borrow (i.e. whether the units of the first operand are smaller/larger than the units of the second operand) and with small/large distance between operands in adolescents. They discovered that the borrow problem has a large impact on response accuracy and reaction time (RT), but a somewhat smaller impact on the eye movements. Surprisingly, large or small distance between operands did not show any significant differences (neither in RT nor in response accuracy or in eye movements). These results suggested that mental calculation with large numbers is not based on mental representations of operands and shifts of attention along an 'internal number line'.

Strategies of simple and complex arithmetic have been already studied. Lemaire et al. (2007) were investigating strategies used to solve two-digit addition and subtraction problems. Participants used the full decomposition strategy, i.e. they decomposed both operands to tens and units and the partial decomposition strategy, i.e. they decomposed the second operand only. They used full decomposition more often than the partial decomposition strategy to solve addition problems, but to solve subtraction problems both strategies were used equally often. Also, it was of great importance whether the problems involved carryover or borrow and weather the size of the operand was big or small. Torbeyns et al. (2009) studied efficiency and flexibility of indirect addition (IA), i.e. the use of addition

in subtraction tasks (e.g. 53 – 29 = 53 – 30 + 1) in the domain of three-digit subtraction using the choice/no-choice method. Results indicated that (i) adults spontaneously apply IA on three-digit subtractions and use IA with the same frequency as direct subtraction (DS) strategies, (ii) IA resulted in faster responses without any loss in accuracy than DS and (iii) adults flexibly applied IA and DS strategies on the basis of task and individual strategy performance characteristics. Levstek et al. (2012) showed that adolescents, which were not using arithmetic in everyday's life, used many different strategies of mental subtraction in choice condition, full and partial decomposition strategy and also the intuitive approach to solve subtraction problems (e.g. indirect addition). Almost 70% of participants were using full/part decomposition strategies and did not change the manner of subtraction during the mental calculations. They suggested that strategy is stored in a long-term memory like other arithmetic facts and it is used by retrieval. Torbeyns et al. (2004) were also investigating the differences between children with strong and weak mathematical abilities. Both children with and without mathematical abilities solved simple arithmetic problems by means of three different types of strategies, (a) retrieval, (b) decomposition strategies, (c) counting strategies. Both groups differed in the frequency, accuracy, and adaptiveness with which they applied these strategies. Children without mathematical disorders adapt their strategy choices to the difficulty of the problems; children with disabilities make less adaptive strategy choices. As age and experience increase, the differences in both the accuracy of counting strategies and the adaptiveness of strategy choices decrease. This was taken as evidence that the development of children with mathematical disabilities is delayed in comparison with the development of their normally progressing peers.

In our research we studied the group of adolescents, who experienced mild to moderate hypoxic-ischaemic encephalopathy (HIE) in neonatal period. The outcomes of HIE vary between death and normal, healthy outcome. The spectrum of long term morbidity in survivors ranges from normal to mild motor and cognitive deficits to cerebral palsy and severe cognitive and motor delay. The outcomes can be perceived as a continuum spectrum form normal-no deficits to severe deficits and death, which has important implications for the prediction of outcome and the indications for intervention (Perlman et al., 2011). In our studied group, using MRI Bregant et al. (2011, 2013) observed volume loss of gray matter in specific brain regions, especially in hippocampus and right temporal lobe and thinner corpus callosum in some cases. Studied group reported subjectively good health. During schooling, difficulties when learning mathematics, were observed. With our study we tried to find differences between healthy adolescents and adolescents with HIE in mental subtraction of two digit numbers. We hypothesized that (i) adolescents with HIE will take longer to calculate, (ii) they will have higher number of errors and more fixations, (iii) borrow trials will take longer to calculate and will lead to higher number of errors, (iv) adolescents with HIE will use more (alternative) strategies to solve problems and (v) the distance between operands will have an impact on calculating. The differences between studied groups could point to a new problem area in otherwise healthy survivors of HIE. It could also open a new way for the prediction of outcome. The results could help us define new strategies to improve their arithmetic skills and help them deal with specific learning difficulties.

2 METHODS

2.1 Subjects

Eleven adolescents (7 males and 4 females), born between 1988-1990 and admitted to the PICU, University Medical Centre Ljubljana, due to mild to moderate HIE, participated in our study. Their average age was 22, one was employed, nine were university students and one still had to finish the secondary school. We compared them with a group of healthy adolescents (9 males and 4 females), who voluntarily participated in the study (see Levstek et al., 2012). They were age- and education-matched with our studied group.

2.2 Measurements

Participants had been tested on the subtracting tasks with the eye-tracker device EyeLink 1000 DeskTop Mount, supported with the EyeLink SR Research Experiment Builder program. Recording was monocular, calibration HV9, camera 500 Hz, head stabile. The tasks have been separated into 4 groups of 10 calculations, depending on numbers' distance (small distance was between 15 and 35 and large distance was between 42 and 62) and borrow – no borrow problem (for details see Levstek et al., 2012). Participants pressed the key on the Cedrus box when they calculated the difference between two operands; with this we measured the reaction time. Then they answered the question on the monitor whether the suggested result was correct or not with 'Yes' or 'No' using the Cedrus box. Subjects also reported their strategy of subtraction verbally at the end of experiment.

With the eye-tracker device we investigated the reaction time, i.e. the time spent for calculation, eye fixations, blinks, and saccadic movements. We also analyzed the accuracy of the answers. Data were analyzed with SPSS Statistics 17.0 software. We calculated descriptive statistic

(frequencies, means and standard deviations) of different measures in different conditions. To compare experimental conditions and studied groups of participants, we used χ^2 tests for categorical data and non-parametric Mann-Whitney *U* tests for ordinal and interval data. All hypotheses were tested at .05 alpha error rate.

3 RESULTS

3.1 Response accuracy

We found no significant difference in response accuracy between studied groups. In healthy sample (Hlth) adolescents solved 88.4% of tasks correctly and in HIE group even better, 89.5% ($\chi^2(1) = 0.30$, $p = .586$). It is interesting that we found the significant difference between borrow and no-borrow trials in healthy group ($\chi^2(1) = 12.85$, $p < .001$), but not in HIE group ($\chi^2(1) = 0.87$, $p = .350$). And yet, the difference between operands did not influence the accuracy neither in healthy nor in HIE group. Detailed numbers are seen in Table 1.

Table 1: *Percent numbers of correct answers in HIE and healthy (Hlth) adolescents for four groups of tasks.*

	SnB	SB	LnB	LB
HIE	**91,8**	**90,0**	**90,0**	**86,4**
Hlth	**92,3**	**83,8**	**94,6**	**82,9**

Note: S = small difference, L = large difference, B = borrow, nB = no borrow.

3.2 Reaction times (RT)

On average, adolescents with HIE were calculating longer (M=9317 ms, SD=5334 ms) then healthy peers (M=8372 ms, SD=4551 ms), Mann Whitney $U = 99763.50$, $Z = -3.37$, $p = .001$. The average RT for the borrow problem in HIE group was larger than the average RT for the no-borrow problem (see Table 2), Mann Whitney $U = 20815.50$, $Z = -2.54$, $p = .011$. This holds true also for healthy adolescents ($p < .001$), but the significance was more notable in healthy group. It was also interesting that in no-borrow trials significant difference between HIE and healthy groups in RT existed (Mann Whitney $U = 23646$, $Z = -3.27$, $p = .001$), while in borrow trials this difference was not significant (Mann Whitney $U = 26039$, $Z = -1.62$, $p = .104$).

Table 2: *Descriptive statistics for RT (in ms) for HIE and healthy (Hlth) groups with regard to borrow problem.*

	Borrow		No borrow	
	M	***SD***	***M***	***SD***
HIE	**9881**	**5694**	**8754**	**4896**
Hlth	**9109**	**4745**	**7547**	**4216**

And finally, the distance between operands did not influence on RT neither in healthy ($p = .794$) nor in HIE group. In HIE group the average RT for the tasks with large difference was 9110 ms ($SD = 5386$ ms) and with small difference 9524 ms ($SD = 5285$ ms), Mann Whitney $U = 23154$, $Z = -0.78$, $p = .430$.

3.3 Fixations

We found a significant difference in the number of fixations between adolescents with HIE and healthy peers. On average, the number of fixations in HIE group was 28 ($SD = 25$) and in healthy group 22 ($SD = 14$), Mann Whitney $U = 97335.50$, $Z = -3.94$, $p < .001$. It was also interesting that borrow problem did not affect the number of fixations in HIE group (Mann Whitney $U = 22661$, $Z = -1.15$, $p = .248$), while in the healthy sample it did ($p = .004$). It is also worth to mention that although the participants did not know the results of calculations, we found a significant difference in the number of fixations between correct and incorrect answers. The results were interesting especially for adolescents with HIE, they made on average 27 ($SD = 25$) fixations in trials with correct answer and 36 ($SD = 26$) fixations in incorrect trials, Mann Whitney $U = 6145$, $Z = -3.58$, $p < .001$. The significance in adolescents with HIE was more important than in healthy group ($p = .004$). We also found a significant difference in duration of fixations between studied groups, adolescents with HIE had shorter durations of fixations, Mann Whitney $U = 93535.50$, $Z = -4.83$, $p < .001$.

Significant difference between studied groups occurred also in blinks' number. Adolescents with HIE had on average 4.23 blinks in a trial ($SD = 5.43$) and healthy peers only 1.52 ($SD = 1.8$), Mann Whitney $U = 75053$, $Z = -9.34$, $p < .001$. Borrow problem did not affect blinks neither in HIE nor in healthy group. However, the response accuracy affected blinks' number, but only in HIE group, incorrect answers had more blinks then correct ones (Mann Whitney $U = 7409.50$, $Z = -2.05$, $p = .041$). We should also emphasize a huge deviation of blinks' numbers in HIE group, but only for incorrect answers (see Figure 1).

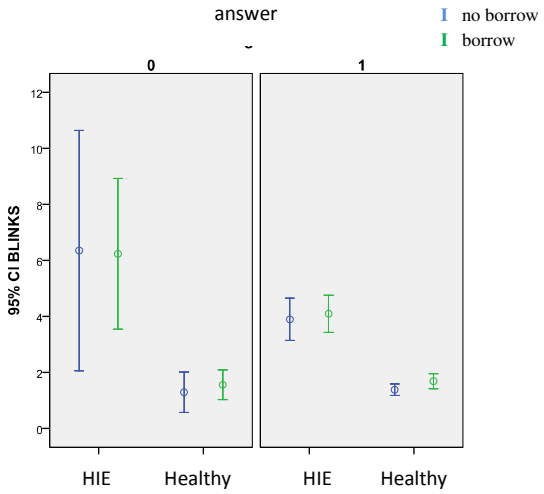


Figure 1: *Average number of blinks in HIE and healthy groups for incorrect (0) and correct (1) answers with regard to borrow problem.*

We also analyzed the amplitude of saccades. Saccades are fast ballistic movements of the eyes that re-locate the point of fixation. Amplitude of saccade is determined by the angular distance between two fixations in succession and is measured in degrees. In our experiment the amplitudes were small due to the stabile head, but we found statistically significant differences between studied groups, nevertheless. On average, the amplitude in HIE group was 2,3° (*SD* = .96°) and in healthy group 2,51° (*SD* = .7°), Mann Whitney $U = 77564$, $Z = -6{,}44$, $p < .001$.

3.4 Calculation strategies

Participants reported their strategy of calculation verbally at the end of the experiment with the help of a questionnaire, where four tasks (one from each group) were presented. The strategies used varied a lot and we could divide them into six groups. If, for example, a participant should solve an equation 73-46, then the strategies would be the following:

S1: first tens 70 – 40 = 30 or 7 – 4 = 3, then units 3 – 6 = -3, 30 – 3 = 27 or 33 – 6 = 27;

S2: first 73 – 40 = 33, then 33 – 6 = 27;

S3: first tens 70 – 40 – 10 = 20, then units 13 – 6 = 7, together 20 + 7 = 27;

S4: participants used a mixed strategy, e.g. 73 – 46 = 73 - 50 + 4 or (46) + 4 + 20 + 3 (= 73);

S5: participants transformed the horizontal tasks into columns;

S6: participants sequentially subtracted 10 from the first number, e.g. 73-10-10-10-10=33, than 33-3-3=27.

S1 and S3 are full decomposition strategies (decomposition of both operands) and S2 is a partial decomposition strategy (decomposition of the second operand only). The strategy use differed for adolescents with HIE and healthy peers (see Table 3), adolescents with HIE used more alternative strategies.

Table 3: *Numbers of adolescents with HIE and healthy (Hlth) adolescents with regard to the strategy use.*

	S1	S2	S3	S4	S5	S6
HIE	**4**	**2**	**1**	**2**	**1**	**1**
Hlth	**3**	**3**	**3**	**4**	**0**	**0**

Further we tried to find differences in response accuracy, in RT, in numbers of fixations and in their durations between studied groups with regard to strategies. We analyzed only strategies S1, S2 and S4 due to small number of participants. We observed that adolescents with HIE solved the tasks using S1 and S2 much better than their healthy peers (adolescents with HIE had 97% and 98% correct answers using strategies S1 and S2, but their healthy peers only 83% and 89%), but using S4 the results were vice versa (83% correct answers in HIE group and 93% correct answers in healthy group). The differences occurred also in RT, in HIE group the strategy S4 was the fastest, then S1 and S2 followed (see Table 4). In healthy group, the differences between strategies were large, in average S1 demanded the longest RT and strategy S2 was the fastest.

Table 4: *Descriptive statistics of RT (in ms) grouped by strategies for adolescents with HIE and healthy peers (Hlth).*

	S1	S2	S4
HIE			
M	**8339**	**8714**	**7095**
SD	**3573**	**3924**	**3162**
Hlth			
M	**11496**	**5644**	**8158**
SD	**4722**	**2311**	**4606**

It was interesting to observe numbers of fixations in HIE and healthy groups with regard to strategies (see Table 5). Surprisingly, numbers of fixations did not differ significantly in studied groups, but deviations were extremely high in HIE group using S1 and in healthy group using S4. Statistical analysis showed the significant difference in fixations' numbers between studied groups using strategy S1 only, Mann Whitney $U = 6790$, $Z = -4.193$, $p < .001$.

Table 5: *Descriptive statistics of fixations' numbers with regard to strategies for adolescents with HIE and healthy peers (Hlth).*

	S1	S2	S4
HIE			
M	**29**	**16**	**23**
SD	**24**	**8**	**13**
Hlth			
M	**28**	**13**	**24**
SD	**9**	**5**	**21**

But we observed quite opposite results analyzing durations of fixations, where the use of strategy S1 did not show any significant difference between studied groups (Mann Whitney $U = 8441$, $Z = -1.73$, $p = .084$), while in other strategies the differences were significant (using S2: Mann Whitney $U = 3109.50$, $Z = -4.22$, $p < .001$, using S4: Mann Whitney $U = 4764$, $Z = -3.16$, $p = .002$).

4 DISCUSSION

Analyzing eye tracking data collected during subtraction of two-digit numbers in adolescents with HIE and their healthy peers we found some interesting results. First, there was no significant difference in response accuracy between studied groups, even more, adolescents with HIE calculated a bit, but not statistically significantly better. Then, the borrow problem had a significant impact on correctness of answers, but only in healthy group. In adolescents with HIE we did not find difference between borrow and no-borrow tasks with regard to response accuracy. We could speculate that adolescents with HIE do not perceive the difficulty of the tasks as much as their healthy peers; perhaps they calculate more automatically.

Further we investigated the reaction time (RT) and, as expected, adolescents with HIE calculated longer then their healthy peers. We could also confirm the hypothesis that the borrow problem has a significant impact on RT in healthy group (p<0,001) and in HIE group (p=0,027). But we have to emphasize that the significance in adolescents with HIE was smaller. It is also interesting that in no-borrow tasks, i.e. easier tasks, there was a significant difference in RT between studied groups, but in borrow tasks the difference was not significant. In other words, healthy adolescents calculated easier tasks faster, however, it seems that adolescents with HIE do not distinguish the difficulty of the tasks with regard to the reaction time.

Eye tracker device enabled us to study the number and the duration of fixations during calculations. We discovered that adolescents with HIE had significantly more fixations than healthy adolescents (p<0.001). We could correlate this result with longer RT in HIE group ($p = .001$), but the significance of fixations' numbers was more obvious. We also have to stress that the deviation of fixations' numbers in HIE group was large ($SD = 25$) compared to healthy adolescents ($SD = 14$). Perhaps we could presume that there are noticeable differences in eye movements among HIE adolescents themselves. Next, we found that the response accuracy had a significant influence on fixations' numbers in both studied group, but with regard to the borrow problem there was no significant difference in the fixations' numbers in HIE group, while in healthy adolescents significance was noticeable. This findings again confirm that adolescents with HIE do not perceive the difficulty of the tasks as much as their healthy peers.

Analysis of fixations' durations showed a significant difference in fixations' durations between studied groups (the durations in HIE group were shorter), and still, borrow problem had a significant impact on durations, but only in healthy group. It is interesting to compare RTs, fixations' numbers, and durations of fixations. In healthy adolescents shorter RTs leaded to smaller fixations' numbers and also in HIE group longer RTs caused higher numbers of fixations. But the durations of fixations were shorter in HIE group than in healthy group ($p < .001$). We could assume that fixations' duration is a measure which distinguish adolescents with HIE from their healthy peers.

We got an additional insight into calculations with the study of blinks. Adolescents with HIE had significantly more blinks than their healthy peers and borrow problem did not affect the number of blinks neither in HIE nor in healthy group. However, the response accuracy significantly affected blinks' numbers, but only in HIE group ($p = .041$). Although the participants did not know the results of the tasks, some kind of uncertainty was present in incorrect answers, which was manifested in the higher number of blinks. Perhaps we could correlate blinks' number with uncertainty and with subjective, unconscious engagement in precarious situations.

We also hypothesized that trials with large and small distance between operands will result in different measures. Surprisingly, in both studied groups there were no significant differences between these two levels (neither in RT nor in response accuracy or in eye movements). The so called 'problem size' may be evident only in manipulating with the size of operands, but the distance between operands seems to have no impact on the calculations. Although the numerical representations are rooted in cortical networks and also subserve spatial cognition (Zorzi

et al., 2011), our results suggest that mental calculation with large numbers is not based on mental representations of operands and shifts of attention along an 'internal number line' neither in adolescents with HIE nor in healthy adolescents.

Analyzing saccadic movements we found significant differences in amplitudes of saccades between HIE and healthy groups. In healthy adolescents the amplitudes were higher, also with regard to the borrow problem. We could speculate that healthy adolescents are researching the field of interest more widely then adolescents with HIE.

We also found significant difference in average fixation pupil sizes between studied groups ($p<0,001$). It is logical that the duration of fixation and the pupil size are linearly correlated, i.e. shorter duration leads to smaller pupil size. But adolescents with HIE had significantly smaller pupil sizes than their healthy peers, nevertheless. The pupil size indicates significant difference between HIE and healthy adolescents. Whether this could be linked to vagal oversensitivity, observed in HIE group while EEG recording, it is not known.

In the end we tried to find some new aspects of subtracting with analyzing the strategies of calculation. Participants were not instructed how to make the calculation, they just reported their way of calculating at the end of the experiment. Almost 70% of healthy adolescents were using full/part decomposition strategies and only four of them tried new ways of calculating, using both strategies and also an intuitive approach for closeness of operands or decade numbers. This holds true also for adolescents with HIE (64% of adolescents with HIE used decomposition strategies), but they reported more alternative strategies of subtraction, nevertheless. We could confirm our hypothesis that adolescents with HIE use more diverse strategies, probably they develop compensatory manners of subtracting.

With regard to different strategies (S1, S2 and S4) we found significant differences in response accuracy between HIE and healthy groups. HIE adolescents calculated better using S1 or S2 then healthy peers. Differences occurred also in RT, in HIE group they calculated faster using strategy S1, but healthy adolescents were the fastest using strategy S2. Analyzes of numbers of fixations showed that numbers of fixations, grouped by strategies, did not differ significantly between HIE and healthy groups, significant difference in fixations' number between groups occurred only with S1 strategy use. We speculate that the strategy S2 (partial decomposition strategy) is the most convenient manner of mental subtracting in both studied groups with regard to response accuracy, RT and fixations' number.

5 CONCLUSION

With our experiment we found correlates between eye movements and complex subtraction and also the differences between HIE and healthy adolescents during mental calculating. The drawback of the experiment is small number of participants, but the results are applicable, nevertheless. On average, adolescents with mild perinatal hypoxic-ischaemic encephalopathy solved the tasks well compared to healthy adolescents. We expected worse outcome, that is more troubles while calculating regarding the correctness and time spent to reach the results, due to perinatal brain lesions leading to volume loss in specific brain regions. We presume that family support with medical, social, and educational assistance has a crucial role in development and maturation of HIE subjects from infancy to adulthood.

However, analysis of eye movement data demonstrated significant differences between HIE adolescents and healthy peers in fixations, saccades and pupil sizes. This field is waiting for further investigations and we recommend new research projects about vision characteristics of individuals with hypoxic-ischaemic encephalopathy.

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PROCESSING OF WORDS AND PSEUDO-WORDS IN PATIENTS WITH DEMETIA

Katarina Marjanovič, Christina Manouilidou, Tatjana Marvin
Mei:CogSci
University of Ljubljana
e-mail: katarina.marjanovich@gmail.com

ABSTRACT

This paper presents a case study of Slovene word and pseudo-word processing in patient with dementia of Alzheimer's type. One of the early problems of patients with dementia is difficulty with naming and word finding, which could suggest a decay of lexical representations. The aim of our reasech is to find out how this decay progresses. We approach this issue by using an acceptability task for words and pseudo-words which violate various aspects of word formation in the Slovenian language.

1 INTRODUCTION

The goal of our research is to investigate how the decay of lexical representations progresses in patients with dementia. We approached this issue by creating a task with regular words of the Slovenian language and pseudo-words, which violate different aspects of the Slovenian word formation rules. The task was first presented to a young control group, for normative purposes, and later also to one patient with dementia (Alzheimer's disease), and to two age- and sex-matched control participants.

With the help of this task, we tried to find the answers to the main questions. Firstly, we were interested in whether the patient will make a clear line between the pseudo-words that violate word formation rules of the Slovenian language and words that do not when compared to the controls. Secondly, we were interested in finding out whether all violated rules will have the same significance for the patient in comparison to the control participants, or whether there will be any signs of degradation of word formation rules and vocabulary.

Following these research questions, we did not only gain an insight in the decay of lexical representations and word loss in patients with Alzheimer's disease, but also in pseudo-word processing in healthy native Slovenian speakers. Furthermore, this study also represents the first attempt to use the Slovenian language as a diagnostic tool for dementia in Slovenian-speaking populations, which could contribute to the development of a diagnostic tool with higher sensitivity when compared to the one that is in use at the moment.

2 PSEUDO-WORDS

The term *pseudo-word* refers to word formations which resemble regular words of a certain language, but nevertheless have no meaning and are not lexicalized. An example of an English pseudo-word (Ps-W) is **blunk,* a word that does not exist in English despite the fact that it could potentially be part of English vocabulary given that it does not violate any English phonotactic rules. Pseudo-words (Ps-Ws) such as **blunk* can be subject to further derivation, either respecting or violating word-formation rules in the language. For example, from **blunk* we can derive the Ps-W **reblunkable*, in which the affixes added impose the lexical category on the Ps-W **blunk* – adding the prefix *re-* forces **blunk* to become a verb and when *-able* is added to the Ps-W **reblunk*, the word-formation rules for English are respected, as *-able* attaches to verbs to form adjectives.

On the other hand, if we attach the affix *-ity* to the pseudo-verb **reblunk*, the result is an ungrammatical Ps-W **reblunkity* since the rules of English word formation allow the suffix *-ity* to attach to adjectives but not to verbs.

Possible Ps-Ws do not only contain words based on non-existing roots such as **blunk*, but also words derived from existing roots, which can then either violate or respect word-formation rules of their language. For example, **recarable* is a Ps-W in English, the parts of which are all existing morphemes in English (*re-*, *car*, *-able*), but it is not a possible word in English because it violates English word-formation rules – neither the prefix *re-* nor the affix *-able* attach to noun roots such as *car*. On the other hand, if the same word processes are used on an existing verb root, the word is a possible word of English, e.g., *reclickable* 'that can be clicked again'.

Both types of Ps-Ws described above appear in our experiment. We test a list of words that are phonotactically acceptable in Slovenian yet do not exist because their roots do not exist in the language (termed *non-words* in our paper, e.g., **dovina*). In addition, we test lists of words that are derived from existing roots and either respect Slovenian word-formation rules (Ps-Ws that are possible words of Slovenian but are blocked by already existing words derived in a different manner, e.g., **risalec* intended meaning: 'drawer') or do not respect Slovenian word-formation rules (Ps-Ws with various types of violations, e.g., **viselec* intended meaning: 'hang-er', *preplavalec* intended meaning: 'swim-pf-

er', *črkilec* intended meaning: 'letter-er'). See section 3.1 for an explanation and for further examples.

2.1 Pseudo-words in present study

In our experiment we focus on various violations of word-formation rules, creating lists of Ps-Ws containing different types of violations and asking native speakers of Slovenian to provide their acceptability judgments. We limit ourselves to the derivation of Slovenian deverbal nouns involving the suffix *-ec*, whose meaning is 'a masculine agent of the event denoted by the root verb'. Similarly to the research based on Modern Greek (Manouilidou, 2007), we consider thematic (2.1.1) and categorial (2.1.2) violations. We add yet another type of violation, not found in Manouilidou's research, so-called aspectual violations (2.1.3) as well as deverbal nous denoting an agent in *-ec* that do not violate any word formation rule but are, nevertheless, non-existent in Slovenian due to the existence of another word with the same meaning, so-called *possible pseudo-words* (2.1.4). The last group of Ps-Ws contains so-called *non-words*, words that sound like words of Slovenian, but are not found in the language (2.1.5). Our morphological analysis of agentive nominalization relies on the analysis found in Marvin (2002).

2.1.1 Pseudo-Words with Thematic Violations

Slovenian deverbal nouns with the suffix *-ec* can only be derived from verbs in which the subject is the agent of the action described by the verb, as pointed out in Marvin (2002). Therefore, intransitive verbs, in which the syntactic argument of the verb is not a semantic agent of the verb, cannot be found in such nominalizations, as illustrated in (1).

(1) a. **umiralec* 'die-er'
b. **viselec* 'hang-er'

2.1.2 Pseudo-Words with Categorial Violations

Slovenian deverbal nouns with the suffix *-ec* can only be derived from a base that includes a verbal root. If we derive these nominalizations out of a base that includes a nominal root, such as *črk-* 'letter' and *vaz-* 'vase' in (2), the results are ungrammatical forms.

(2) a. **črkilec* 'letter-er'
b. **vazilec* 'vase-er'

2.1.3 Pseudo words with aspectual violations

Aspectual properties of the base also have to be taken into consideration in Slovenian agentive noun formation with *-ec*. Such nouns can only be derived from the imperfective forms, such as, e.g., *plavati* 'to swim-imp' (*plavalec* 'swimmer') and *moriti* 'to murder-imp' (*morilec* 'murderer'), but not from the perfective forms *preplavati* 'to swim -pf' and *umoriti* 'to murder-pf', as observed in Marvin (2002) and illustrated in (3). In our experiment, we thus created a list of words containing what we term *aspectual* violations:

(3) a. **preplavalec* (from *preplavati* 'to swim –pf')
b. **umorilec* (from *umoriti* 'to murder-pf')

2.1.4 Possible Pseudo-Words

In our experiment we created yet a fourth type of Ps-Ws, consisting of words that do not violate any word formation rule of Slovenian, but nevertheless do not exist in Slovenian vocabulary since there are other lexicalized forms conveying the meaning of a masculine agent in the language. For example, the word **risalec* could be a word for 'draw-er' as it does not violate any categorial, thematic or aspectual rules, however, it is not found in the language because it is blocked by the word *risar* 'drawer'.

(4) a. **risalec* 'draw-er' (existing word: *risar* 'drawer')
b. **kuhalec* 'cook-er' (existing word: *kuhar* 'cook')

2.1.5 Non-Words

The last group of Ps-Ws created for the purpose of our experiment contains so-called non-words. These are words which do not break phonotactic rules of Slovenian and sound as if they belonged to Slovenian vocabulary but do not exist in the language and do not carry any meaning because their roots have not been lexicalized:

(5) **dovina, *lastje*

3 THE EXPERIMENT

The main goal of our research was focused on lexical representations in patients with dementia. Our research on progression of word loss in patients with dementia was guided by the following research questions: (1) Will the patient be able to differentiate between Ps-Ws that violate word formation rules of the Slovenian language (e.g. *umorilec, *črkilec) and words that do not violate any rules (e.g. *risalec, igralec) when compared to healthy control participants? and (2) Will all the violated rules have the same significance for the patient in comparison to the control participants? Are there any signs of degradation of word formation rules and vocabulary?

Based on the findings of a previous research for Modern Greek (Manouilidou, 2007), we expected that the control group will show a continuum in the acceptance/rejection rates of Ps-Ws, starting with massively rejecting Ps-Ws with categorial violations (e.g. *črkilec) and being more flexible in accepting Ps-Ws with thematic violations (e.g. *viselec) (**Hypothesis 1- H1**). What we also expected was that the participant would be equally flexible in accepting aspectual violations (e.g. *preplavalec) as well, even if this assumption is not based on previous research. However, a different pattern was expected for the patient, who was expected to accept more Ps-Ws as possible words, thus, making more errors, since her lexical representations will already be in decay (**Hypothesis 2 -H2**).

3.1 Methodology

In order to test the above hypotheses and to find the answers to our research questions, we created an acceptability task in which we presented stimuli belonging to six different categories. The study was conducted in two phases. In the first phase, the normative study took place in order to decide about the final list of stimuli, based on judgments of native speakers of Slovenian. We included 20 young Slovenians (M age: 27.3) in this phase, whose results were taken into consideration when performing the second phase of our research, the case study with the AD patient and two control participants. These were age- and sex-mached with the patient and were also given the MMSE (The Mini Mental State Examination) test, to make sure they are cognitively unimpaired. The tested patient with AD was 87 years old, female, diagnosed with probable moderate Alzheimer's disease with late onset (based on DSM IV). Her MMSE score was 21/30, her score on the language part of this test was 7/8, suggesting almost intact linguistic knowledge.

The participants were presented with a list of 180 selected stimuli (120 in the second phase) - Ps-Ws. For each of the stimuli, they had to provide a "yes" or "no" answer, indicating whether or not the presented word belongs to the Slovenian vocabulary. In case they thought it did, they were also asked to provide the meaning of this word.

In our research we used four different groups of Ps-Ws and one group of non-words, as presented in section 2. We also added a group of common Slovenian words for masculine agents (e.g. bralec "reader") which do not violate any word formation rules. In each group we selected a pool of 30 items (20 in the second phase), which were chosen according to their frequency, tested in the Corpus of the Slovenian language FidaPlus (FidaPlus).

3.2 Analysis, results and discussion

Young participants accepted only existing Slovenian deverbal nouns for masculine agents (e.g., plavalec), and rejected practically all the Ps-Ws with violations. The only exception was the category of possible Ps-Ws (e.g., *risalec) with no word-formation violation. These had a slightly higher acceptance rate, and this difference was statistically significant. This results indicate that young participants made a clear line between Ps-Ws that violate the word formation rules of Slovenian (aspectual, categorial, and thematic violations) and words that do not (existing Slovenian words for masculine agents and possible Ps-Ws). This is also an indication that for native speakers of Slovenian all the violated rules have the same significance while at the same time they are less sensitive to the Ps-Ws that do not violate any word formation rules of Slovene.

The results (acceptance rates) of the second phase, given in Table 1, indicate how many times the participants (AD patient and controls) said the presented stimulus is a word of the Slovenian language.

Separate analyses were carried out on the data for the patient and each control participant. The analysis revealed that there was no significant difference in the performance of the two control participants when comparing their correct answers. Nevertheless, focusing solely on the acceptance rates, we consider that our results support H1, proposing a continuum in the acceptance rates across categories of pseudo-words among the control participants, starting with massive rejection of pseudo-words with categorial violations and expressing more flexibility in accepting pseudo-words with thematic and aspectual violations.

Further comparison of the patient's and controls' performance revealed a significant difference in the category of pseudo-words with aspectual violations (pseudo-asp, e.g. *pogasilec) in comparison with both, first ($p < 0{,}005$) and second ($p < 0{,}002$) control participant. However, for the other categories of presented stimuli, no significant difference was revealed.

When comparing the patient's results with the results of the control participants, a difference in the sensitivity to the rules for the patient with AD and both control participants was revealed. Based on the controls' data, the rules about verbal aspectuality (violations of which result in Pseudo-Asp stimuli, e.g. *preplavalec) and those about basic relationships concerning agent roles (Pseudo-Them stimuli, e.g. *ljubilec) are most violable and the participants are equally sensitive to both of these rules, whereas the rules about appropriate lexical category of the base (Pseudo-Cat stimuli, e.g. *črkilec) are the least. In most categories, the patient's sensitivity to the presented word formation rules does not differ from the control participants. However, an important difference in the patient's sensitivity to the violated rules when compared to the controls can be noted in the category of aspectual violations, since for the patient the rules about verbal aspectuality are the most violable and differ significantly from the controls' sensitivity for these rules.

These results partly support H2, stating that the patient with dementia is expected to accept more Ps-Ws as possible and thus making more errors compared to the control participants. The patient namely accepted more Ps-Ws within one category of Ps-Ws (Ps-Ws with aspectual violation), but in other categories of Ps-Ws the patient's performance did not statistically differ from the controls' performance.

Table 1: *Acceptance rates (AR) for two control participants and patient with AD.*

	Non-w	Pseudo-Asp	Pseudo-block	Pseudo-Cat	Pseudo-them	W-X
Control 1	0%	45%	90%	25%	76%	100%
Control 2	0%	55%	90%	20%	53%	100%
AD patient	5%	95%	100%	10%	65%	100%

The analysis indicates that the control participants as well as the patient differentiated between pseudo-words with different types of word formation violations, suggesting that not all violated rules have the same significance for them (H1). This difference can be noted already when looking solely at acceptance rates. However, when comparing the patient with AD with the control participants, the results indicate different sensitivity to word formation rules of the Slovenian language for the patient with AD. The patient is not sensitive at all to the rules about verbal aspectuality, since she was treating the presented Ps-Ws with this type of violations as real words, which indicates that she has lost this rule completely (H2). Furthermore, she seems to be more sensitive to the rules about basic relationships concerning agent roles, and most sensitive to rules about the appropriate lexical category of the base, indicating that the representations of these two word formation rules are not yet in decay at this stage of the disease. The latest rule seems to be of the highest sensitivity also for the control participants, but in their case the other two rules seem to be of the same significance. The fact that she is still sensitive to two word formation rules, while she is not at all sensitive to the rule about verbal aspectuality, could suggest that her knowledge of word formation rules is at the initial stage of decay. The analysis further indicates that the patient's representations of the real words and Ps-Ws, which do not violate any word formation rules, remain preserved at this stage of the disease. This conclusion can be drawn from the patient's results for the categories of regular words for masculine agents, possible Ps-Ws and non-words. A similar conclusion can also be drawn for the category of non-words, which are just pronounceable word units. Therefore, all groups of participants rejected all the presented non-words, including the patient with AD. This result indicates that her processing of this kind of stimuli is preserved, since she was able to distinguish between the non-words with no meaning and pseudo-words which look and sound the same as regular words of the Slovenian language and also apply some lexical meaning.

Taking all these results into account, a tendency towards a difference in the sensitivity to the violated rules between the patient with AD and the control participants can be observed. This tendency was noted in the comparison of the AD patient with both control participants. Therefore, we think that detecting this difference could be a very important contribution, which should be investigated in more detail and with more participants in future research, since it indicates that in patients with AD the decay of lexical representations could start with the decay of the representation of the word formation rule about verbal aspectuality.

Furthermore, these results also offer an explanation on why the patient scored very high on the language part of the MMSE test, even if her mental lexicon is already in decay and her knowledge of Slovenian word formation rules and vocabulary is degraded. This impairment is not detectable via a coarse measures such as MMSE, since this measure only includes words which do not violate any word formation rules, therefore, it only includes the stimuli in which the patient's performance is yet intact.

4 CONCLUSION

The results of our study provided conclusions about pseudo-word processing in healthy participants and also, most importantly, in a patient with Alzheimer's disease. Regarding the latter, the results indicated a complete loss of sensitivity to one type of Slovenian word formation violation rule, indicating that the patient's knowledge of word formation rules are already in decay. Nevertheless, this decay cannot and was not detected via MMSE, since this coarse measure only includes words which do not violate any word formation rules, therefore, it only includes the stimuli in which the patient's performance is yet intact. However, it should be pointed out that the conclusions we reached are based on a case study which makes us cautious when making statements about pseudo-word and word processing and the decay of lexical representations in patients with Alzheimer's disease in general. However, since the patient's results were compared to two control participants separately, and both comparisons resulted in the same pattern, we can make an assumption that the same pattern can be expected also when performing the research on a bigger sample. Thus, our case study offers an important insight into Slovenian word and pseudo-word processing in patients with Alzheimer's disease and reveals potentially important data and results, which could serve as a good basis for future work and development of diagnostic tools for dementia, based on the Slovenian language.

The proposed pattern of decay is, thus, a good starting point for more in-depth research with more participants, but should not be considered as the finishing point of this research. Furthermore, this study represents the first attempt to use the Slovenian language as a diagnostic tool for dementia in Slovenian-speaking populations and makes a contribution to the research of the loss of the lexical representation in patients with Alzheimer's disease and represents a good starting point for more in-depth research with more participants with different types of dementia.

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CRITICAL REFLECTIONS ABOUT NEUROSCIENCE AND ITS APPLICATION

Olga Markič
Filozofska fakulteta, Univerza v Ljubljani
Aškerčeva 2, 1000 Ljubljana, Slovenija
e-mail: olga.markic@guest.arnes.si

ABSTRACT

The author discusses the impact of recent developments in neuroscience on the philosophical viewpoints about the mind body problem and presents different frameworks for understanding the mind inspired by neuroscientific research.

1 INTRODUCTION

The belief that the mind is the product of the brain is nowadays generally accepted. We have learned that the malfunctioning brain results in deficient mind. But could we say that that the brain is the mind? The nature of the relation between brain and mind is an old problem and also nowadays scientists and philosophers offer different solutions. Although almost everybody would agree that the brain gives rise to perception, cognition, emotion, volition and other mental states, there remains a challenge to precisely determine how mental phenomena rise from the brain. I will briefly present some influential neuroscientifically inspired frameworks for understanding the mind.

2 NEUROSCIENTIFIC FRAMEWORKS FOR UNDERSTANDING THE MIND

Recent developments in cognitive science, particularly in neuroscience, have huge impact on the proposed solutions to the mind body problem and many neuroscientists and philosophers feel that the proper framework for understanding the mind is developed by neuroscience. The reasoning goes like this: "For those who do neuroscience, it is highly effective to assume that brain events are "'the" cause of mental events. There is overwhelming empirical evidence that whenever a mental event occurs, something happens in the brain. Conversely, when something happens to the brain, it frequently has an effect on the mental events of the person who possesses that brain. The omnipresence of these reciprocal causal connections has prompted the natural assumption that the mind is the brain" (Rockwell, 2007: 54).

The indication of such viewpoint was explicitly expressed by philosopher Patricia Churchland who wrote a book Neurophilosophy (1986), a provoking title for that time. Many but not all philosophers and scientists are using the concept neurophilosophy in an eliminativist manner as a substitution for philosophy. Patricia Churchland herself nowadays rejects such characterization and argues for a more balanced view, a kind of "co-evolution" of the disciplines. In her later book Brain-Wise (2002) she lays out three hypothesis that are underpinning her book.

Hypothesis 1
Mental activity is brain activity. It is susceptible to scientific methods of investigation.

Hypothesis 2
Neuroscience needs cognitive science to know what phenomena need to be explained. To understand the scope of the capacity you want to explain – such as sleep, temperature discrimination, or skill learning – it is insufficient to simply rely on folk wisdom and introspection. Psychophysics, and experimental psychology generally, are necessary accurately to characterize the organism's behavioral repertoire and to discover the composition, scope, and limits of the various mental capacities.

Hypothesis 3
It is necessary to understand the brain, and to understand it at many levels of organization, in order to understand the nature of the mind (Churchland, 2002: 30).

Although not all cognitive scientists agree that brain is identical with mind, they all agree that its presence is a sine qua non for it, suggesting that a successful theory explaining the mind will be neuroscientific. But it is not clear what exactly they mean by that. Ian Gold and Daniel Stolyar (1999) have argued that it is not clear what this claim means and that it is ambiguous between two views: "one plausible but unsubstantive, and one substantive but highly controversial". They characterize the first one, the so-called trivial neuron doctrine as: "the view that a successful theory of the mind will be a solely cognitive neuroscientific theory. According to this doctrine, to the extent that psychological phenomena will be explained at all, the science that will do so is cognitive neuroscience" (Gold, Stolyar, 1999: 813). This theory adheres to the thesis that mind is a biological

phenomenon (potentially) explicable by science. But this is not to say that the understanding will be based on biological concepts alone – psychological concept may and very probably will be required. On the other hand, it is possible to construct a much more radical theory if we simply replace cognitive neuroscience by biological neuroscience. Gold and Stolyar call this the radical neuron doctrine. According to the radical doctrine, neurobiology alone will provide the necessary conceptual resources to understand the mind. Consequently, "a successful theory of mind will be a theory of brain expressed in terms of basic structural and functional properties of neurons, ensembles or structures" (Gold, Stolyar, 1999: 814).

A similar reductionist view was expressed by the neuroscientist Francis Crick: in his famous book The Astonishing Hypothesis where he wrote: "The Astonishing Hypothesis is that "You," your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules. As Lewis Carroll's Alice might have phrased: "You're nothing but a pack of neurons." This hypothesis is so alien to the ideas of most people today that it can truly be called astonishing" (Crick, 1994: 3). He thinks that "the scientific belief is that our minds – the behavior of our brains – can be explained by the interaction of nerve cells (and other cells) and the molecules associated with them" (Crick, 1994: 7).

Some eliminativists (e.g. Paul Churchland, 1988) have advocated the elimination of folk psychological concepts, and they see neuroscience as the appropriate scientific approach for explaining behavior. However, Gold and Stolyar offer persuasive arguments against the radical neuron doctrine and suggest that it is false. On the other hand, trivial neuron doctrine does not lead to radical philosophical positions. John Bickle (1998, 2003) has argued that we should wait for scientific psychology and neuroscience to mature and only then examine the existent intertheoretic relations between available theories and thus potential reduction or elimination.

Some prominent philosophers of neuroscience (Bechtel, 2008; Carver, 2007) consider the idea of intertheoretic reduction as inappropriate from the point of view of neuroscientific praxis. They argue that neuroscience is best understood as the study of neural mechanisms that help us better understand cognitive processes. The question is if understanding neural mechanisms alone will suffice. Neuroscientist Gerald Edelman suggests that this is not the case: "even if we could accurately record and analyze the activity of millions of brain neurons as an individual formulates a sentence, we could not precisely specify the contents of that sentence by reference to neural recording alone. The idea that we might develop a "cerebroscope" capable of doing so is confuted by the complexity, degeneracy, and unique historical causal path of each brain" (Edelman, 2006: 66).

3 CRITICAL REFLECTIONS

We have seen that there are different views about the exact role neuroscientific research plays in explaining and understanding mental phenomena, although reductionist neuroscience seems to prevail. It is often that neuroscientists give "explanations" of memory, fear, love, or consciousness and "locate" them in specific brain areas, neuronal networks or molecular processes (Rose, 2012). By ascribing psychological predicates to the brain or even parts of the brain they commit what Daniel Dennett (1991) and Bennett and Hacker (2003) call mereological fallacy in neuroscience. Bennett and Hacker stress that "human beings, but not their brains, can be said to be thoughtful or thoughtless; animals, but not their brains, let alone the hemispheres of their brains, can be said to see, hear, smell and taste things; people, but not their brains, can be said to make decisions or to be indecisive" (Bennett, Hacker, 2003: 73).

The reasoning behind "the natural assumption that the mind is the brain" (see the beginning of previous section) is according to Rockwell due to the questionable additional assumption that pragmatic and complete causes are the same. He applies Mill's distinction between popular idea of a cause expressed in ordinary language which he calls the pragmatic cause, and conditions, which he calls the complete cause. His explanation is as follows: since there are numerous causal connections in the brain when someone thinks or feels, neuroscience naturally assumes that brain activity is the sole cause of mentality. He acknowledges that this may be a useful assumption for neuroscientific practice, but does not prove the metaphysical fact that the mind is, in fact, the brain. Rockwell suggests that scientists are unable to understand the mind without referring to factors outside of neuroscience, such as behavior or meaning reference. According to this view mental states do not supervene only on intrinsic brain states – the supervenience base also includes relations that bind all three key players: brain, body, and world. Different versions of embodied, embedded and situated cognition (e.g. Varela, Thompson, Rosch, 1991; Clark, 1997; Wilson, 2002; Gibbs, 2006) thus stress that cognition is not an activity of the brain as such, but is instead distributed across the entire interacting situation, including brain, body, and environment.

I agree with those (Rose, 2012) who take methodological reductionism as an essential experimental tool for the natural science (e.g. neuroscience) but stress the inadequacy when its explanatory power is over-extended. Humans are social beings and it is necessary to take into account both human biology and human culture. New subfields of social and cultural neuroscience have just begun to investigate the influence of cultural backgrounds on cognition. On the

other hand researchers are becoming more and more aware of the rhetoric around neuroscience and begin to analyze the allure of the "neurotalk" in the broader popular, social and political contexts. So, the proponents of the so called "critical neuroscience" aim to make contribution from human sciences to neuroscience and as Jan Slaby and Suparna Choudhury suggest "to demonstrate the contingencies of neuroscientific findings and, at the same time, to open up new experimental and interpretive possibilities" (Slaby, Choudhury, 2012: 46).*

*The paper draws in part on material from Markič (2012).

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A COMPUTATIONAL MORPHOLOGY APPROACH TO CROATIAN NOUN INFLECTION – FOCUSING ON GENDER PREDICTING

Milena Mihajlović
mihajlovic.milena@gmail.com

ABSTRACT

This paper presents research of noun inflection and gender in Croatian and a computational model built with the aim to predict noun gender in Croatian language. The model is being generated with regard to several different approaches: Network Morphology approach, recent Natural Morphology account on Croatian, descriptive linguistic approach and the one that served as a framework for the Croatian National Corpus.

1 INTRODUCTION

Croatian belongs to the South Slavic language subgroup. It is an inflecting-fusional language, meaning that the Croatian morphology is characterized by rich inflection, where one morpheme could denote different grammatical properties (e.g. the inflectional suffix -a in stolic-a 'chair' denotes three pieces of information: feminine gender, nominative case and singular form).

Gender of Croatian nouns is highly interesting to explore, both from the cognitive and linguistic point of view. Traditionally, the whole Croatian noun inflection system is seen as gender-based, i.e. gender is regarded as the main factor that governs the inflection of nouns. However, gender alone is not sufficient for the proper description of the noun inflection. Furthermore, a classification based exclusively on gender is problematic for a computer analysis.

In addition, although inflection of nouns is something native speakers know well, gender something native speakers know all too well, it is very hard to devise a model that would predict both of it. In this respect also interesting is that many languages do not have gender distinction in the plural (e.g. German). On the other hand, Croatian belongs to the group of languages that do have it.

2 DATA

As the focus of the paper is the noun inflection and gender system in Croatian, it is important to note that nouns in this language have gender as an *inherent* property, and number and case as *morphological* properties. Given the fact that we are going to focus on the notion of gender in much more detail in the subsequent section of this paper, at this point it is sufficient to say that Croatian is characterized by the masculine, feminine and neuter grammatical genders and have two values for the category of number – singular and plural. Furthermore, there are seven cases nouns can vary in

Table 1: *Noun inflection classification in Croatian.*

Sing.	*Class a*			*Class e*	*Class i*	**Pl.**	*Class a*			*Class e*	*Class i*
	Masculine animate	inanimate	Neuter								
N	student 'student'	*zakon* 'law'	sel-o 'village'	sten-a 'rock'	mladost 'youth'	N	student-i	zakon-i	sel-a	sten-e	mladost-i
G	*student-a*	zakona-a	sel-a	sten-e	mladost-i	G	studenat-a	zakon-a	sel-a	sten-a	mladost-i
D	student-u	zakon-u	sel-u	sten-i	mladost-i	D	student-ima	zakon-ims	sel-ima	sten-ama	mladost-ima
A	*student-a*	*zakon*	sel-o	sten-u	mladost	A	student-e	zakon-e	sel-a	sten-e	mladost-i
V	student-u	zakonu-u	sel-o	sten-o	mladost-i	V	student-i	zakon-i	sel-a	sten-e	mladost-i
L	student-u	zakon-u	sel-u	sten-i	mladost-i	L	student-ima	zakon-u	sel-ima	sten-ama	mladost-ima
I	student-om	zakon-om	sel-om	sten-om	mladost-i	I	student-ima	zakon-om	sel-ima	sten-ama	mladost-ima

(in singular as in plural), see Table 1.
Additionally, there are three main inflectional classes nouns can belong to (cf. Table 1) according to the traditional grammar (Barić et al., 1997), though there are many subclasses that do not exactly fit the basic patterns of inflection and have patterns on their own.
As defined by Aronoff (1994: 64) 'an inflectional class is a set of lexemes whose members each select the same set of inflectional realization'.
Thus, nouns are traditionally classified into three main declensional classes named after the ending in the genitive singular, (e.g. G singular igrač-a 'player' , žen-e 'woman', kost-i 'bone' – class a, class e, class i). However, it is important to point out that there also exists a small number of indeclinable nouns (e.g. personal foreign names such as Ingrid, Karmen, Nives) (Barić et al., 1997). Class a is the largest class and it is further divided into two subclasses according to the gender of the nouns (masculine and neuter) belonging there. Class e comprises most feminine nouns terminating in -a, while class i consists of most feminine nouns ending in a consonant (Barić, 1997).

2.1. Natural morphology account on Serbo-Croatian noun inflection

Typological generalizations made in terms of inflectional classes are part of the second subtheory (typological adequacy) of Natural Morphology. In this respect, with reference to data obtained by Natural Morphology approach, languages characterized by strong inflection – such as Croatian, 'have the most complex structure on all levels, i.e. they generally have more macroclasses and a greater number of productive microclasses.' In the ideal inflecting-fusional type there are more productive inflectional categories and rules, but more unproductive microclasses, while at the opposite end would be an ideal agglutinating language, where all the morphological patterns are productive (Dressler et al., 2006). However, it is also truth that 'The more genders a language has, the more macroclasses and productive microclasses it may have' (Dressler&Thornton, 1996; 23 in Radisavljević, 2103)
Recently, a Master Thesis on Serbo-Croatian noun inflection within the framework of Natural Morphology saw its completion, providing us with new pieces of information concerning Croatian language. Namely, this classification is gender-based with three macroclasses with both productive and unproductive microclasses being settled and defined. I find the viewpoint of Natural Morphology quite important for the model design and the interpretation of the data as well, since productive and unproductive classes could be dealt with in different way, rendering the model simpler and more accurate at the same time.

3 GENDER ASSIGNMENT

3.1. Network morphology approach to gender assignment

The aim of this subsection is to illustrate Network morphology approach to noun inflection classification and gender assignment. This framework was firstly developed for Russian. However, a lot of work has been done nowadays to implement this defaults-based approach to other languages as well. Moreover, much information on this work is conjoined recently in the book written by Brown & Hippsley (2012).

Default inheritance is defined in Corbett & Fraser (1993: 120) in the following way:

'If X and Y are nodes, X may inherit from Y if a fact identifying Y as an inheritance source is included at X. All attributes: value pairs at Y become available at X, except those having an attribute which is already present in an attribute: value pair at X.'

In order to clarify more the notion of *default inheritance*, it is also important to introduce the notion of Network morphology, as well as its basic concepts. Network morphology is based on the formal language DATR, which allows for computer interpretation.
In brief, there are *values* (contain either atoms or list of a sequence of atoms, where atoms are considered to be undividable objects), *attributes* (might be either atoms or may consist of list of atoms), *facts* (consist of a pair of attribute and value), *nodes* (locations where facts are stored), and finally, *networks* which consist of relationships between nodes and facts (Corbett & Fraser, 1993).
The basic concept underlining this theory is that a word inherits the properties from the node put in a higher place in the hierarchy, with only exceptional properties to be added further. If, however, something specified in the upper node does not hold for that particular node, the local information may override the inherited information (default).
The notion of default will be illustrated with a well-known example involving the noun *penguin*. Penguin is a noun which would inherit all the properties of the noun bird, but would override the default that a bird flies, since it cannot fly (Corbett & Fraser, 1995).
The main idea of Network morphology approach is thus related to inheritance; there exist certain defaults which hold for the majority of examples, exceptions, which are defined locally and finally, there is the possibility of defaults being overridden.
Gender is determined by either the semantics of noun or its declensional class membership.

(1) ž ena:
<> == NOUN
<gloss> == woman
<root all> == ž en
<sem sex> == female
(cf. Brown & Hippisley, 2012: 140)

The example above shows that semantic gender could be sufficient for declensional class assignment.

(2) Student:
<> = NOUN
<declensional class> == N_I:<mor>
<gloss> == student
<root> == student
(cf. B&H, 2012: 53)

The example (2) illustrates how gender could be inferred from declensional class: since it belongs to class I, it has masculine gender.
However, an interesting example would be the noun muškarč-in-a which denotes not only a man, but a manly man; has feminine grammatical gender, but denotes a male person, would need to have it specified which declension group belongs to. It would be defined like this:

(3) Muš karč –ina:
<> == NOUN
<gloss> == man
<declensional_class> == N_III : <mor>
<root all> == muš karč in
<sem sex> == male
(cf. Brown & Hippisley, 2012: 141)

This Network morphology approach shows how the dynamics between gender and declensional class looks like in terms of computational linguistics.

3.2. Croatian National Corpus – the approach to gender assignment

While the traditional grammar, as we have seen, uses as its onset point the gender to define declensional classes, the defaults-based approach works in the opposite way – from a declensional class to gender assignment. The Croatian National Corpus could be regarded as a mixture of the traditional and default-based approaches, since there is a list of possible stems, list of endings and combination rules. Inflection is paradigmatic, meaning that different inflectional forms are used in different contexts, where paradigm of a word refers to all possible synthetic forms of a word. Although the basic patterns for the inflection of nouns are taken from the traditional grammar, they are adapted for a computer analysis (Tadić, 1994).
The inflectional model of the Croatian National Corpus, in particular the sample paradigms, consists of lemmas (contained in the lexicon), endings and transformations (allowed on stems).
Within this approach, which is done for the computer analysis as well, and it is thus interesting for this thesis, the information about gender is listed only if not predictable from the declensional class.

4 A COMPUTATIONAL MODEL FOR GENDER PREDICTING

The gender of nouns is to be induced from:

1) *Proper noun endings*:
The difference should be obtained between suffixed and unsuffixed nouns where e.g. both the unsuffixed noun most 'bridge' and the suffixed one *radost* 'joy' end in *–ost*, however, the unsuffixed would take masculine agreement (except *kost* "bone" – takes feminine agreement), while the suffixed would take feminine agreement. Furthermore, the difference between definite and indefinite adjectives should be accounted for, the feature that is still notable on the morphological level in the first noun inflectional class (most nouns terminating in a consonant with masculine gender).

(4) lep most & lep–i most vs. lep–a rad–ost
'a beautiful bridge' 'the beautiful bridge' 'beautiful joy'

2) *Agreement with adjectives :*
Since gender is defined through the agreement with adjective words, it is thus natural to use agreement with attributive and predicative adjectives so as to induce gender. In this respect the Croatian National Corpus is to be accessed, forasmuch as the aim is not the analysis of the existing grammar rules but to build a model that will illustrate what people really use.

5 CONCLUSION

The grounds of the model for predicting gender of nouns were presented in this paper, mainly the descriptive linguistic grammar and Network Moprhology framework.
The model which is aimed to predict gender of nouns in Croatian was built in the programming language Python and it is being tested at the moment.
Although inducing gender is counterintuitive, since it is an inherent property of nouns, developing and using a tool such as this might be of great interest for everyone intent on exploring and learning Croatian.

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MODELING OF SOCIAL TRANSMISSION IN CORVIDS

Nace Mikuš, Christine Schwab, Ipek Kulaehci, William Hoppitt***
Department of Cognitive Biology, University of Vienna,
*Princeton University, **Anglia Ruskin University Cambridge
e-mail: nacemikus@gmail.com

ABSTRACT

Research in social learning is vital for understanding the evolutionary origins of culture in humans. Laboratory research has uncovered a wide array of social learning mechanism but has failed to account for what happens in groups of animals in the wild. We present a statistical method that enables us to study the transmission of social information across a group of captive or wild animals in regard to the social structure of that group. The method termed Network Based Diffusion Analysis [1] applied for the analysis of a spread of foraging behavior in a group of captive ravens (N=12) indicates that ravens do in fact learn socially and the path of transmission seems to follow affiliative social networks. The approach we used can be further developed and applied for various studies of social learning of groups of non -human animals and humans alike. On the other hand, by progressively understanding bird cognition we can come closer to uncovering which cognitive abilities common to social animals including humans are irrespective of phylogeny.

1 INTRODUCTION

Some Tanzanian chimpanzees use tools to fish out termites while chimpanzees in Ivory Coast don't, but might use stones to crack open nuts. Similarly, only capuchin monkeys in Costa Rica do peculiar gestures of sniffing each other's hands and putting fingers in each other's mouths. Whales have different songs in different regions as do some of the birds [2]. These spatial variations of behavior across species beg the question if animals could be said to possess culture or is the term reserved only for the pinnacle of mammalian evolution. In all of these examples individuals seem to be learning from each other or *learning socially*. Questions like what exactly are they learning and under which conditions are of considerable theoretical significance for uncovering the roots of cultural processes in humans. Furthermore, social transmission mechanisms in animal species might offer a means of inheritance and adaptation much more rapid then genetic processes.

Until recently research in social learning strategies has been limited to dyadic laboratory experiments which have revealed evidence for a number of mechanisms but do not reflect the processes involved in the spread of behavioral traits in groups of animals in a more natural [3]. A better alternative is to use the cultural diffusion experiment, where innovations are seeded in a group of animals and the spread of the innovation is documented. By experimentally controlling innovations in behavior and by tracking the diffusion of the innovation in a group setting we can come closer to bridging the gap between experimental settings and natural group level phenomena.

2 METHODS

The classical method of inferring social transmission in groups was plotting the cumulative number of individuals that have acquired the trait against time. By analyzing this so called "diffusion curve" one could either infer social learning, when the curve was S-shaped, or asocial learning, when the curve was r-shaped [4]. There are however cases where the results show an s-shaped curve in the absence of social learning and conversely, situations resulting in a r-shaped curve when social learning occurs, which makes this method quite unreliable [4]. Franz and Nunn [1] tackled this challenge by developing a new statistical model called Network Based Diffusion Analysis (NBDA) that analyses the spread of behavioral traits in regard to the social structure of the group. The method was further developed and extended by Hoppitt et al. [4],[6].The methods now roughly divide into order of acquisition analysis and times of acquisition analysis which use different assumptions about the baseline learning rates and so making it applicable to various contexts (for details see [7]).

2.1 Network based diffusion analysis

The basic idea behind the NBDA model is to assume that the social learning rate of an individual is linearly proportional to the association between them. The type and numerical strength of association differs on the types of social networks we use. What the assumption is based on is that the probability that a naïve observer learns from the demonstrator is proportional to the social link between them. The social learning rate of a naïve observer i at time t could be written as

$$\vartheta_i(t) \propto (1 - z_i(t))(\sum_j a_{ij} z_j(t)), \qquad (1)$$

where $z_i(t)$ is 1 for informed and 0 for naïve individuals and a_{ij} is the strength of the social connection between individuals i and j. Since there is always a chance that the

naïve individual is learning asocially with the baseline learning rate $\vartheta_0(t)$, we can write the learning rate of an individual as a sum of social and asocial learning rates:

$$\vartheta_i(t) = \vartheta_0(t)(\,(1 - z_i(t))\left(s\sum_j a_{ij}z_j(t)) + 1\right). \quad (2)$$

By using maximum likelihood estimation we can assess the social learning parameter s that best fits the diffusion data. We can further compare the asocial modesl (where $s = 0$) and social models that correspond to different social networks by using Akaike criterion (for more details see [4] and [7]). The model was implemented in R.

3 EXPERIMENTAL DESIGN

The model we developed has only recently been applied to groups of captive and wild animals (eg. [8]). We have conducted a diffusion experiment on a group of captive ravens (N=12, aged 3) at the Haidlhof Research Station south of Vienna. By collecting observational data of the group (the ravens were observed daily in 5 minute focal protocols for months) we determined the social structure by applying social network analysis [1]. We have presented the group with a box problem experiment, where the birds had to figure out how to open the box to get to food, and recorded the times it took the birds to open the box.

4 RESULTS

Totally 11 ravens learned how to open the box. We have defined several different social networks that could be roughly divided into proximity, affiliative and agonistic networks. Using the OADA we have compared the models that correspond to the social networks with the asocial one. The results show that the social models mostly fit better then the asocial one with the models based on two specific networks seemed to fit best. The network corresponding to preening and touching (an affiliative network) had a social learning rate of 0.13 with a 95% confidence interval (0.003750979, 1.7036), which means that if a naïve individual A was seen preening or beak touching an informed individual B 10 times, then A would learn approximately 1 + 0.3*10 = 4 times faster than by learning by trial and error (see formula (2)). The general affiliative network seemed to fit best, with a social learning rate of 0.13 with a 95% confidence interval of (0.002015974, 0.7793486).

5 CONCLUSION

Our results suggest that ravens tend to learn from one another. Furthermore, they tend to learn more from individuals who they have more positive connections with. The methods we used could be widely employed by those studying diffusion of social transmission in various forms of non-human animals and humans. We intend to further developed the model and apply it to a population of wild crows. By shedding some light on avian cognition we are coming closer to understanding the selection pressures that may have boosted the evolutionary development of social cognition in humans and other primates.

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RESEARCH METHODS AND MODELS OF SYNAESTHESIA

Nina Mikuš
Department of Philosophy
Faculty of Arts
University of Ljubljana
e-mail: mikuska@gmail.com

ABSTRACT

Synaesthesia is a fairly rare phenomenon in which the subject in contact with certain stimulus in one modality experiences unusual extra sensations in other modalities, such as seeing or feeling colors while listening to music or personifying of letters and numbers. The phenomenon was long perceived to be merely a product of imagination and associations. Latest research, however, is based on a multidisciplinary approach, which includes first-hand synaesthetic reports, neuroimaging and behavioral tests used in confirming and explaining the phenomenon's presence as well as its neurophysiological foundations. This article presents an overview of such investigations through the lens of cognitive and psychophisical paradigms, genetic studies and neural models of synaesthesia.

1 INTRODUCTION

Synaesthesia is a phenomenon in which an otherwise normal person, while being stimulated in one modality experiences an emergence of sensations in other modalities. The original ancient Greek meaning is composed from two words: *syn* (joining) and *aisthesis* (sensation).

Although it is only for the last 200 years that synaesthesia has been scientifically defined, it has for a long time been very well known to the mankind through arts. What distinguishes it from the other mental states are its unvoluntarity and automacy.

Synaesthesia was first described by Francis Galton, in *Visualized Numerals* [1], where he presented the types of synaesthetic experience accompanying mathematical reasoning or the variations of polymodal experience of mathematical concepts, space and time.

As a proof of their distinctive eidetic memory, the synaesthetes state their parallel feelings (for example »I know the result is 2, becouse it is blue.«). Synaesthesia can include the spatial dimension. This is particularly noticable in the case of so-called »number forms«, where the spatial, formal and color perceptions get synaesthetically merged with semantically organized concepts such as alpahbet, temperature, months etc. [2, 3].

In the past synaesthesia was often dismissed as being exotic and unreliable simply because the state of synaesthetic experience could be verified only via subject's first-hand mental state reports [3]. Since there are no direct tests for synaesthesia, everything else are mere interpretive tools. Current studies rely on indirect methods of recording brain activity as well as on some of the newer methods of synaesthesia 'verification', which employ the observed 'typical features' characteristic of 'synesthetic' experience as their diagnostic criteria.

Probably the most common form is graphem-color synaesthesia. Particularly due to the availability of comparisons and combining of various methodological approaches, most of the studies and experiments are being adjusted to and focused on this type and its subtypes. The key areas of synaesthesia research in the last 20 years are: cognitive and psychophysical studies/theories; gene studies; neural models/ theories and studies of localisation of the phenomena by fMRI and other neuroimaging techniques (MR, CT, etc.) [4].

2 COGNITIVE AND PSYCHOPHYSICAL PARADIGMS

The cognitive and the psychophysical paradigms in synesthesia research are similar in their approaches. They differ mostly in terms of openness and aplicability. The behavioristically grounded approaches have some problems with processing and verifying the synesthetes' introspective reports, as well as with the conclusions derived from them. Reliability of the reports, for example the ones about synaesthetic colors, is sought to be confirmed by means of various experiments.

The most common one is the so-called ***Revised Test of Genuineness***. It focuses on verifying or rejecting the assumptions that synesthetic associations differ from ordinary associations and that (perhaps also for that reason) the synesthetes posess a much better memory than non-synesthetes do. The test is based on verifying the automatic mnemonic capabilities or consistent ability of retrieving information (of words, sentences, colors). For synaesthetes, this specific »information« acts also as a stimulus for the emergence of synaesthetic sensations, which could be crucial for absolute remembrance [4].

One of the oldest approaches is ***Stroop Color-Word Test of Interference***. By manipulating the representations of graphems (words or numbers) it checks the reaction time of subjects over the specific stimulus and identifies the

presence of automatic sensorical response. The subjects are tested with a list of color names printed in colored ink. For example, the word »BLUE« is printed in congruent (blue) or incongruent (some other) color [4]. The response time needed for naming the color and reading the word is much slower in the incongruent conditions, than in the congruent ones. *The Stroop test* for synaesthesia is conducted in the same way as the classical Stroop test, except that the combinations are adjusted to the synaesthetes in the group. For a synaesthete who sees the number 2 as blue, a 2 represented in blue would appear as congruent, whereas a 2 presented in any other color would appear to him or her as incongruent. The findings are similar: in case of inconsistency between the graphemes and synaesthetic colors, the response times of synaesthetes are also slower than in the congruent condition, which leads us to believe that the formation of synaesthetic colors takes place automatically and involuntary [5].

Albeit exposing the automacy of sensory perception in synaesthesia, both of the tests do not contribute to answering the question, whether the synaesthetic perceptions are of conceptual or sensory nature. In the last decade new paradigms are seeking to determine what exactly makes the difference between the perceptions of a synaesthete and a non-synaesthete. Ten years ago, neuroscientist Ramachandran designed a popular experiment ***»pop-out« test***, in which he presented to subjects the matrices with different graphemes, measuring afterwards the response time needed for recognizing the positions and numbers of specific graphemes in the matrix. Usually a matrix with number 5's is used, in the middle of which a triangle composed of 2's is situated. The control subjects have difficulties in recognising the difference and finding the triangle, whereas to the synaesthetes this presents no problem [5]. [1]

3 GENETIC BASIS OF SYNAESTHESIA

In his research Galton noticed that significant number of his subjects had relatives who were also synaesthetic [1]. Later on nearly all the studies have been mentioning the hypothesis that synaesthesia is hereditary. However up to 1990's only few studies have attempted to determine the frequency of occurence of synesthesia within a given population or to analyse the synaesthetes' family history [3]. There are major discrepancies in assessing the frequency of synaesthesia, as well as in determining its connection to the family pedigree.

Galton, for example recorded high frequency of the phenomenon in a 1:30 ratio in men and 1:15 in women [1]. Studies that were made four decades later reported exactly the opposite. Synaesthesia is estimated to be rather rare with the ability for such experiencing ranging to one person in 25.000 [3]. Due to significant variations, the latter mentioned studies possess a merely general informative value. One of the main reasons for their unreliability is inadequacy of the rated groups, which had been put together on the basis of reactions to an newspaper ad.

The tests of last ten years estimate the frequency of synesthesia to be as high as 1 in 200 [6]. In spite of methodological rigidity all the past investigations have been confirming an important information: there are two additional parameters within the frequency of synaesthesia: the sex of the respondents and their familial ties.

Modern research techniques have confirmed the assumption that synaesthesia has a close genetic linkage. Up to 40% of the synaesthetes have at least one close relative (parent, sibling, offspring) with the same type of synaesthesia, whereas in some families even more different types are present [7].

It is estimated that synaesthesia is more common in females than males, however the direct linkage to X chromosome is not yet fully confirmed.

The two main arguments against the abovementioned assumption are imprecision of past methods as well as the comparative studies of monozygotic twins. Cognitive tests in the 80's and 90's of the 20th century were namely not focused on precise determination of the genetic locus and were not considering the possibility of population often being unevenenly represented in favor of women. The claim of X-chromosome dominance is being challenged also by some of the latest comparative studies of monozygotic twins, that were not both consistent for synaesthesia, and by data which shows that the phenomenon may occasionally skip generations or can be inherited through male line[6]. High rate of synaesthesia among family members points to inherited abilities, and may at the same time serve as an affirmative argument for physiological or neurological basis of synaesthesia.

Genotype does indeed support and to a certain extent influence predisposition of an individual towards specific talents or personality traits. In a similar manner it also influences one's physical attributes.

Let us take as an example a case of simple, yet specific inheritance of a sensoric ability such as the ability to taste the PTC substance (present in pickles) as either bitter or tasteless. The proportion of non-tasters ranges from 20% in African population up to 30% in European descendants.

The ability to taste PTC as bitter is highly specific in that the substance can be recognised by the »taster« only when dissvolved in his own saliva and it is therefore not related to overall taste acuity [3]. Cytowic claims that it is not naive to seek a single-gene determinant for synesthetic ability. The argument for such an assumption are current cases, in which a specific gene determines the occurence of a complex mental phenomenon, as for instance in Tourette's syndrome, in types of X-linked mental deficits, color blindness and inherited deafness. Results of the tests done on twins suggest the high influence of the hereditary components on susceptibility for certain visual illusions, eidetic (photographic) memory, various optical illusions (afterimages), spatial orientation and for flicker fusion frequency [3].

Similar example are certain strongly expressed talents. One of the talents that are supposed to be inherited is the

[1]Test with a numerical matrix is of course appropriate for those synesthetes, who, due to the »cross-wiring« are able to see and visualize the numbers in colors. Usually the matrices are printed in black on white base and are only occasionally presented with letters and other symbols.

musical ability. The family trees of world's famous musicians such as Bach, Mozart and Beethoven speak in favor of such claims. For this kind of inherited ability it is characteristic to emerge early in life, to improve steadily, and persevere among the gifted, independently from the circumstances [3]. A similar development may be spotted in synaesthetes as well in terms of possessing a memory of their trait that goes way back into early childhood and is perceived as a natural part of their perception (the latter applies to the developmental synaesthesia but not to the acuired one) [ibid].

At this point we may establish an analogy between synaesthesia and the perfect pitch. The latter phenomenon namely also shows high familial inhidence, occuring more often in females and invariably manifesting itself at a very early age. Developmental synaesthesia and perfect pitch share some further similarities as well, such as the absolute presence of phenomenon. In both cases the skill emerges naturally without the necessity to develop it trough practice [3].

From neurological point of view the perfect pitch is believed to be located in the left planum temporale, more precisely in the auditory cortex. We shall see later on, the neural models of synaesthetic perceptions point to the increased activity taking place exactly in the area of planum temporale during synaesthetic experience [8].

4 NEURAL MODELS OF SYNAESTHESIA

In the 19th century, the popular theories of undifferentiated neural activity suggested that synaesthesia was caused by an immature nervous system. They linked synaesthesia with the normal syn-kinesis (the joining of voluntary movements with involuntary ones), that can be observed in babies. When baby reaches for a toy, he exhibits a flow of involuntary movements of the body and extremities. With the maturity of corticospinal and cerebellar motor pathways and with aquired myelin insulation, a human being is capable of performing the fine movements separately without tranfering them over to other muscle groups. As synaesthesia was for a long time considered to be essentially a mental impairment and an accidental perceptual response, the phenomenon was mistaken for some form of atavism or »sensory incontinence« [3].

Two broader theories of neural basis for synesthesia have been developed. They both derive from the confirmed assumption that synaesthesia is a neurophysiologically localised phenomenon.

5 LOCAL CROSSACTIVATION

On the neurophysiological level the models of synaesthesia differ according to their initial questions. The two basic questions from which they begin are namely whether synaesthetic experience arises from and is conditioned by failed neural pruning or may there be some kind of inability of reducting the long-range disinhibited feedback from the visual system.

The regions that participate in letter and number recognition (the areas of parietal and central lobe) also lie close to the area that participates in color processing (V4). Due to the close location of both areas there is a high probability of reinforced linking between the two, which can lead to the so-called crossactivation between the area for the grapheme recognition and V4. We may conclude that the extra-color experience while seeing graphemes is indeed a consequence of crossactivation of V4 area [4]. As the main reason for crossactivation *The pruning model* points out failed development of synaptic pruning. The development process of pruning is one of the most important mechanisms of synaptic plasticity in which the connections between brain regions are partially curtailed and eliminated during the development. This insufficient pruning is sugessted to be the cause of intensive activation of neural pathways between the brain areas, which in the case of a synaethete leads to increased entry of information and therefore to perceptual cross-wiring [4].

The same model might be applied to other forms of synaethesia. Lexical-Gustatory synaesthesia, for instance, could emerge due to increased pathways between areas in the depths of lateral sulcus which participates in processing of taste information and is located next to the frontal lobe and thus next to the areas in charge of processing the auditory information. [4]. However, it is crucial to point out that the crossactivation model is a hypothetical one which can not explain all the forms of synaesthesia.

6 LONG-RANGE DISINHIBITED FEEDBACK

The second theory is based on studies which defend the hypothesis that the causes of synaesthesia may be attributed to the disinhibited feedback from a »multisensory nexus«, such as temporo-parietal-occipital junction [4]. The principle of disinhibited feedback has been established for a long time already. Its main idea is that the information does not only travel from the primary sensory areas to asociation areas (i.e. the parietal lobe), but that it also travels in the reverse direction, therefore from »high ordered« cortical regions to basic sensory areas. In cases of ordinary responses there is a balance of excitatory and inhibitory postsynaptic potentials. When, however, the response is not appropriatelly inhibited, the signals from later stages of processing might influence the earlier processing stages [6]. This process might possibly explain why the activation of visual cortical areas in synaesthetes is more intense than in non-synaesthetes, when listening to sound tones, for example. The reports about temporary synaesthetic-like experiences as a result of psychedelic drug consumption, also speak in favor of this model [3].

7 CONCLUSION

During the early development of scientific thought synaesthesia stood mostly in the focus of humanities and only partially within the domain of natural science. Research was being based above all from the theories on metaphores and associations. Another path of development was opened much later when neuroscience was formed.

Due to its inherently subjective nature, synaesthesia was for a long time being pushed aside on part of behaviorists and the interest for the phenomenon was thus to be rekindled only in the last two decades of the previous century.

During the past two decades it has become possible to speak of a trend of increased interest in synaesthesia, that was fostered by increasingly popular focusing on sensoric experience established in cases of synthetic drugs use, rapid development of informational science, growing interest in methodic brain research by means of mesuring devices and - last but not least - by the invention and development of widely avaliable diagnostics in brain research.

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CONNECTING NEUROSCIENCE WITH ANTHROPOLOGY - NEW ANSWERS (AND QUESTIONS) IN UNDERSTANDING COMPLEX HUMAN COGNITIONS, SUCH AS MATHEMATICAL REASONING

Zarja Muršič
MEi:CogSci
University of Ljubljana
e-mail: zarja.mursic@gmail.com

ABSTRACT

The paper presents anthropological view on human nature and culture. It argues that complex cognitive skills, such as mathematical reasoning, are additions that humanity achieved with specific human culture.

The main thesis of the paper is that culture mainly affects the process of ontogenetic development in specific environments, but it may influence specific current behaviour as well. Further objective of the paper is that culture, with affecting the process of ontogenetic development in specific environment and social settings, leads to all complex cognitive skills, such as mathematical reasoning.

Further focus of the paper is mathematics. The paper presents and summarises a couple of research papers on mathematics. The first example is the case study of patients with damaged language centres. Despite suffering from severe aphasia, preventing them from understanding or producing grammatically correct language, they can perform basic mathematical operations. The second example comprises the comparison between the Asians and the Westerns in solving simple mathematical tasks. Results from both examples show important connections between brain wiring and abilities in solving tasks, as well as the influence of the environment on tasks solving.

In the last section, the paper presents neuroanthropology as a possible new pillar of cognitive science. With this emerging sub-field, the connection between neuroscience and human variability might become established.

1 INTRODUCTION

Throughout the history of anthropology there was a question regarding who are human beings, what is the humanity and what shapes us, humans. Some scholars argue that human biology can be analytically separated from culture and that it is meaningful to study only human biological evolution (Marks 2012). However, even Marks (2011) stresses the importance on culture and human history.

When we separate human biology from environment and culture that leads to deterministic view of human beings, as if we could explain everything with understanding the beginnings of the species *Homo Sapiens*, as well as other preceding animal species.

However, sometimes we cannot understand animals with explanation of their basic behavioural operations. Studies done in natural environment prove the complexity of animal behaviour. The complexity observed in animals is not necessarily internal to the biological frame of the animal's organism. Behaviour often emerges from the interaction between the animal and the surrounding complex environment (Simon 1996).

Population-specificity can be observed in humans as well as in populations of, e.g., chimpanzees (*Pan troglodytes*). Let's take for the example the use of tools in different populations of chimpanzees. Boesch and Tomassello (1998) wrote about their behaviours like ant dipping and leaf clipping that differ in form and function among many different populations of chimpanzees.

Furthermore Sapolsky and Share (2004) reported the emergence of a unique culture in a troop of olive baboons (*Papio anubis*), related to the overall structure and social atmosphere of the troop. Baboons lived in groups with dominant males acting aggressively towards the subordinated. They were also attacking females. The dominant male baboons went to the garbage pit at the dawn for food and did not let any lower-ranking baboons near the food source. However, the outbreak of bovine tuberculosis occurred, originating from infected meat in the dump. These deaths greatly altered baboons' group composition; there were fewer males than females left and only less aggressive and submissive males survived. Presented was the reason for group dynamic to change; males started to groom females, they did not develop aggressive behaviours. The male behaviour persisted even when the males of the primary group were replaced more than seven years later. Sapolsky (2004) also checked hormone levels for markers of stress: these values remained changed.

This example shows how can a change in group interaction pattern cause biological change in its members, including how they acted male and female, how they raised children,

how they mated (Downey 2013). Even in animals social interactions can have profound effects on biology. The latter example shows us the importance of studies in animal cognition and their observations in natural environment, where we can observe how living creatures adapt in their behaviour. It is clear that at least social animals do not just act based on innate fixed rules.

Examples from animal cognition show clear complexities in behaviour. Behaviour shows higher level of action in the environment. There is a growing number of evidence for the support of the thesis that human actions are wired in our brain. One of the reasons that this is possible is the prematurity of human children. Somewhere in human evolution, there has been a significant extension of the period of dependency, affected by slowing down the rate of maturity. Latter enabled young humans to learn to communicate, to adapt to their surroundings, and to be successful participants in a social group (Marks 2011). Therefore, the important question arise on what are innate properties of brain and how can we relate brain wiring during the lifespan of a subject to its environment and culture.

The humans are well known to develop a specific social-cognitive niche (Whiten & Erdal 2012). The main components of the latter are cooperation, egalitarianism, mindreading (theory of mind), language and cultural transmission. However, all the listed components primarily enabled human to become unique and highly competitive predatory organism. It is important to note that almost all forms of niche creation are unintentional (Downey 2013).

We are hyper-social and have access to complex cognitive skills. One of them is also our capability to compute and use of mathematics. It is important to note that our brain did not develop to solve mathematical mysteries. We solely developed it to survive and reproduce within a given environment. Our basic capabilities, such as spatial orientation and innate computation that help us finding our way in the surrounding environment are as important for us as for any other animal species.

For example, computers are much better in computing than we are. However, the machines are not able to recognize objects, obstacles and they cannot find a way around the world as easy as we do. The important distinction is that humanity developed through millions of years of evolution to do those tasks successfully.

One of the main reasons for our success lies in our nervous system. The first nervous system was developed in animals that had to move and change environment where they lived. One of the main reasons why we have the nervous system is interaction with the surroundings and perceiving of the environment (Downey 2013).

On the other hand, we have some abilities that no other animal posses. The objective of the paper is to argue that all complex cognitive skills, such as mathematical reasoning, are an addition achieved with our culture.

Additionally all specific ways of acting, perceiving and knowing, we are accustomed to call cultural, are incorporated, in the course of ontogenetic development, into the neurology, musculature and anatomy of the human organism; thus they are equally facts of biology (Ingold 2001, 2007; from: Downey & Lende, 2012). Ingold (2001, p 28) writes: "Cultural differences, in short, are biological." Essentially, Ingold (2010) suggests that "development thinking allows us to recognize that we are not dealing with separate but parallel system, respectively biological or cultural, but rather that the biological process of development, of the living human organism in its environment, is precisely the process by which cultural knowledge and skill are inculcated and embodied."

2 MATHEMATICAL REASONING

Animal comparative studies have shown that animals are able to count. Experiments with raccoons, canaries, some monkeys and other animals have shown that some form of the sense for numbers is widely shared (Dehaene 1999). Studies with rhesus macaques (*Macaca mulatta*) showed that they can distinguish between small numbers (< 4); but when numbers are higher, the ability to distinguish precisely between amounts becomes more difficult (Hauser 2000).

This means that we have to take the sense of number (Hauser & Carey 1998, Dehaene 1999) as something that exists prior and external to language. Then perhaps, basic arithmetic may also exist without language.

The latter example can be observed in studies of patients with damaged language centres of the brain, but can still solve simple arithmetic tasks. Varley and colleagues (2005) studied patients with large left-hemisphere perisylvian lesions that led to severe grammatical impairment and some difficulties in processing phonological and orthographic number words. The patients did not have any problem with solving mathematical problems, involving recursiveness and structure-dependent operations. The results demonstrate the independence of mathematical calculations from language grammar in the mature cognitive system (Varley et al. 2005).

Moreover, the way in which we are solving simple mathematical tasks does not depend on our language per se (Varley et al. 2005). The way of solving simple mathematical operations depends on the environment and other cultural factors, such as mathematics' learning strategies and educational systems.

Tang and colleagues (2006) did a study with native Chinese and native English speakers. Using functional MRI, they demonstrated different cortical representations of numbers between Chinese and English speakers. Native Chinese speakers engage a visuo-premotor association network for simple task in addition. In comparison, native English speakers largely employ a language process and rely on left perisylvian cortices for the same tasks. Additional observations were done. There was a functional distinction among the brain networks involved in the task for numerical quantity comparison between Chinese and English groups. The interpretation of the difference between Asian and

Western performance of addition lies in the neurodynamic differences during mental arithmetic as resulting from habitual use of abacus in primary school, which results in ability of Asians to use visual-spatial simulation for mental calculations. On the other hand, Western subjects used only verbal processing systems (Downey & Lende 2012).

The latter example represents the important skill-like dimension of culture. The Asians learn or train to use visual-spatial domain of cognition to calculate more efficiently. The presented differences prove that culture and environments, where the humans ontogenetically developed, played much more important role in specific human abilities and manners in task solving. The presented study as well supports Ingold's idea that biological process of development is the process by which cultural knowledge and skills are inculcated and embodied (Ingold 2010).

3 MATHEMATICAL REASONING THROUGH THE EYE OF NEUROANTHROPOLOGY

In the final part of the paper I will present the idea that neuroanthropology represents a very good approach to combine all previously presented examples. We have to understand that mathematics in humans does not develop because of natural evolution, but is a product of cultural evolution. When we understand it in that kind of manner, we can understand also the biological properties of our ontogenetically developed mind that enable us to compute and solve complex mathematical tasks.

Firstly, we can gain important views on human cognitive abilities from patients and their experiences; as for example does Oliver Sacks who actually called himself a neuroanthropologist (1995; from: Downey & Lende 2012). A study of patients with damaged language centres shows the important fact that mathematical reasoning does not depend only on language. It is, basically, an additional and independent part of our cognition. Furthermore, with cross-cultural studies of mathematics, the so-called ethno-mathematics (d'Ambrosio 1985), we gain the knowledge about how our development in specific environment shapes our cognition. For further investigation it would be interesting also to study patients with same lesions raised in different environment. Presented research and views on human mind and cognition also provide new views on education. Further findings in the presented field might also change our educational systems and bring some novel ideas into it.

Neuroanthropology does not focus on broad-based concepts, like habitus and cognitive structure; instead, it focuses on how social and cultural phenomena actually achieve the impact they have on people in material terms (Downey & Lende 2012). It is important to take into consideration structural inequalities and differences between people from various places and cultural background. The paper presented such difference between the Asians and the Westerns, which became apparent because of their exposure to different social and cultural environments. Neuroanthropology, with taking such differences in consideration and with linking neuroscience and anthropology, should provide another important pillar of cognitive science (Downey & Lende 2012).

4 CONCLUSION

The combination of case studies and cross-cultural studies has a great potential in bringing anthropology back to cognitive science and might lead to more general understanding of human mind. It might not perhaps lead us to universal understanding; however, it will provide solid foundations to show the wiring of the brain in its connections to the environment.

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THE CONCEPT OF COHERENCE IN MODELS OF THE MEANING IN COGNITION: "ENACTIVISM" AND NEUROPHENOMENOLOGY APPROACH TO MIND-BODY-ENVIRONMENT INTEGRATION

Matej Plankar[1], Simon Brežan[2]
[1]Inštitut BION, Stegne 21, 1000 Ljubljana
[2] Independent researcher
e-mails: matej.plankar@bion.si, s_brezan@yahoo.com

ABSTRACT

Coherence substantiates a dynamic order between a system's components, thus representing an important organisational principle in life and cognition. Coherent activity of neuronal assemblies correlates with all basic cognitive functions, including consciousness, and coherence is also an important mechanism of interneuronal signal processing, e.g., information en-(de)coding, communication and synaptic plasticity. However, according to enactive approach to cognitive science that emphasises organisational autonomy, the brain is not only an information processing machine, it also interprets information from its environment according to the system's norms, and thus creates the meaning. We specify the potential role of coherence as a dynamic relation principle- within a cognitive system and with its environment- that could mediate the meaning.

1 INTRODUCTION

Coherence is one of the most prominent emergent properties of complex self-organising systems that are based on feedback interactions between their elements. In broader sense, it denotes dynamic correlation among the system's components, which maintains a consistent organizational pattern or identity of the system. In its narrower meaning, coherence reflects synchronous or consistent phase relationship or frequency entrainment of coupled rhythmical oscillators over time. The power of coherence stems from synergic summation of contributions of individual components, which enables greater responsiveness to external stimuli, while at the same time it affords the system with a potential for efficient communication, i.e. encoding and transfer of information, based on phase, frequency and amplitude of oscillations (Osipov et al., 2007). Therefore, coherence maximises energy transfer and information processing, representing as such one of the basic principles of self-organisation (Arenas, 2008). Examples of coherent dynamics can be found at all levels of biological organisation, from molecular and metabolic level (e.g., quantum coherence, coherent metabolic cycles), various physiological rhythms (e.g., coherent brain oscillations, circadian rhythms, locomotion) to ecological and social level (e.g., collective dynamics of groups of animals, coordinated social interactions or social cognition). Since cognitive systems (human, animal, artificial) generally categorise to complex systems, we may expect a significant role of coherence in cognitive processes (Plankar 2010, 2013, Plankar et al. 2013).We specify the role of coherence not only in terms of information processing, but also its relation to *meaning* in cognitive systems.

2 NEURONAL COHERENCE AS A PRIMARY MODE OF BRAIN INFORMATION PROCESSING

For more than a decade, neuronal oscillatory coherence has played a central role in system and cognitive neuroscience. Research provided key findings that neurons do not operate independently as specialized representational »feature detectors« or functionally and/or localization-based simply predetermined stimulus-response modules, but instead work in dynamic concert, so that neurons within differently sized and spatially distributed groups of neurons (neuronal assemblies) precisely coordinate their temporal activity and functionally couple when involved in a common task. Synchronous neuronal electromagnetic oscillations- generated by intrinsic mechanisms of individual neurons in combination with internal (excitatory and inhibitory) recurrent network interactions, modulated by external sensory input- were proposed as a main candidate for the mechanism of such coupling, subserving functional connectivity as demanded by cognitive constraints (Buzsáki and Draguhn, 2004; Fries, 2009).

In recent years it has become clear that oscillations are not mere epiphenomena, but are causally related to cognition. Namely, different temporo-spatial measures of neuronal coherence, i.e. synchronization of neuronal electrical impulses (action potentials) and/or macroscopic brain oscillations (as measured by, e.g., EEG) within and between different brain areas at different frequency bands (e.g. theta, alpha, beta, gamma) functionally correlate with all main cognitive functions, e.g. perception, attention, memory,

sensorimotor integration, decision-making, and even consciousness (Uhlhaas et al., 2009). It has been suggested that coherence mediates not only coupling of distinct brain regions involved in the same function, but also cooperation between different ongoing cognitive processes in different regions, from which unified mental constructs and goal-oriented meaningful behaviour emerge (Basar, 2006). Different frequency bands have specific functional and behavioural correlates, activating contexts, mechanisms, spatial scales, and inter-relations (Niedermeyer and Da Silva, 2005), collectively resulting in highly interdependent and parallel information processing at multiple spatio-temporal scales. Mechanistically, there are many functional roles of oscillatory coherence: it does not only promote an efficient information transfer (via e.g., input summation and coincidence detection) and communication (interacting neurons can exert a stronger impact on one another if they are depolarised at the same time), it also acts as an information coding system based on phase, frequency and amplitude of neuronal oscillations, and on timing of neuronal spiking relative to oscillatory cycles (phase-coding). Firing patterns are considered fundamental for information coding in the brain, and in a such temporal-coding framework, oscillatory synchronisation could mediate the exchange of phase-coded information (Buzsáki and Draguhn, 2004; Jensen, 2001). Additionally, coherence enables selective interactions and inhibits potentially distracting pathways (via decreases). This is needed for efficient functional coupling of different groups of neurons, implicated in the same specific function, but could also mediate attentional top-down control (Fries, 2009). Temporal dynamics of coupling of pre- and postsynaptic neuronal activity also affects synaptic plasticity (Wespatat et al., 2004), i.e. neuronal activity-dependent change of synaptic strengths, which forms the basis for development, learning, memory and self-change.

3 NEURONAL COHERENCE AND PURE MENTAL STATES (EXPERIENCING/ CONSCIOUSNESS)

Perhaps the most significant finding for the cognitive science is that different measures of neuronal coherence represent the closest correlate of phenomenal mental states, or experiencing. Senkowski and co-workers (2008) review research where the same audio-visual stimulus causes different subjective experiential interpretations that could be predicted by the patterns of neuronal synchronisation in the gamma and beta frequency bands. The authors conclude that coherence represents a prominent mechanism for binding of different sensory modalities between various brain regions into a unified cognitive synthesis. Similarly, Uhlhass and co-workers (2009) review research collectively showing that transient bursts of synchronous oscillations in gamma and beta bands between distant brain regions significantly correlate with consciously perceived stimuli, but not with non-perceived stimuli that only correlate with local synchronisation. Whether the long-range synchronisation as such is necessary for maintaining or merely initiating conscious states, or in other words, how 'directly' does it correlate with phenomenal awareness, remains to be determined.

The idea about dynamic patterns of neuronal synchronisation as the neuronal correlate of mental states (or consciousness, as it is commonly articulated) has been present in cognitive science for over a decade. Evan Thompson and Francisco Varela (2001), for example, have suggested that neuronal coherence should not only subserve the binding of sensory attributes, but the overall integration of all dimensions of a cognitive act, including memory, motor planning, and emotional tone. In the context of complex dynamic systems, coherence is an emergent process, meaning that it can exert global-to-local influence on individual components through changes in global control parameters and boundary conditions that constrain their behaviour (i.e., downward or circular causation). It follows that if conscious states are indeed closely correlated with synchronised neuronal assemblies, then accordingly they can have causal effects on local neuronal activity, and therefore consciousness may be an active participant in constituting an agent's life (Thompson and Varela 2001), and not just a passive by-product of neural processes, or a mere"self-illusion" of the brain (such views seem questionable also from evolutionary point). In support to this conjecture, Beauregard (2007) has reviewed research from different experimental paradigms (emotional self-regulation, psychotherapy, placebo effect), demonstrating a direct causal effect of purely mental states (like beliefs, intentions, hopes, anticipations, as first-person perspectives) on various physiological and neurophysiological parameters, i.e., mental causation (of course, these higher mental states have their own complex neural grounds).

4 THE FREEMAN–VITIELLO THEORY OF DISSIPATIVE BRAIN DYNAMICS

On another line of research, a concept of dynamic patterns of neuronal coherence as the carrier of the agent's sense-making activity (or meaning) – called a wave packet – has been proposed by Walter Freeman (2003a), using high-density electrocorticography. A wave packet is a global attractor of self-organised cortical dynamics that constrains local neuronal assemblies according to a macroscopic order parameter. It is characterised by a defined carrier frequency of synchronous oscillation in the gamma and beta range and its phase and amplitude modulation across the measuring surface. Another prominent characteristic of wave packets is their extremely fast onset from the transient period of stochastic background activity (called a null spike) that could not be sufficiently explained by the models of synaptic transmission (Freeman and Vitiello 2006).

In order to explain the unusual properties of the wave packets and different inconsistencies of traditionalist views,

Freeman and Vitiello (2006, 2009) have developed the dissipative brain dynamics model, which employs mathematical framework from the quantum field theory. The rapid onsets of the wave packets are modelled as spontaneous symmetry breaking whose predicted molecular carriers are electrical dipoles within a polarisationally dense medium. The breakdown of the symmetry manifests in the coherent (unisotropic) condensation of electronic dipole excitations from thermally excited (isotropic) fluctuations, which marks the phase transition of neuronal activity from microscopic assemblies to a collective field of macroscopic brain dynamics, i.e., the wave packet. The coherent condensation at the molecular scale is thought as to mediate the long-range correlations that 'steer' the functional neuronal connectivity through the attractor landscape.

There has been a considerable debate whether long-range molecular interactions (mediated through quantum and/or electromagnetic effects) could exist and exert biologically meaningful effects in the "warm, wet and noisy" biological environment. The recent experimental progress, especially on photosynthetic systems (Lambert et al. 2013), have made a proof-of-principle that organisms can harness quantum coherence to maximise their energy efficiency. The recent experimental support (Sahu et al. 2013) to the hypothesis that microtubules support coherent electromechanical vibrations (Kučera in Havelka 2012, Cifra et al. 2010) further expand the scope of coherent long-range interactions to neuronal information processing and to theories that use the conceptual tools of quantum physics to explain consciousness. The concept of dynamic order manifested through multi-level coherence could thus afford a bridge between different disciplines and their proposed mechanisms concerning brain dynamics, independently of their organisational level (Plankar et al., 2013).

5 COHERENCE AND "ENACTIVISM" APPROACH: SENSE-MAKING AND MIND-BODY-ENVIRONMENT INTEGRATION

The wave packets have two interesting properties: their power and spatio-temporal extend correlate with the degree of the subject's engagement with environmental stimuli; and their phase and amplitude modulations lack invariance with respect to stimuli, meaning that they continuously change and adapt with intrinsic state and context – e.g., cumulative experience with the same stimuli, manner of reinforcement, state of expectancy, etc. (Freeman and Vitiello 2006, Freeman 2003a). Based on these and above mentioned self-organising properties, Freeman (2003a,b, 2009) argues that the wave paket is not a mere representation of objects and events in the environment – i.e., information that is subject to internal processing, storage and retreival according to internal syntactic rules – but already is the carrier of meaning. Its content constitutes an activated part of the agent's knowledge base, capable of intentional action, and thus represents the basic unit of the action-perception cycle (a concept formulated by Merleau-Ponty, namely the capability of the brain to proactively relate to the environment, by which an agent continuously constitutes and updates its knowledge of the world).

This view departs from purely information processing models of cognition that leave unexplained the autonomous organisation of cognitive agents, since without autonomy there can be no original meaning, nor the "self" – there is only the derivative meaning attributed by an outside observer (Thompson and Stapleton 2009). Seen in this context, the dissipative brain dynamics theory – and coherence as its primary operational principle – is compatible with and lends neurophysiological support to the *enactive approach to cognitive science*, which asserts that cognition is primarily a meaning- (or sense-) making activity – an inherently relational process that takes place between the system and its environment with respect to norms and values established by the agent's self-constituted identity. In this framework traditional modular distinctions between emotion and cognition get transcended, too (Thompson and Stapleton 2009, Di Paolo 2009).

In further support to the role of coherence in the integrative »enactive, embodied, embedded brain« approaches, we point to research showing that coherent coupling takes place also at the level of brain-body »interface«. For example, corticospinal/ corticomuscular coherence, where sensorimotor cortex oscillations synchronize with the activity of contralateral spinal motoneurons, increases during steady muscle contractions in the beta range, whereas during dynamic force output predominantely at gamma frequencies; such coherence strongly correlates with the motor performance, reflects certain recalibration processes, and was proposed as a mechanism for effective corticospinal interaction (Mima and Hallett, 1999; Gwin and Ferris, 2012). Brain-muscle functional connectivity is an important means of the agent's abilitiy to "enact" the world, which obviously could not be realized without its coordinated motor actions enabling meaningful exploration and interaction with the environment.

Moving outside the still dominant isolated brain perspective, some recent studies of social cognition report inter-subjective brain coherence in cooperation paradigms, like music playing, social games and other communicative acts involving multiple subjects (also termed »hyperbrain« concept and measured via »hyperscanning«, e.g., dual EEG) (Sänger et al., 2012). For example, Cui et al. (2012) found increased coherence between subjects in superior frontal cortices during cooperation, and this correlated with an increase in cooperation performance during the game, but could not be deducted by single-brain analysis alone. To sum up, all above mentioned findings support the important role of coherence in the agent's bodily and social interactions, by which the agent makes sense of the world.

As Freeman (2003b) puts it, "there is no widely accepted definition of meaning by which to express it in a set of state variables in a model. It is not subject to quantitative measurement, prediction and description with mathematical and statistical tools. It cannot be transmitted using information as a carrier." To naturalise the meaning in biology and cognitive science is a primary challenge of biosemiotics. Briefly, biosemiotics asserts that semiosis, i.e., sign activity, is a defining characteristic of life (Hoffmeyer 2008, Barbieri 2008, Emmeche and Kull 2011). Organisms differ from machines in that they *interpret* information, not process it. Interpretation in its broadest sense is a *relation* of a *sign* to its *meaning*, which is independent of specific physical and chemical characteristics of the sign. It is exactly this arbitrariness of relations that allows freedom from direct determination by the physical laws and thus warrants open-ended evolution (Pattee 2008).

Evolutionary fixed relations (such as a DNA code) are necessary to support basic life processes and preserve its historical continuity. Cognition can be understood simply as a continuation of this process where new relations with the agent's environment are continuously formed and gradually become embodied as memories and value systems (i.e., intrinsic mental dispositions such as beliefs, desires, episodic memories etc.) that constitute its normativity. Experiencing thus already is a meaning, i.e., an interpretation of intrinsic mental dispositions that attributes a qualitative value to the agent in its interaction with the world. In this framework, coherence could be understood as an important operational principle, i.e., a mediating mechanism that establishes *dynamic relations* at multiple organisational levels, in order to encode them into norms (e.g., through synaptic reinforcement) and decode those norms into meaningful bodily, cognitive (anticipatory/ experiental), and social interactions. Coherence, however, could only work as a 'binding' mechanism for establishing new relations and integrating past (memories), present percepts and future predictions; it does not, of course, phenomenologically explain how mental states emerge from the body, which remains the core ("hard") problem in cognitive science.

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DIFFERENTIAL GENE EXPRESSION IN ASSOCIATION WITH HIGHER STATES OF CONSCIOUSNESS

Metka Ravnik-Glavač [a,b], Sonja Hrašovec [a], Jure Bon [c], Jurij Dreo [c], Damjan Glavač [a]
[a] University of Ljubljana, Faculty of Medicine, Institute of Pathology,
Department of Molecular Genetics, Zaloška 2, Ljubljana, Slovenia
[b] University of Ljubljana, Faculty of Medicine, Institute of Biochemistry, Ljubljana, Slovenia
[c] University Medical Centre, Department of Neurology,
Laboratory for Cognitive Neuroscience, Ljubljana, Slovenia
Tel: +386 1 5437183; fax: +386 1 5437181
e-mail: metka.ravnik-glavac@mf.uni-lj.si

ABSTRACT

Higher states of consciousness in which the human mind can transcend the boundaries of logic and reason are envisioned as natural to the experience and potential growth of every human being. So far they have been mostly monitored by electrophysiological methods. We were particularly interested in discovering the molecular transcriptional basis of higher states of consciousness. In addition to phenomenological reports of meditators the generated higher states of consciousness were also EEG recorded. We assessed the whole genome gene expression analysis of long-term meditators in six separate trials and detected significant differential gene expression in association with higher states of consciousness. The number of differently expressed genes as well as high proportion of genes themselves differed between meditators. Despite this, gene ontology enrichment analysis found significant biological and molecular processes shared among meditators' higher state of consciousness.

1 INTRODUCTION

Science and spirituality have been becoming closer and closer in recent years. Increasing basic scientific interest in the effects of meditation has led to several studies that were primarely focused on the effects of meditation on brain functions and have shown that the combination of neuroimaging and neurodynamics is a particularly promising methodological approach to revealing obvious neurophysiology changes induced by meditation (1-8).

However, there are not many studies on how meditation influences peripheral biological processes important for health and illness, especially on the molecular level using modern molecular approaches. It was shown recently with a few gene expression studies that long-term and short-term meditation practitioners may regulate immunity, metabolic rate, response to oxidative stress, cell death (9-13). Althoug similar genomic pattern changes occurred overall, indicating a common relaxation response state in practitioners regardless of the techniques used to elicit it, it was not clear from these studies what subjective levels of meditation were achieved by different practices and practitioners. Namely, long-term meditators of Transcendental meditation techniques are described who have experienced periods of pure consciousness known to oriental thinkers for many centuries, in which the brain can transcend the boundaries of logic and reason, and experience states of extended awareness, commonly unrecognized (14). These states of consciousness are characterized by breath suspension episodes without compensatory hyperventilation, accompanied by high intra- and interhemispheric EEG coherence in alpha and theta frequencies, especially in the frontal areas of the brain, periods of low metabolic rate and stable autonomic activity (8, 15, 16). We were particularly interested to show whether differences in the subjective perception of a precisely experienced higher states of consciousness which were supported by phenomenological reports and EEG recordings are also connected with significant and specific molecular genetic changes.

2 RESULTS

2.1 EEG monitoring

EEG data were recorded from Meditator 1 while he was sustaining higher state of consciousness with eyes opened for 25 min. Signal power increased in theta (4–7 Hz) and alpha (8–12 Hz) frequency range in continuous manner during mediation, mainly in parieto-occipital and frontal or fronto-central regions. EEG data from Meditator 2 were recorded while he was continuously meditating with eyes closed for 25 min. Signal power increased in theta (4–7 Hz) and alpha (8–12 Hz) frequency range in continuous manner during mediation, mainly in occipital regions. Power changes in alpha 1 frequency range (8–10 Hz) were most consistent with the time course of meditation of both Meditators (Fig. 1). According to Travis & Shear (8) higher (transcendental) state of consciousness is connected with increased alpha 1 (8–10 Hz) frequency band and was so far only reported in

connection with Transcendental meditation practices and in one long-term Qigong practice meditator (8, 16).

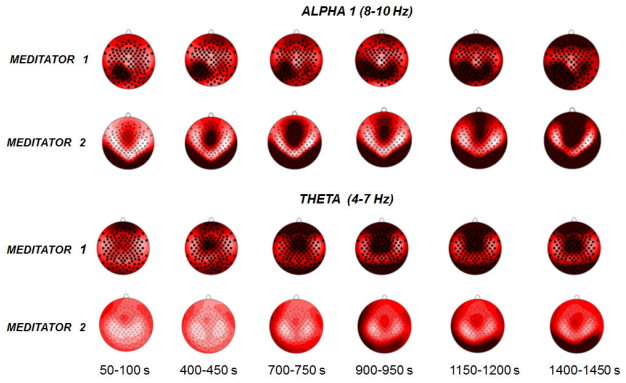


Figure 1: *EEG signal changes are shown as scalp topographies of average power in frequency range, calculated for consecutive 50 second time intervals. In the time course of meditation signal power increased and then fluctuated in alpha (8-10 Hz) and theta (4-7 Hz) frequency range, mainly in occipital and frontocentral regions.*

2.2 Phenomenology reports

Meditator 1 who has more then 20 years of meditation experiences used a Zen meditation technique accompanied with Kundalini meditation that included rising of energy from lower parts of the body into the head and out of head mentally, by breathing and visualization. The state of the mind during the higher/transcendental state of consciousness, according to the report of the Meditator 1 was free from any selfish motivation, instinctual pressure and mental conflict, a state in which the energy flow through the body is as if there is no resistance of the body and egotistic structures disappear. In this state one can live naturally with spontaneity, presence and natural wisdom. It is unitary, undifferentiated, reality-consciousness, an essential being, which can only be experienced by spontaneous intuition and self-understanding. There is a natural sense of well-being, with self-understanding, spontaneous joy, serenity, freedom, and self-fulfilment.

Meditator 2 was a Buddhist lama who is according to his testifying living most of his time in a state of extended awareness. For the purpose of the study he meditated on mental quietness and visualization of Buddha to enter into higher states of consciousness in which his mind was peaceful, concentrated without tension, without disturbed emotions like desire or irritation.

2.3 Whole genome gene expression changes

Transcriptional differences between ordinary and higher states of consciousness of both Meditators were assessed by micro array analysis and qRT-PCR (17). Heatmaps generated using differently expressed genes in two different states of consciousness exhibited remarkably consistent gene expression profiles across the two groups of samples of Meditator 1 (Fig 2).

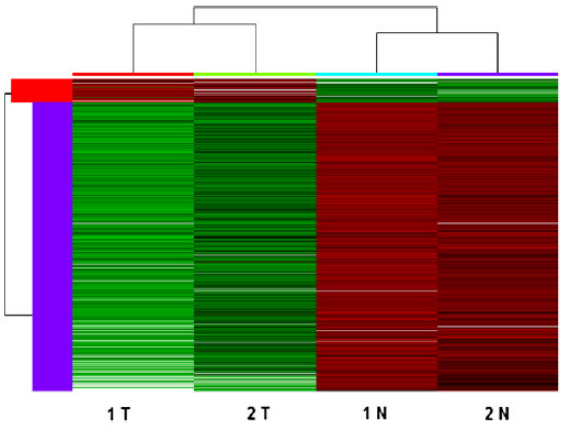


Figure 2: *Heatmap of significantly differently regulated probe sets ($p < 0.05$, FDR <= 5%) between two higher states of consciousness (T) and two ordinary states of awareness (N) of Meditator 1. Rows represent probe sets and columns represent samples.*

Volcano Plot filtering between both states of consciousness identified differentially expressed mRNAs with statistical significance of Meditator 2. The threshold was Fold Change >1.3, p-value < .05. (Fig 3).

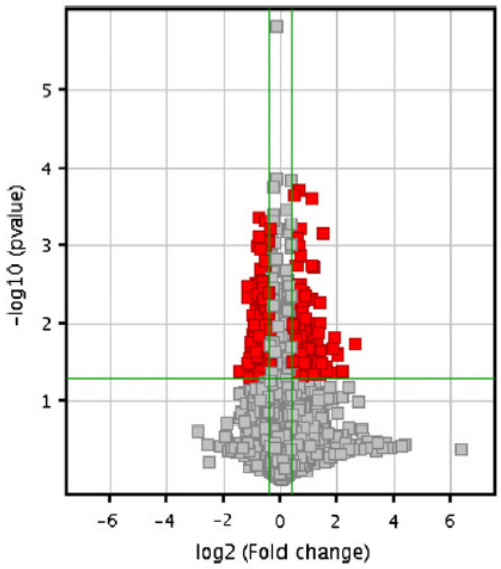


Figure 3: *Volcano Plot analysis of three higher states of consciousness and three ordinary states of awareness of Meditator 2. The red point in the plot represents the differentially expressed mRNAs with statistical significance.*

The results indicated that there were distinct differences in gene expression between higher states of consciousness of both Meditators compared to their ordinary states of awareness. However, the number of differently expressed

genes as well as the majority of genes themselve associated with higher states of consciousness differed between Meditator 1 and Meditator 2. Despite this, differently expressed genes associated with both meditators' higher states of consciousness were found to be involved in some shared more general biological and molecular processes. Using Gene Set Enrichment Analysis (GESA) (18) the detected common biological processes included general down regulation of metabolic and cell cycle processes, signaling, protein transport, regulation of gene expression, DNA repair, epigenetic mechanisms. Immune system activity, apoptotic processes were both up and down-regulated, as well was the response to stress. We observed less similarities in over-expressed molecular and biological processes among higher states of consciousness of both meditators than in under-expressed processes. While the higher state of consciousness of Meditator 1 was characterized by up-regulation of genes involved in hemoglobin synthesis, transport of oxygen and nitric oxide, significantly enrichment in glutamate transport, ionotropic glutamate receptor activity as well as NADH dehydrogenase activity was observed in connection with higher state of consciousness of Meditator 2. The number of significantly differently expressed genes connected with higher state of consciousness of Maditator 1 was 1668. The majority of differently expressed genes 1559/1668 (93.5%) were found to be down-regulated in higher state of consciousness and over-expression was detected in 109 (6.5%) genes. In higher sates of consciousness of Meditator 2 we detected 608 differently expressed genes, 338 (55.6%) being significantly up-regulated and 270 (44.4%) being significantly down-regulated. Majority of common shared genes that showed connection with higher states of consciousness of both Meditators were under-expressed (134 genes) (Fig.4).

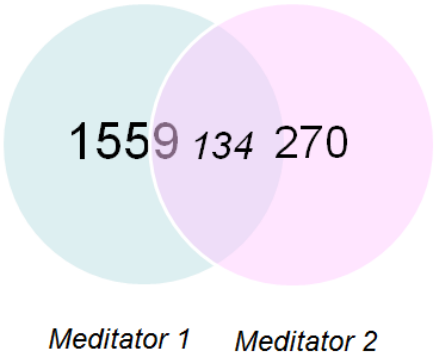


Figure 4: *Venn diagram depicted the overlap of differently expressed genes identified in higher state of consciousness of both Meditators.*

Shared genes include those involved in regulation of transcription*:* *BAZ1A*, *ZNF148*, *ELK3*, *DR1*, *ELF2*, *AES*, *ZEB2*, *MEF2A*, *FUBP1*, *ZNF600*, *SP3*; signal transduction: *G3BP2*, *CD164*, *RASGRP1*, *NEDD9*, *RAPGEF2*; apoptosis: *SLK*, *JMY*, *MAP3K7IP3*; cell cycle: *CCNG1*, *PPP6C*, *NEDD9*; DNA repair: *UBE2A*, *SLK*, *RRM2B*. In association with higher states of consciousness of both Meditators we also detected sets of transcripts significantly enriched in epigenetic mechanisms (*HRAC1*, *DNMT3A*, *CPA4*, *MORF4L1*, *EYA3*, *UBE2A*, *SNCA*, *JMJD6*, *EPC2*, *SMARCA5*, *SMARCE1*, *CHD9*, *TLK1*, *ASF1A*, *CBX3*, *HMGB1*, *RB1*, *HDAC2*, *UBE2A*, *BMI1*, *H2AFY*, *MLL3*, *RCBTB1*, *MORF4L2*, *EPC1*, *TBL1XR1*, *HIF1A*) indicating that some gene regulation mechanisms were mediated through epigenetic control.

3 CONCLUSIONS

We can conclude that higher state of consciousness induced by meditation is associated with significant changes in gene expression. We detected common and different biological processes and functions associated with higher states of consciousness of different meditators. We could hypothesize that differences in gene expression signature associated with higher states of consciousness of Meditator 1 and Meditator 2 are mostly due to their different level of ordinary awareness connected to their way of living. For Meditator 1, the spontaneous switch to higher state of consciousness during intensive process of meditation probably represented bigger difference for the molecular biology of his body than in the case of Meditator 2. Meditator 2 according to his phenomenological report is sustaining higher state of awareness during his normal life style.

It is very likely also that different meditation techniques contributed to different expression of genes. It is also possible that results of molecular genetic analyses more reflected the differences the body needed to overcome in order the mind senses the subjective state of higher state of consciousness than the state of mind itself. Additional studies with greater number of advanced meditation practitioners are needed to discover whether there is a common gene expression profile generated by higher state of consciousness of meditators who are using similar meditation techniques, for example transcendental meditation technique. The impact on health and well-being of the detected complex gene expression changes induced by higher state of consciousness is important to discover. It would also be interesting to discover whether individual constitutional genetic background could influence the ability to achieve higher state of consciousness among long-term meditation practitioners.

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FUNCTIONAL MRI OF THE HUMAN BRAIN: INVESTIGATING FUNCTION AND DYSFUNCTION OF BRAIN PROCESSES

Ronald Sladky
MR Center of Excellence
Center for Medical Physics and Biomedical Engineering
Medical University of Vienna
Lazarettgasse 14, 1090 Vienna, Austria
Tel: +43 1 40400 1795; fax: +43 1 40400 7631
e-mail: ronald.sladky@meduniwien.ac.at

ABSTRACT

Functional neuroimaging, the *in vivo* investigation of human brain functions, has become an indispensible source of insight for all disciplines of cognitive science. In the following, a current study on social anxiety disorder is used to highlight the possibilities and limits of state of the art functional magnetic resonance imaging (fMRI). It shall be demonstrated that by the use of effective connectivity modeling methods, such as dynamic causal modeling, fMRI has evolved into a method that can be used to investigate the interaction within large-scale neuronal networks not only during normal brain functions but even their dysfunction in the presence of psychiatric disorders.

1 INTRODUCTION

It is well known that ancient Greek philosophers, such as Plato and Aristotle, already contemplated about the nature of mental processes and how they manifest themselves in functions of the human body. When considering how much time has passed since, it is astonishing that the most important progresses to unveil these mysteries have been made within the last 25 years. Interdisciplinary research endeavors have enabled immense methodological advancements that entailed improved theoretical concepts about cognitive processes and their embodiment as neural networks inside a human brain.

Modern neuroimaging applications can provide reliable measurements of physiological changes in the brain that are known to accompany neural activity. Functional magnetic resonance imaging (fMRI), a well-established and non-invasive method used throughout the herein presented doctoral thesis, relies on the change of local blood oxygenation, which is a consequence of increased energy demand of active neuronal clusters.

Essentially, an fMRI analysis is conducted on a dataset derived from repeatedly acquired three-dimensional brain images. Therefore, the temporal signals of all points in space can be analyzed for localized physiological changes, which can be induced by an experimental task. The results can be assessed and visualized using statistical maps to relate the activity of distinct brain regions to distinct mental capacities, such as, motor control, vision, memory functions, and logical reasoning. Today, even those brain structures that are involved in the processing of emotions and social signals can be identified. Moreover, modern fMRI applications extend beyond statistical activation mapping. Connectivity analysis methods can be applied to the dataset to establish functional networks that model the interdependencies between active brain regions.

It easily follows that fMRI has also become a cornerstone for clinical applications (e.g., pre-surgical planning) and pre-clinical research to provide better understanding of neurological and psychiatric conditions (e.g., providing the transfer from animal models into humans). In return, the research on the pathophysiology of brain functions is highly informative for all related disciplines within the cognitive sciences. First, dysfunctions and lesions can highlight the causal role and relevance of a certain brain region. And then, pathophysiology can be considered a limiting case of normal brain function. Therefore, proposed theoretical cognitive and neurobiological models should be expected to also model and predict these abnormal brain functions.

1.1 Dynamic causal modeling

Dynamic causal modeling (DCM) is a hypothesis-driven method to investigate effective connectivity, which has been introduced to fMRI data analysis by Friston et al. [1]. DCM consists of a neuronal model to model the neuronal behavior, which is not directly observable using current human neuroimaging methods, that can be related to the BOLD changes that are observable by functional MRI using a biophysical forward model (Balloon model, [2]). The neural state equation of DCM is given by:

$$\frac{dz}{dt} = \left(A + \sum u_j B^j\right) z + Cu$$

having vector z representing the time series of the neural behavior, vector $\boldsymbol{u}$ containing the time course(s) (1, …, *j*, …, *n*) of the external perturbation (i.e., the experimental paradigm), the internal steady state connectivity parameters $\boldsymbol{A}$, modulatory effects on these connections given stimulus u_j given by $\boldsymbol{B}$, and the direct influence of a stimulus modeled by $\boldsymbol{C}$. Therefore, the DCM equation describes a linear combination of internal and external influences (i.e., intrinsic connectivity $\boldsymbol{A}$, modulation $\boldsymbol{B}$, and inputs $\boldsymbol{C}$) to explain neural activity as it is observed by functional MRI and other neuroimaging methods (e.g., DCM for EEG and MEG). Based on a relative score, the *model evidence*, several competing plausible models can be compared, which shall motivate the discovery of the most adequate model.

From a pragmatic and even an epistemological point of view, it is evident that no absolute measure for the goodness of a model can be given. However, one can compute a relative score for all models within the search space, or model space, that informs about the relative merits of one specific model compared to the other. A model can be considered superior to another model, if it succeeds to explain the empirical data in a more accurate way, while preserving generalizability and parsimony. Therefore, all unbiased estimators of model evidence need to assess accuracy and encompass a punishment term for model complexity. This avoids the unjustified favoring of too complex models.

Highly complex models can lose their generalizability, as they tend to not only model the effects of interest yet also the intrinsic noise within the particular training data set. This over-fitting is a biased description of the random variables and could mask the actual relationships that might be present on a population level. In short, the model would describe the data with high accuracy (i.e., with small error terms). However, it would be useless, as it is only able to explain the one data set it is optimized for (also see e.g. [3]).

2 DISRUPTED EFFECTIVE CONNECTIVITY BETWEEN AMYGDALA AND ORBITOFRONTAL CORTEX IN SOCIAL ANXIETY DISORDER

Social anxiety disorder (SAD) is characterized by over-reactivity of fear-related circuits in social or performance situations and is associated with marked social and emotional impairment. Although several studies revealed neurobiological alterations of subcortical and cortical brain regions in SAD, little is known about the interaction of the implicated brain areas on a network level. Here we used dynamic causal modeling (DCM) to test our hypothesis that SAD patients would exhibit dysfunctions in the amygdalar-prefrontal emotion regulation network.

2.1 Participants and methods

15 unmedicated patients with SAD and 15 healthy controls matched for age and gender performed a series of facial emotion (FACE) and object discrimination tasks (OBJECT) [4] while undergoing functional magnetic resonance imaging. All measurements were carried out on a Siemens 3T TIM Trio whole body MR scanner with a 32-channel head coil. 225 whole-brain volumes (matrix size: 128×128 px^2 × 20 slices) were obtained at a repetition time of TR = 1.8 s employing a single-shot echo planar imaging (EPI) sequence. Data were preprocessed (slice timing correction, realignment, segmentation and normalization, 8 mm FWHM spatial smoothing) and analyzed (GLM, DCM10) in SPM8 (FIL Methods Group, University College London, UK).

The task-active emotion-processing network as identified by a task-related contrast (FACE > OBJECT, threshold $p<0.05$ FWE corrected) [5] (Figure 1) motivated the selection of the right amygdala, OFC and DLPFC as volumes of interest for the DCM model space of this study. Note that the results of this study were in high accordance with the statistical maps from a recent meta analysis of fMRI face processing studies [6]. Bayesian model averaging (BMA) [7] was used for inference on the model structure, the connectivity parameters and their modulations across groups.

2.2 Results

BMA for DCM revealed abnormal connectivity between the OFC and the amygdala in SAD patients. In healthy controls, this network represents a negative feedback loop. In patients, however, positive connectivity from orbitofrontal cortex to amygdala was observed, indicating an excitatory connection (Figure 2 and 3).

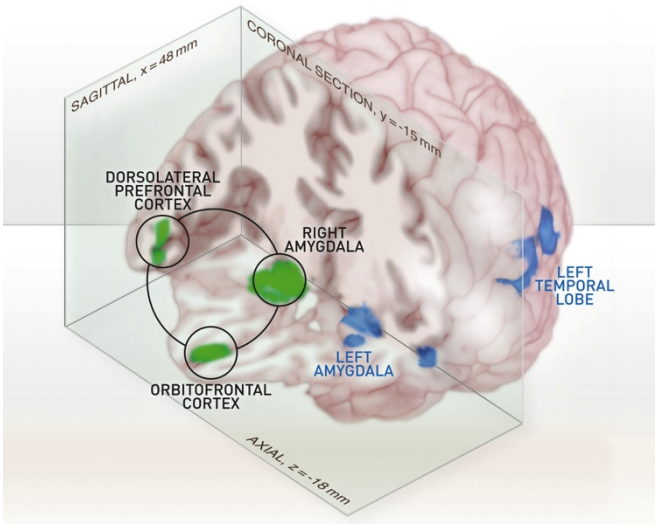


Figure 1: Rendering of the statistical parametric map from the emotion discrimination task. *This map is based on the group-level result from all subjects (n = 30), with FACE > OBJECT as contrast of interest, thresholded at p < 0.05 (FWE corrected) Right amygdala, OFC, and right DLPFC are highlighted and were used as volumes of interest for the subsequent DCM analysis.*

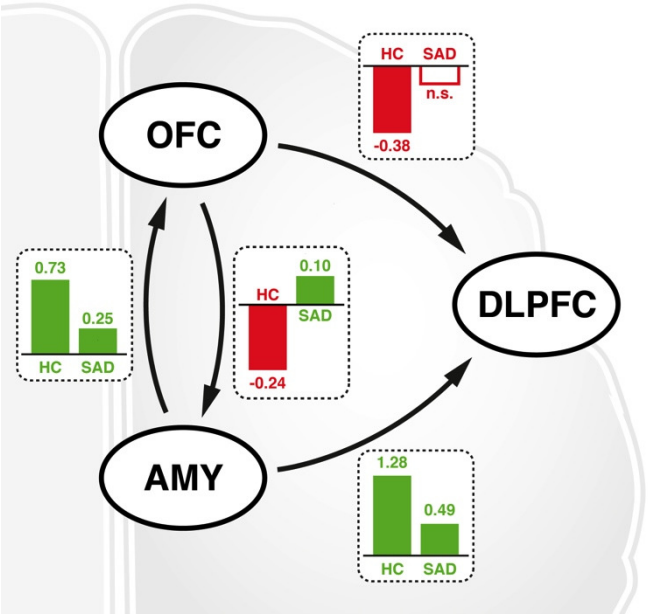


Figure 2: Significant group differences between healthy controls (left) and SAD patients (right). *Most importantly, the negative feedback loop between amygdala and OFC, found in HC, is dysfunctional in SAD.*

2.3 Conclusion

These results for the first time demonstrate that SAD patients exhibit alterations in effective connectivity of neuronal circuits involved in the processing of social cues. Of particular interest is the disruption of down-regulating feedback mechanisms between the amygdala and the OFC. Using DCM it was possible to highlight not only the neuronal dysfunction of isolated brain regions, but also the dysbalance of a distributed functional network.

These findings form the foundation for further studies that analyze neuronal function on a network level not only in unmedicated patients but also during pharmacological and non-pharmacological treatment.

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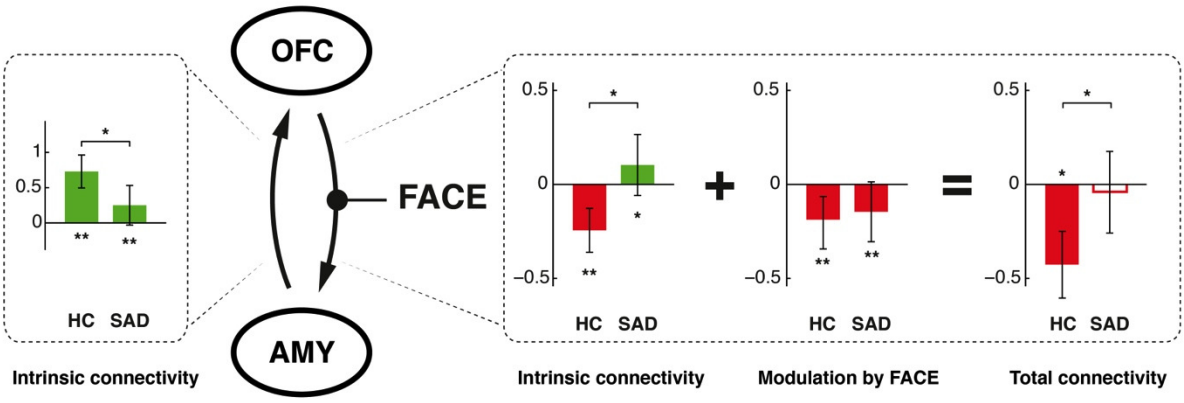


Figure 3: Modulation of the OFC to amygdala connection by emotional faces. *The modulatory influence of the emotion decimation task was not different between groups. However, in combination with the positive intrinsic connectivity, the negative modulatory influence was not sufficient to effectively down-regulate amygdalar activation in SAD patients. Group BMA results and SD are shown, * indicates $p < 0.05$ in two-sided two-sample t-test.*

INTERFERENCE EFFECT AND COGNITIVE CONTROL: THE CASE OF PITCH CLASS CHANGE DETECTION

Anka Slana[1*], *Bruno Gingras*[2], *Tecumseh Fitch*[2], *Grega Repovš*[1]
[1]Department of Psychology, Faculty of Arts, University of Ljubljana
[2] Department of Cognitive Biology, University of Vienna
*E-mail: anka.slana@psy.ff.uni-lj.si

ABSTRACT

When two responses are possible and in conflict, the response to the relevant stimulus is prolonged. This effect has been shown in the cases of both automatic as well as controlled stimulus-response mappings. In this study we have explored whether the interference effect can be observed also in the case when the response depends on the comparison of two successively presented stimuli. Thirty eight musicians and non-musicians participated in a pitch class change detection task in which the target tones were embedded in a chord context that changed or stayed the same congruently or in incongruence with the change of the pitch class of the target tones. The reaction times were shorter in congruent vs. incongruent condition, confirming a presence of an interference effect.

1 INTRODUCTION

We live in a complex environment where we are constantly exposed to a vast amount of information eliciting or requiring a different behavioral response. To be capable of goal directed behavior, we have to be able to attend to relevant information and select appropriate responses while inhibiting irrelevant ones. This becomes especially hard when the incoming stimuli trigger incompatible responses leading to cognitive interference situations. Due to their high load on cognitive control processes, tasks eliciting such stimulus and/or response conflicts present a valuable tool of research.

Traditionally, the understanding of cognitive control (and situations of cognitive interference) is based on the distinction between two fundamental processing modes (Shiffrin & Schneider, 1977; Shiffrin & Schneider, 1984; Schneider & Chein, 2003): automatic and controlled. Automatic processes are based on well learned behavior automatically retrieved from procedural long-term memory, do not require attention, have no capacity limits and can be performed in parallel. They are difficult to ignore or suppress once learned. Controlled processes on the other hand are highly resource demanding, require attention, and are of limited capacity; however, they allow generation of flexible behavior in response to ever-changing environment.

In this paper, we focus on cognitive interference tasks that build upon conflict between automatic and control processes to study the mechanisms and properties of cognitive control.

2 STIMULUS – RESPONSE MAPPINGS IN COGNITIVE INTERFERENCE TASKS

When a subject is presented with a stimulus in a speeded response task, the response can be generated using different types of stimulus-response (SR) mappings. For the purpose of this paper, we distinguish between automatic and controlled mappings, which can be further divided into natural and arbitrary SR mappings. Examples of each mapping type will be given throughout the paper.

Further paragraphs focus on three cognitive interference tasks: Stroop task, Flanker task and Eriksen Flanker task. In each of the tasks in the critical (incongruent) condition the presented stimulus or stimuli elicit two responses, only one of which is a correct one, while the other presents a source of interference. The tasks however differ in the mappings that lead to the required and the interfering response (see Table 1).

2.1 Stroop color-word task

The Stroop task is the original cognitive interference task, designed by Stroop (1934) and subsequently modified in numerous ways (for comprehensive review see MacLeod, 1991). In the task the subject has to name the color of the presented stimulus. In the critical condition (e.g. word RED written in green) two responses are possible, one related to the relevant aspect of the stimulus - color -, and the other, to the word itself (Figure 1).

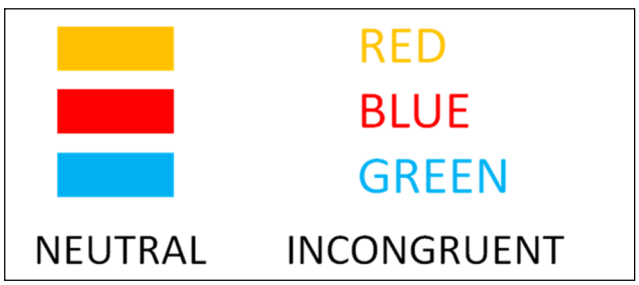


Figure 1: *Example stimuli in the Stroop color-word task.*

Stroop (1934) showed that when subjects were naming colors of incongruent words, the reaction times were longer than when naming colors of color patches. The observed "Stroop interference effect" demonstrates that when the mapping of the irrelevant alternative aspect of the stimulus is automatic, it is processed and mapped to a response that interferes with the response formed by controlled natural mapping of the relevant aspect of the stimulus (Table 1).

The question remained, whether it is only the automatic mapping of the irrelevant aspect of the stimulus that can induce an interference effect.

2.2 Flanker task

It is hard to apply the explanation of the Stroop interference effect to a Flanker task in which both relevant and irrelevant responses are obtained by a controlled natural mapping. Specifically, in the version of the task used by Kopp, Mattler and Rist (1994), the subjects have to indicate the direction in which the central arrow surrounded by flanking arrows is pointing (Figure 2). In the incongruent condition, when the central and flanking arrows are pointing in opposite directions, similarly as in the Stroop task, an interference effect is observed: the reaction times in the incongruent condition are longer than those in the congruent one. These results show that an interference effect can be obtained even when the SR mapping of the competing stimuli is not automatic.

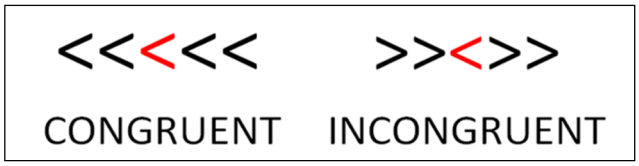


Figure 2: *Stimuli in a flanker task (adopted from Kopp, Mattler & Rist, 1994).*

2.3 Eriksen Flanker task

Another example of the cognitive interference task is the Eriksen Flanker Task (Eriksen & Eriksen, 1974), in which SR mappings are not only controlled but also completely arbitrary. Namely, instead of arrows "naturally" showing the response direction, the response is coded by an arbitrary association with letters H and K for response "right" and C and S for response "left" (Figure 3). Again, the response indicated by the target and flanker stimuli is either congruent or incongruent, and interference effect is shown in the latter case.

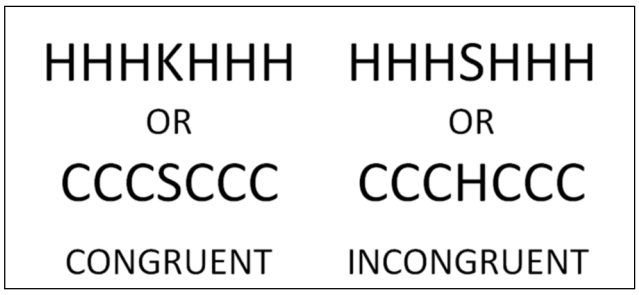


Figure 3: *Example stimuli from the Eriksen flanker task.*

Jointly, the flanker tasks show, that interference effect can be obtained even in the case of controlled (natural or arbitrary) SR mapping of the competing stimulus, as long as the flanking stimulus is in the focus of attention and maps to a candidate response.

In the present study we explored if the interference effect can be expanded to a novel modality and SR mapping.

Table 1: *Cognitive interference tasks and SR mapping types of target and competing stimulus (distractor).*

Task	Target	Distractor
Stroop	Natural	Automatic
Flanker	Natural	Natural
Eriksen Flanker	Arbitrary	Arbitrary

3 INTERFERENCE EFFECT IN PITCH CLASS CHANGE DETECTON TASK

We extended the previously reported cognitive interference tasks by first, using a different modality (auditory), and second, by requiring the subjects to respond, not to the target stimulus itself (such as naming the color ink in Stroop task), but rather to the presence or absence of change between two successively presented target stimuli. Specifically we tested whether the subjects will find it more difficult to detect the change in pitch class when the target stimuli will be embedded in a stable or changing chord context.

3.1 Method

Thirty-eight Slovenian students, nineteen musicians (age 25.6 [19-41], 10 females) and nineteen non-musicians (age 27.5 [19-45], 12 females) took part in the study in which, two target tones that either belonged to the same pitch class or a different pitch class[1] were sequentially presented, each along with a stable or changing distractor chord, resulting in four possible target - context change combinations:

[1] Tones that stand an octave apart are said to have the same pitch class and are in musical sense considered as being in some way the same. They exhibit strong perceptual similarity (Shepard, 1964).

a) same pitch class target tones presented within the stable context,
b) same pitch class target tones presented within a changing context,
c) different pitch class target tones presented within the stable context,
d) different pitch class target tones presented within a changing context.

Combinations a) and d) represent congruent situation (both the target tone pitch class and the chord either changed or stayed the same), whereas conditions b) and c) represent incongruent situation (either the chords or the pitch class of the target tones changed) (Figure 4).

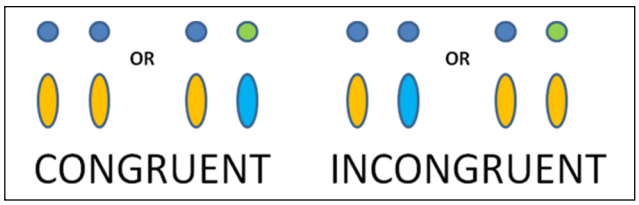


Figure 4: *Schematic demonstration of the experimental conditions in the Pitch class change detection task. Note that the circles represent the probe tones, and ellipses represent the chords, while the colors represent their relevant qualities.*

3.2 Analysis procedure

For the subject to provide a correct response the stimuli need to be processed through a number of stages (Figure 5). Two stages are specifically important when considering the possible effects on the reaction times. Of key research interest is the effect of target-context change congruency on reaction times, however, we need to consider the possibility that change in either target tones or chords is processed faster or slower than no-change, which can mask or possibly even interact with the congruency effect. To take that into account, when analyzing the effect of congruency, we decided to also explicitly control for the effect of change vs. no-change in either tone pitch class or chord.

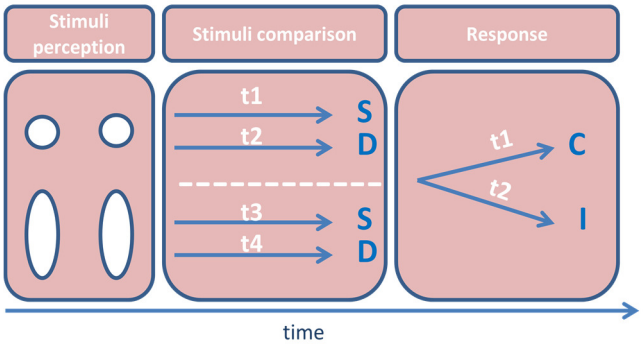


Figure 5: *The three key stages of processing during task performance. The stimuli need to be perceived, a comparison whether the two successive stimuli are the same (S) or different (D) need to be made, followed by a response to target tone, which can be the same as for the context (C - congruent situation) or different (I - incongruent situation).*

Two analogous 3-way repeated measures ANOVAs were performed. Group (musicians vs. non-musicians), and congruency (congruent vs. incongruent) factors were the same in both analyses, whereas the third factor was pitch class change (same vs. different) in one, and context change (same vs. different) in the other. As the two factors are perfectly correlated, it is first, not possible to distinguish between the two factors, and the analyses yield the same results.

To control for possible outliers only correct responses that were longer than 300 ms and shorter than 2.5 s and were within 3 standard deviations of each condition mean were included in the analysis.

3.3 Results

The first ANOVA revealed a significant main effects of group ($F(1, 36) = 16.8$, $p < .001$), reflecting longer reaction times for non-musicians, and congruency ($F(1, 36) = 13.3$, $p < .001$), reflecting shorter reaction times in congruent situation (Figure 6), but no significant effect of pitch class change ($F(1, 36) = 1.78$, $p = .191$). The interaction between congruency and pitch class was also significant ($F(1, 36) = 4.81$, $p = .035$), reflecting stronger congruency effect in the case when the pitch class remained the same. No other statistical tests yielded significant differences.

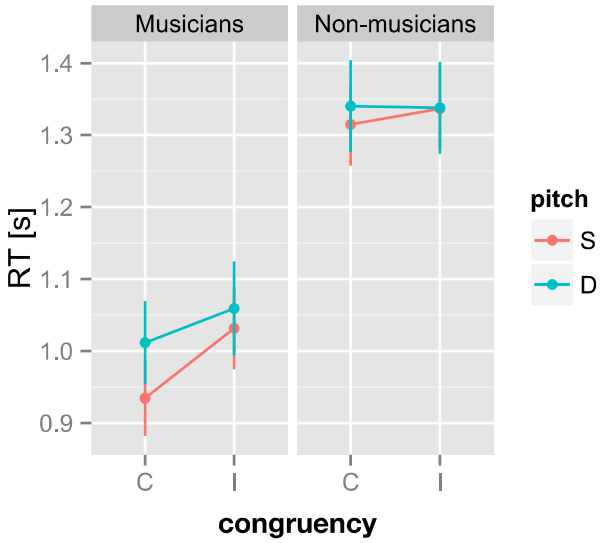


Figure 6: *Mean reaction times for the "congruent" and "incongruent" conditions, shown separately for musicians and non-musicians and the same and different context. Error Bars: +/- 1 SE.*

When the ANOVA is conducted with context change as the third factor, the previous interaction of congruency and pitch class change is translated to main effect of context change,

reflecting shorter reaction times when the context remained the same (Figure 7).

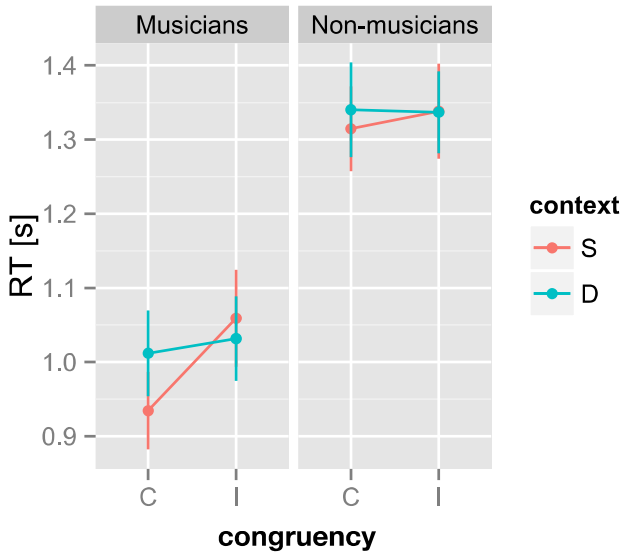


Figure 7: *Mean reaction times for the "congruent" and "incongruent" conditions, shown separately for musicians and non-musicians and "same" and "different" context. Error Bars: +/- 1 SE.*

4.3 Discussion

These results demonstrate that the interference effect can also be observed in a Pitch class change detection task, suggesting that the subjects are processing and comparing both the target tone pitch class and chord context.

In addition, the results have shown that presence or absence of change in target tone pitch class and possibly also in context affects the reaction times. As pitch change and context change are inseparable in the present task design, the effect cannot be unambiguously attributed to only one or the other. Further analyses could also address the question whether the comparison of both pitch class of the target tones as well as chords need to finish before response generation can begin, or, alternatively, the generation of response commences as soon as comparison of target tone concludes.

4 CONCLUSION

The previous studies have shown that the interference effect due to competing responses occurs not only when the interfering stimulus can be processed automatically but also when the stimulus-response mapping depends on controlled processing. The present study showed that the interference effect can also be observed in auditory modality and extended to the task in which the response relates to the presence or absence of change between two successively presented target stimuli rather than processing of a single stimulus.

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INDISPENSABLE HEURISTIC OPERATIONS WITH THEIR POSITIVE AND NEGATIVE SIDE

Tjaša Slevec
e-mail: tjasa.slevec@gmail.com

ABSTRACT

Heuristics are spontaneous mental strategies which people use to reduce the complexity of decision making and judgmental tasks. Heuristic rules are the rules of System 1, the intuition, whose processes are fast, automatic and associative. System 2 can endorse, correct or override intuitive answers of System 1. Every decision or judgment is the result of concurrently working operations of both Systems. Heuristics are smart and efficient mental strategies, although they can sometimes lead us to biases.

1 INTRODUCTION

In everyday decision making as well as in solving scientific problems, people use heuristics. Heuristics are mental strategies that help us solve specific problems [9]. One example of a simple perceptual heuristic rule is the fact that close objects are seen more sharply than more distant objects [12]. In general, this rule has some validity, but in the case of haziness it can lead us to biases, optical illusions. In addition to perceptual heuristics there are also cognitive heuristics that people use to simplify their choice when they encounter a decision problem. Cognitive heuristics can also lead us to biases, to the illusion of knowing [9]. A famous example of a cognitive bias is the birthday problem:

If 25 people are in a room, what is the probability that at least one pair will share a birthday? [10, p.40]

Nearly everyone guesses too low, and for most people the problem is a form of cognitive illusion [10]. We will focus on cognitive heuristics and approach them with the dual process model, where we distinguish between System 1 and System 2. In the case of the presented perceptual heuristic, the impression of distance was due to the failure of System 1, but the effect of haziness on the final judgment was due to the failure of System 2, which should have considered the haziness and corrected the impression of System 1[6].

2 DUAL - PROCESS MODEL

Dual-process theories distinguish between two modes of processing information. Because of the discrepancy between the different theories we cannot speak of a unified dual process theory, but the evidence supports the notion that we can distinguish between processes that are fast, automatic, effortless, non-conscious and processes that are slow, controlled, effortful, conscious [3]. Kahneman and Frederick [7] use the neutral labels System 1 and System 2, where "System" stands for a collection of cognitive processes. System 1 processes are fast, parallel, automatic, effortless, associative, slow-learning and emotional [4]. Because of these characteristics it seems that intuitive judgments come to us spontaneously and need little attention. System 2 processes are slow, serial, controlled, effortful, rule-governed, flexible and neutral [4]. System 2 can quickly endorse and apply new information, but because processes are effortful they demand our attention.

System 1 and System 2 are two ways of processing the same information and the decision or judgment is the result of the concurrent operation of both Systems. The Stroop test illustrates two System operations [6]. The purpose of the Stroop test is to report the color with which words are printed. If the word BLUE is printed in blue, the task is done quickly with almost no effort. If the word BLUE is printed in red, responses are not as quick and fluent as in the former task. When we read the word BLUE System 1 automatically and associatively responds with the color blue. System 2 applies the task rule – it reports the printed color, and corrects (if needed) the spontaneous intuitive response. Errors in the Stroop test are rare, showing the successful monitoring of System 2 [6].

Kahneman and Frederick [6] suspect that under normal circumstances System 2 often endorses System 1.

A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost? [6, p.58]

The high rate of errors (10 cents) in the bat and ball problem show that people often trust their quick intuitive judgments and that System 2 lightly monitors System 1 responses [6]. Results also show that people did not take the trouble to check their answers [7], which we can interpret as not being committed to the task.

3 HEURISTICS

3.1 Heuristics and biases research program (Kahneman and Tversky)

Heuristics are System 1 mental strategies that help us to reduce complex tasks to simpler judgmental operations [12]. In the heuristics and biases program, Kahneman and Tversky [12] explored heuristics that people use in their judgments of the probability of uncertain events. They

describe three types of heuristics: representativeness, availability and adjustment and anchoring.

Research has shown that when given a probability task people often use representativeness heuristic and answer a probability question as a similarity question. There are two determinants of representativeness; the similarity of the sample population, which determines that the sample preserves the proportion of the general population, and the reflection of randomness [8]. In fair coin tosses people regard the sequence of heads and tails such as *HTHTTH* to be more likely than the sequence *THTHTH* or *HHHTTT*, because the first sequence reflects the randomness and is therefore more representative [12]. The belief in local representativeness leads to erroneous intuitions about randomness and to biases, to a misconception of chance, which also reflects in gamblers fallacy [8]. When people asses probability with the representativeness heuristic the reliance on the heuristic rule can lead to biases. Biases appear because factors that affect representativeness don't affect probability. Representativeness is insensitive to prior probability, sample size and predictability, but those factors have a mayor effect on probability [12].

People often use availability heuristic for assessing frequency and probability. Availability heuristics are the result of our life experiences, where we learn that instances of large classes and likely events are more available and are recalled quicker and better than instances of small classes and unlikely events [12, 11]. Availability heuristic is a useful rule which helps us to assess frequency, but it can be affected by factors of familiarity and time distance, and can consequently lead us to biases. One of the types of biases that availability can lead us to are biases of imaginability. We use imaginability when instances are not stored in memory and so we have to generate them [4]. Ease of construction reflects the assessment of the frequency of subjective probability which doesn't always reflect the actual frequency. When we imagine the danger which we can encounter in our venture we can underestimate or overestimate the actual risk.

The third heuristic – adjustment and anchoring – occurs when the given initial value dominates in our final estimate. The anchoring effect can also occur when no initial value is given. In the study of numerical estimation [12] there were two groups, which each received one numerical expression. The task was to estimate within 5 seconds the numerical expression $8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$ or $1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$ [12, p. 1128]. This time limit makes it impossible for most people to make an accurate computation. After a few computing steps people adjust their final results. The first group started with high numbers and had an average estimation of 2250, while the second group started with small numbers with an average estimation of 512, both far from the exact result 40320 [12].

3.2 Attribute substitution

Kahneman and Frederick [6] revisited early studies on heuristics and biases and proposed an operation of attribute substitution as a general feature of heuristic judgments. Attribute substitution occurs when people substitute the target attribute with the heuristic attribute, which comes easily to mind (is more accessible) [6].

Kahneman and Tversky's task of categorical prediction [6, pp. 60-62] provides the direct evidence for attribute substitution. There were three experimental groups; the base rate group, the representativeness group and the probability group. The base rate group had to evaluate the relative frequency of students in nine fields of specialization. The estimates ranged from 3% for Library science to 20% for Humanistic and Education. The representativeness group received a description of a fictitious student named Tom W. and had to rank fields according to the resemblance with the description.

Tom W. is of high intelligence, although lacking in true creativity. He has a need for order and clarity, and for neat and tidy systems in which every detail finds its appropriate place. His writing is rather dull and mechanical, occasionally enlivened by somewhat corny puns and by flashes of imagination of the sci-fi type. He has a strong drive for competence. He seems to have little feel and little sympathy for other people and does not enjoy interacting with others. Self-centered, he nonetheless has a deep moral sense. [6, p. 61]

The description deliberately included information that make Tom W. more representative for less popular fields of specialization (library science). The manipulation was successful, as the representativeness group ranked that the description was more representative of less popular fields (library science). The probability group received additional information stating that the description has dubious validity and had to rank the fields by the likelihood that Tom W. would specialize in them. Because the description is invalid, the probability group should consider the relative frequency of the students in each field and the probability ranking should resemble the base rate ranking. The researchers had anticipated that the respondents in the probability group would substitute the difficult probability task with the easier representativeness task. The results confirmed what was anticipated; the probability group estimated that Tom W. will most likely choose the less popular fields. The correlation between probability and representativeness was nearly perfect [6].

The probability group answered a probability question as a similarity question and neglected the base rate. The probability that Tom W. will choose one of the fields should vary according to the relative frequency of a particular field. In categorical prediction people use two separate acts of substitution [6]. Category is substituted with a prototype exemplar and the probability task is

substituted with a representativeness task [6]. Prototype exemplars include average values of the salient characteristics of the category members [4], but don't include information about the size of the category [6]. Prototype exemplars are nonextensional and because they substitute the category that is extensional, they can lead us to the following biases: scope neglect in our willingness to pay, duration neglect in our evaluation of experiences and the violation of dominance [6].

4 ACCESSIBILITY EFFECT

We introduced attribute substitution as the general characteristic of heuristic judgments. But in the example of anchoring and adjustment we don't perform substitution. Instead we are anchored to the initial value, which also dominates our judgments. The general feature of attribute substitution and anchoring is the accessibility effect [6]. In judgmental problems we have to apply a particular value to the target attribute. Different target attribute values are more or less accessible, which refers to the ease with which value comes to mind [6]. When the target attribute is relatively inaccessible the search for value can evoke values that are associatively related and more available [6]. Heuristic values of representativeness and availability are usually more accessible that the probability value. In the anchoring effect the initial value is highly accessible and dominates our judgment about the target attribute [6]. Some attributes are always highly accessible and are called natural assessments. These mostly refer to size, distance, similarity, mood, affective valence… [6].

4.1 Emotional responses and context

When people are confronted with emotionally arousing stimuli they spontaneously respond to the stimuli and the response triggers the tendency to approach/accept or avoid/reject the given stimuli. Researches have shown that people respond to affectively charged words quickly and efficiently, indicating that System 1 quickly and automatically detects the distinction between the good words and the bad ones [4]. The evaluation of emotionally arousing stimuli is a natural assessment [4].

Every decision problem is given in its own frame, its own context. Kahneman and Tversky [13] have shown that people passively accept the frame in which the problem is given and are mostly not aware of possible alternative interpretations. The framing effect occurs when alternative descriptions of the same reality evoke different responses [13]. Kahneman and Tversky's famous example of the framing effect is the Asian disease problem [13]:

Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:

Problem 1: If Program A is adopted, 200 people will be saved. (72 %)
If Program B is adopted, there is a one-third probability that 600 people will be saved and a two-thirds probability that no people will be saved. (28 %)
Which of the two programs would you favor?

Problem 2: If Program C is adopted, 400 people will die. (22 %)
If Program D is adopted, there is a one-third probability that nobody will die and a two-thirds probability that 600 people will die. (78 %)
Which of the two programs would you favor? [13, p.138]

The participants in the experiment were divided into two groups, each receiving one decision problem. Beside each option, we can see the percentage of subjects that choose that particular option. Problem 1 and problem 2 represent the same program, expressed using alternative descriptions. We can see that the difference in the descriptions caused a major shift of preferences. Kahneman [5] said that when a decision problem contains a gamble and a sure option, people focus on the sure option, and if the sure option is a good thing they like it. The sure option expressed with saved lives evokes a positive response and a tendency to accept it. When the sure option is bad, expressed in lost lives, it evokes a negative response, and people hate it [5]. People spontaneously respond to good or bad stimuli and therefore different descriptions can evoke different associations and emotions. Kahneman and Tversky's researches have shown that in a decision problem people mostly respond to losses more extremely than to gains and prefer certain outcomes in the positive domain and gamble in the negative domain [13]. Highly accessible features of a given frame strongly influence our decision making.

5 POSITIVE SIDE OF HEURISTICS

A lot of research has been focused on situations in which heuristics lead us to biases, but heuristics can also act as useful and efficient cognitive strategies. In the categorical prediction task we focused on attribute substitution of the probability group. We have to emphasize that the representativeness group successfully solved the similarity task, which indicates a successful application of heuristic rules. Kahneman and Tversky [11] showed in the Retrieval study that people can assess heuristics with reasonable speed and accuracy. Subjects received a series of problems where they had to recall instances of a particular category. The study had two tasks, estimation and construction, which were separated. In the estimation task subjects had 7 seconds to estimate the number of instances they could retrieve in 2 minutes. In the construction task they had two minutes to actually retrieve the instances. The grand mean for the estimated instances was 10.8 (varied from 6.7 for city names beginning with F to 18.7 for four-legged animals). The grand mean for the actual retrieval was 11.7 (varied from 4.1 for city names beginning with F to 23.7 for four-legged animals). The retrieval study was a study of

availability heuristic which we use to assess frequency. The ease with which instances are retrieved (are more or less available) indicates their frequency [11]. Kahneman and Tversky [11] argued that people can assess availability without actual retrieval of instances. It is enough to assess the ease with which operations are performed. [11].

5.1 High skilled System 1 operations

Complex cognitive operations are usually associated with System 2 processes, but operations can migrate from System 1 to System 2 [6]. It takes a lot of time and a lot of practice before the new rule (new knowledge) becomes a part of the spontaneous System 1 processes. An example from everyday life is driving a car. When people start to learn new rules it takes a lot of attention and effort to apply them. But in time and with practice driving a car becomes a mostly spontaneous task, with almost no effort. Kahneman [5] gives an example of team sports where highly skilled individuals see the entire field of play and predict the next game move.

6 CONCLUSION

Epstein [2] argues that labeling heuristics as cognitive shortcuts is misleading; heuristics are normal operations of the System 1 conceptual system (We have identified Epstein's Experimental system with System 1 and Rational system with System 2.). The label indicates that heuristics are fast and effortless, but they can also perform very complex cognitive operations. System 1 is an adaptive system which can respond to situations in accordance with our life experiences [2] and enables us to respond quickly and efficiently to emotionally significant stimuli. Therefore we can spontaneously eliminate options that had led us to bad outcomes in the past and focus on other options. Researches have confirmed that the disruption in emotional responses (System 1 responses) has a great impact on decision making [1]. In real life situations we often don't have objectively correct answers and in such situations heuristics can help us out [11]. Also the probability of many events depends on several interrelated factors which are very difficult to evaluate, so Kahneman and Tversky [11] suggest that people consider only the most available scenarios to assess probability.

Decisions and actions that people make are the result of concurrent operations of System 1 and System 2. Systems work concurrently and interfere with each other. In many cases (e.g. computation) System 2 breaks down the complex problem into actions that can be solved with System 1 operations [3]. Epstein [2] gives us an interesting example to imagine: We are without System 1 and have to cross the street. Now we have to estimate every factor and crossing the street could take an unreasonably long amount of time. Although they sometimes lead us to biases, heuristics are indispensable cognitive operations. If we want to successfully confront everyday problems and situations as well as scientific ones, we need both System 1 and System 2 operations.

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ACCOLADE BY DEFAULT – COGNITIVE MATRIX IN VISUAL CONCEIVING

Julijana Stojan
Rimska 8, SI-1000 Ljubljana, Slovenia
Tel: +386 1 6209972
E-mail: lucka.stojan@guest.arnes.si

ABSTRACT

When writing monography on the Slovene painter Gojmir Anton Kos I became gradually aware of the same compositonal gestalts reappearing, not only in his works, but in the comparative material as well. As it subsequently turned out, the same formal concepts were to be found throughout the artistic production, regardless the time or place they met the day. Be it so, one began to wonder, might there be one unified system underlying the pictorial production as such, and as it turned out, the formal system to a major degree close to the formal logic axiomatic system could be deduced from the observations applied.

1 SURVEYING THE HISTORY

Surveying the work of Gojmir Anton Kos*, among his early paintings one meets the Picnic 1924. What calls the attention in the first place is the mutual approach of the arms of two female figures forming a kind of broken arch, like brace, leading to the bottom right corner. The form is replicated in the upward version by the man's arm extending from behind and the right female's one and somewhat narrowed as the confluent lines of her arm and scarf already cut off by the right edge. In fact the composition is mainly structured as the recursive iteration of the observed gestalt. One is taken by surprise to catch the same introducing constellation on the Marcel Duchamp's early Chess Game 1910. (o1,2) Although his work remains in classical terms of the enclosed pictorial setting featuring the relaxed outdoors scenery, the composition is obviously adapting the same formal concept, the curved antithetic approach of the two rami, diagonally leading to the right bottom ending. In both cases this bracelike arch holds the clue position of the pictorial display, while single components are exchanging their places and consequently the observer's attention from one artwork to another.

The exposed compositional device proved to be the one most frequently adapted throughout the art history. Together with its upward version and their derivatives, be it with or without the realised axial vertical, the very gestalt can be traced as the predominant organizing concept back to the early Summer and predynastic Egypt. The same formative principle(s) dominated the cylinder seals measuring 1-2 inches or wall decorations on a large scale, the huge Persepolis reliefs, Greek pediments, fresco representations from Roman times, the early Christian lunetes and apsides, spaning the Mediaeval age via tympana, great frescoes cycles or illuminated manuscripts to the late Gothic production of 15th centary trespassing on to the early renaissance. (o3-22) The transition period of the 15th century was the time when the coinciding curved antitheis bursted out as the overall recognized form, organizing not only the represented visions within the pictorial field, but also articulating its framing - and more: leaving one of its most voiced imprints in the Famboyant Gothic or the eclectic Venetian Gothic, it spread over the public as well as residential buildings' exteriors, fiting out the windows and entrances frames with decorative networks of the kind. (o23-4) The coinciding brace like arch obviously entered the collective awareness and this under the name of accolade, as the reference informs us, the only one known to the author until now. [1] However, it seems that in Renaissance, enchanted and preoccupied by the newly found solutions that increasing rediscoveries in the domain of Roman artistic heritage brought about, the declared recognition of the accolade formation, inspite of its persisting endurance, sinked back into the un-exposed self-evident presence. Only the acknowledged pyramidal composition, called also the renaissance triangle, might be looked upon as the sediment of the accolade's temporal breakthrough into the artistic i.e. theoretical awareness. Yet the artistic producton remains inhabited by its manifold occurrences. Apart from figurative misenscenes, it is in landscapes that its presence is most easilly recognised, the still lives being to a substantial degree aligned to the ortogonal plane organization. (o25-8) One can convincingly trace - be it clearly exposed or more or less underlying - the conflating descend of lateral trees, slopes or buildings' elements in the curved or graded assembling antithesis, forming the interspace more or less ending in cusp(s) and complemented by an ascending gestalt of the mountain or architectural silhouette in the distance: we have just described the established design staging the scenery of the so called classical landscape composition. (o26)

*Completing his studies with a considerable success at Vienna Accademy in 1918, Gojmir Anton Kos (1896-1970) settled in Ljuibljana to become one of the clue figures of

Slovenian painting of the first half and the middle of the 20th century.

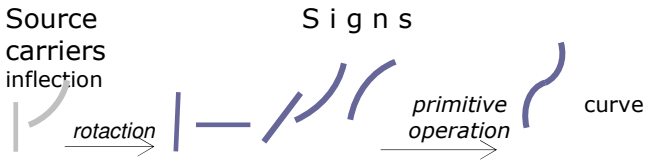
2 REPRODUCED MATERIAL (o1-o28)

1- Gojmir Anton Kos, Piknik 1924, private
2- Marcel Duchamp, Chess Game 1910, Pennsylvania MuArt
3- Jan van Eyck, Madonna with Chancellor Rollin c 1434, Louvre
4- Dioscurides of Samos, Comedy scene, c180 BC, Pompei, Napoli Man
5- God and devotee under the date palm, lateAkad-neoSumer? 2200- 2100, L BrMu
6- TheTamer? detail from Tomb 100 Hierakonpolis c3200 BC
7- Feeding Caprils, plaque from the Pu'abi tomb Ur c 2600 L BrMu
8- Nectanebo I offering Neith, stelle Heraclion 4thBC, Kairo EgMu
9- Feeding cattle, inlay Q ueen Pu'abi silver lyre, Ur c2600 BC, L BrMu
10- King between lions and sphinxs, ahamenidian cylinder seal, Berlin StaaltMu
11- Mountain godess with adorant, Cretan seal from Knosos
12- Peirithoos' wedding , W gable Zeus-Olympia, c460, L NatGall
13- Chariot race, W gable Parthenon Athens, before 432, L NatGal
14- Scribe, Sakkara 5D c2400 Louvre
15- Idyllic Landscape with Egyptian Character, Pompei, Napoli Man
16- Christ as Good Shepardr, Priscilla catacombs, 3rd c. Rome
17- Christ Pantocrator, apsis Cefalu cathedral, before 1170
18- Christian and Muslim playing Chessa, AlonsoX Libro de jeugos fol 64r, 1283, Madrid, RealBibl SLorenzo delEscorial
19- Scene from the Jacob Story, Viena Genesis 6th c., Viena KHM
20- Giotto, Joachim's Dream, 1304-6 CapScrovegni, Padova
21- id. Flight into Egypt, ibid.
22- Giovanni Bellini, Madonna del prato 1505, London NatGall
23- Example of late Gothic altar frameworks
24- Chapel StRoch front gate detail, Millierres-Manche 15/16st.
25- Master Girart, King's Modus Book of Hunting fol 21r, c1455 Flanders, Bruxelles BibiRoyale
26- Pousssin, Landscape with Gathering the Phocion Ashes 1648, Liverpool Walker ArtGall
27- J.M.W. Turner, Shipwrerck in Storm 1823, London BrMu
28- E.Lear, Borghetto and Partenigo 1847, Oxford AshmoleanMu

3 FORMAL SYSTEM OF PICTORIAL PRODUCTION

If, as it turned out, the observation of the accolade as the common source paradigm of visual representation holds, one is consequently compelled to ask, would it be possible to expose an underlying formal system as the unified point of departure for the pictorial genesis as such. Considering the formal logic as the referrence footing, it proved out that the system of sign enlistment, axioms, operations and reference rules corresponds witiin the domain of artistic process to the system of given signs, operations and composing principles-attitudes, that with the weight of axioms enables the convincing esthetic result to take place.

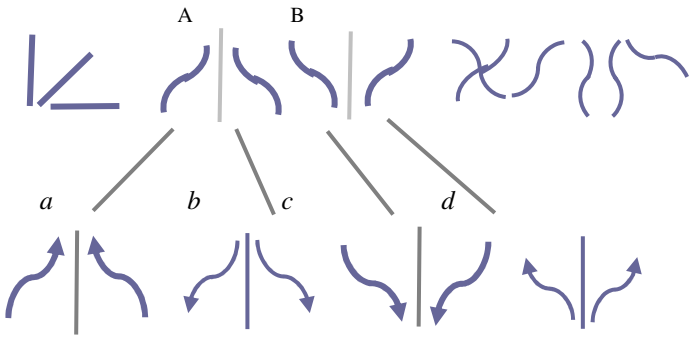
We proceed with handing out the set of signs as follows:



Signs fulfill the double function. Straight lines – carryng signs constitute the structural core - defining the basic orientations for content inputs, vis-a-vis curves forming the representative – descriptive fund. Still, the carrying signs are taking over the representative role as well, i.e. their presence supporting structure may as well fulfil the descriptive function, for instance as architectural edge. On the other hand, at he same time the represented object may act in the role of direction giving line: most obviously the axial figure, or tree trunk as vertical.

Source gestalts

carryng core decriptive/representative core alternative commpounds
atomar formal statements



The direction of movement is determined by the contact educing location. Particular formation is flexible along with contraction-expansion alternative. By the singular semantic input the accolade's original ascend/descend orientations (A,B) may change into their alternatives:

in the coming close/contracting perspective the originally upwards directed curves indeed represent ascending - option a, (oo6,7,11,13,15,16) in the role of deflection they represent the downward stream - b. (ool,8) On the other hand the original downwards directed approach - c (oo1-5) in a role of slipping up expansion designates the alternative quality of ascension – d. (o 9)

4 OPERATIONS – FORMAL PROCEEDINGS (internal)

1 - ROTATION
- 2D – diagonal inclining, axial change
- 3D – (axial) mirroring

2 - DISPLACEMENTS
- in optional directions on plane
- displacement of singular elements
- interspacing - of elements from one another
- covering - some elements with other(s)

→ inducing the dimension/illusion of depth

3 – INFLECTION SWITCH
- of curve's convex/concave parts consequenty the curve's vertex tunrs into cusp or vice versa



4 – EXTENSION/CONTRACTION
- of phase: angle opening/closing



- radial: streching the curve equator
→ inflection slidies along the curve



- linear



- axial disclosement



- object extension/contraction - zoom

5 – COMPOSING/FRAGMENTING
- replication - resulting in sequences:
- additiv,e covering, antithetic...

- gestalt replication - wings flaking
→ antithetic sequences



- (antithetic) structure chains



- source gestalts composing complex compositions – see Figure 1
- Fragmentation:
- only parts of accolade are included, as one-
-wing descend or accolade's extreme neigh-
bourhood



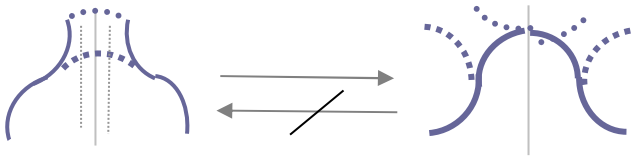
- spliting:
axial curve



MAPPING – external operation

Mapping of given artwork or its components to another may include all the proceedings or just some of them. It consists in transmiting the attained solutions as examples or model into other works.

Ad 3 – If the coinciding antithetic curves undergoes the inflection switch and their parts change from concave to convex and vice versa, the formation consequently shifts from accolade/cusp to vertex. Yet the change by itself is not decisive for the gestalt recognizing threshold – the accolade type curve is more persisting as regards the resulting perception – its identity tolerance proves to be more resistant than in the case with rounded extreems:



Accolade – antithetic conception :
- open, extensive, with high identity tolerance
- stands inflexion switches, inbetween inputs

Rounded- closed arch :
- tends to completion, low identity tolerance
- splitted by vertical, by inflexion switch devalued

Consequently transgressing from the acccolade to the rounded arch shape retains, in spite, perception of the original paradigm, which does not hold for the inverse. The obvious example for instance is the mandorla case.

5 COMPOSING PRINCIPLES

- inference rules – constitutive executive proceedings with the weight of axioms:

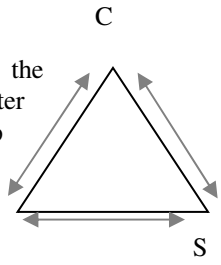
A-PRINCIPLE OF FORMAL CONGRUITY - CORRESPONDING DISTRIBUTION:
tendance to the balanced field engagement from the point of:
- colour
- contrast
- masses distribution
- solid/void shift

B - SYMMETRY PRINCIPLE

as the deciding actor in the pictorial field articulation the symmetry by its immanent search for the counter poise explains from its part the gravity of the coinciding curve antithesis with its (quasi)symmetric tendance. Avoided symmetry concept [2] - makes compositional derivatives (like shift from confrontation to succession or one wind sliding...) explained as derivations from one source – standard gestalt.

C - WEIGHT OF THE CENTER

Center as atractor or (emanating) source co-defines the logic of pictorial inhabitants place occupying. It functions whether realized or empty instance: the absent potential be active as dynamic agent

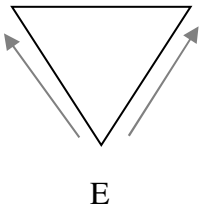


Composing principles conflate in the dynamics of mutual co-activity. The center effect and the symmetry impell keep adjusting to the principle of formal congruity depending on their distance to each one's original placement.

SEMANTIC INVESTMENT

Content implementation actuates the arts representative function, i.e. what we actually look at. Artefact potential is supposed to be triple:

- magic
- narative
- aesthetic



Visual artistic pproduction had been since ever the art of evoking and imbedding the transcedental tenor as well as exposing private or collective property and living conditions. Apart from firsthand decorative role the narrative takes over also the role of communicating social contents, whether they belonged to the limitted social milieu or were they in function of recording the clue collective events, or representing in the role of propaganda the individual's as well as the state status potency that might also be understood as warning. As the meeting place of productive co-relation between form and content, the aesthetic potential sustains the dimension of surplus, where the author's original investment triggers the suggestive artefact's dynamics to be articulated further by the active observer's participation. As such it represents the open potential for the enhanced effectivness of the other two aspects. It happens as hic et nunc event ever anew – or it does not – being the dimension, where the eloquence of formal trespasses, sanctioned against the backgrounnd of the reliable conception and execution, is seting its foot.

TO ASSUME:

Having in mind the accolade as the the pictorial production departure point, the unified formal system can be deduced. One is tempted to ask whether the exposed gestalt, proved as one of the source constellations in percieving and transmitting the reality, might turn out also as to be aligned to the articulation of the basic cognitive constellations in the dynamics of mental activity. Source gestalts looked upon as well formed formulae, structurally articulated entities fit to parallel the role of concepts, may bring down the gap between conceptual and visual thinking.

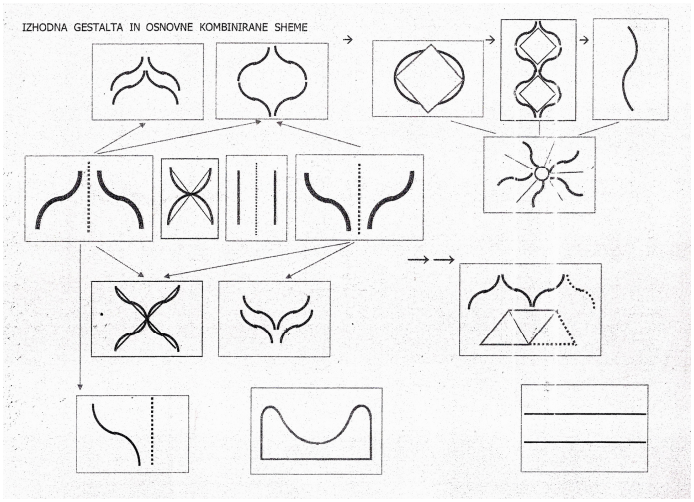


Figure 1: *The two source accolade gestalts and their combinations.*

References

[1] Jacques Mesnil in his book on Masaccio (M. Nijhoff. La Haye l927 pp44/5) exposes in footnote 1 the two distinctive features as for the 15th century transitional period from Gothic to Renaissance: the oval and »la forme en accolade« or »arc mixtiligne«. Search for further references on accolade in this respect brought as for now no results.

[2] The avoided symm as constitutive concept present already in Egypt. practice: F.Tiradritti, Egyptian Wall Painting, Abeville N.Y. 2008, p104.

ROLE OF CATHEPSINS D AND F IN HUMAN NEURONAL CEROID LIPOFUSCINOSIS

Veronika Stoka, Vida Puizdar, Barbara Jerič, Tajana Zajc, Katja Bidovec, Iztok Dolenc, Vito Turk
Department of Biochemistry and Molecular and Structural Biology
Jožef Stefan Institute
Jamova cesta 39, 1000 Ljubljana, Slovenia
Tel: +386 1 4773854; fax: +386 1 4773984
e-mail: veronika.stoka@ijs.si

ABSTRACT

From 14 genetically distinct human lysosomal storage disorders namely, neuronal ceroid lipofuscinosis, only two involve cathepsins. This paper presents a comparative view of the role of the aspartic protease cathepsin D (CLN10) in congenital neuronal ceroid lipofuscinosis and the cysteine protease cathepsin F (CLN13) in adult-onset neuronal ceroid lipofuscinosis – Type B Kufs disease, respectively. Particularly, we evaluated the effect on the protein structure and stability of the disease-causing mutations; thus affecting the mature form of enzyme.

1 CATHEPSINS

Cathepsins were originally identified within the lysosomes as protein-degrading enzymes; however, in the past decade novel biological functions were uncovered [1]. Based on their structure and catalytic type, they were classified into serine cathepsins (A, G), aspartic cathepsins (D, E), and eleven cysteine cathepsins (B, C, F, H, K, L, O, S, V, W, X) [1].

1.1 Cathepsin D

Cathepsin D (EC 3.4.23.5) is ubiquitously expressed in most mammalian tissues at varying levels depending on cell type and developmental stage, with the highest expression in the brain [2]. The primary structure of human cathepsin D precursor consisting of 412 amino acids is post-translationally modified by two major processes, proteolytic cleavage and glycosylation [3]. The latter are required for the enzyme targeting via the mannose-6-phosphate receptor-dependent and independent pathways [3]. Cathepsin D contains three topologically distinct regions that are typical of aspartic proteases, an N-terminal domain (residues 1-188), a C-terminal domain (residues 189-346), and an interdomain, anti-parallel β-sheet composed of the N terminus (residues 1-7), the C terminus (residues 330-346), and the interdomain-linking residues (160-200) [4]. The overall fold of cathepsin D is conserved and similar to other aspartic proteases such as human renin, porcine pepsin and bovine chymosin, thus consisting of two lobes separated by a deep cleft of the active site on the bottom of which there are two catalytic aspartate residues [4]. However, several structural features distinguish cathepsin D from other aspartic proteases. The cleavage and excision of an external loop between residues 98 and 106 in the N domain results in the noncovalent association of light and heavy chains. In addition, the substrate-binding site is wider than in renin with larger subsite volumes in S2 and S4. Moreover, a proline-rich segment (residues 312-317) that occurs only in cathepsin D and renin are located close to the active site [4]. Recently, a quantitative N-terminal proteomics enabled the identification of the largest set of cathepsins D and E substrates thus highlighting that these aspartic proteases, although strongly related, might hold different specificities and cleave different substrates [5]. Moreover, we found that human stefin B and cystatin C are specifically cleaved by cathepsin D whereas they were not affected by cathepsin E [Zajc et al., submitted]. In addition, we recently performed a biochemical characterization and structural modeling of the spliced variant 2 of human cathepsin E, thus showing significant differences in comparison with the wild-type protein [6].

1.2 Cathepsin F

Cathepsin F (EC 3.4.22.41) is widely expressed in human tissues with high levels in the heart, brain, skeletal muscle, testis, and ovary; whereas moderate transcript expression was observed in the kidney, pancreas, placenta, liver, and colon [2, 7]. It is synthesized as an inactive preproenzyme that may be targeted to the endosomal/lysosomal compartment via the mannose-6-phosphate dependent-receptor pathway [2]. The primary structure of human cathepsin F precursor consists of 484 amino acids. After cleavage of a signal peptide (19 amino acids), a 465 amino acids proenzyme is subsequently processed autocatalytically or by other cysteine or aspartic proteases [7]. The cathepsin F fold is typical of that observed in other members of the papain family of cysteine proteases, composed of two domains: an L domain that contains three α-helices, and an R domain that contains a twisted β-sheet and two helices [8]. At the junction between the R and L domains is a cleft that forms the substrate-binding site and contains the protease's catalytic machinery Cys25 and His159 form [8].

A comparison of the binding sites from papain family cysteine proteases highlights that, while many of the general features of these sites are conserved, there are substantial differences in the shape and composition of the binding sites across the family [8]. These differences are responsible for the unique substrate specificity of each protease. Particularly, cathepsin F is a potent endopeptidase with a preference for non-aromatic hydrophobic residues in the S2 binding pocket (Leu, Ile, Val, Met) and broad subsite specificity for subsites S1, S3 and S4 where basic residues Arg, Lys and His are well accepted [7].

2 NEURONAL CEROID LIPOFUSCINOSIS

The neuronal ceroid lipofuscinosis (NCLs) represent a special group within the inherited lysosomal storage disorders. Most human NCLs show an autosomal recessive mode of inheritance, and may have variable ages of onset such as congenital, infantile, late infantile, juvenile, adult or even late adult onset according to the severity of mutation [9]. Most of the NCL-related genes encode soluble and transmembrane proteins which localize to the endoplasmic reticulum or to the endosomal/lysosomal compartment and directly or indirectly regulate lysosomal function [2]. The clinical features of most childhood forms include progressive loss of vision, mental and motor deterioration, epileptic seizures and premature death, whereas the rarer adult-onset forms are dominated by dementia [9]. Besides biochemical and clinical differences, all forms of NCLs share unifying pathomorphological features. These autofluorescent, electrondense, periodic acid-Schiff (PAS)- and Sudan black B-positive granules that bear close resemblance to lipofuscin are resistant to lipid solvents and accumulate in the cytoplasm of most nerve cells and, to a lesser extent, in many other cell types [9]. To date 365 NCL-causing mutations are known, with 91 novel disease-causing mutations reported [10]. The most comprehensive database of NCL mutations is maintained by Dr. Sara Mole at University College London and it is updated regularly [11].

2.1 Congenital neuronal ceroid lipofuscinosis: Cathepsin D (CTSD, CLN10)

Mutations in the cathepsin D gene cause neuronal ceroid lipofuscinosis with congenital classic, late infantile or juvenile onset (OMIM 610127) [2,9]. The histological ultrastructure exhibits granular osmiophilic deposits with accumulation of sphingolipid activator proteins [9].

To date, twelve mutations on cathepsin D gene were found [10, 12-14]. These mutations affected exons 3, 4, 5, 6, 7 9 and introns 3 and 6 [10, 12-14]. The mutation type was missense, nonsense, deletion, splice defect and/or sequence variation and some of them resulted in a protein change [10, 12-14]. A sequence variation p.(Gly282Arg) might have a benign effect, whereas the functional effects of a nonsense mutation p.(Tyr255*) and a deletion p.(Lys331del) are still unknown [11, 12]. On the other side, missense mutations lead to p.(Ser100Phe), p.(Gly149Val), p.(Phe229Ile), p.(Tyr383Cys), p.(Arg399His) with predicted functional effects mostly damaging [11,13,14]. Mutations p.(Phe229Ile) and p.(Tyr383Cys) were indicated on the X-ray crystal structure of human cathepsin D [4] (Phe165 and Tyr329 according to 1lya:D numbering) (Figure 1). These mutations affect secondary structure elements, namely β-sheets (Figure 1), thus exerting an overall destabilizing effect on the protease, with an either favorable or unfavorable torsion angles and stability change (ΔΔG) values of -5.48 and -11.37 kcal/mol, respectively (Table 1). The impact of single amino acid replacements on protein stability due to thermal denaturation was done on the 3D structure of cathepsin D (1lya:D) [4] using the Cologne University Protein Stability Analysis Tool – CUPSAT [15].

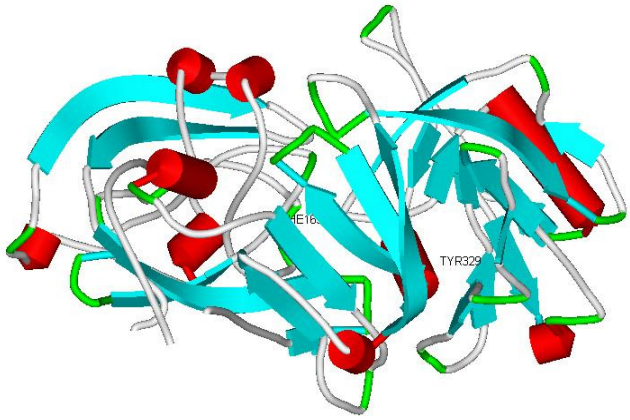


Figure 1. *Point mutations corresponding to selected allelic variants found in congenital neuronal ceroid lipofuscinosis (CLN10) are shown on the 3D structure of human cathepsin D (1lya).*

Table 1. Effect on cathepsin D structure of point mutations corresponding to selected allelic variants found in congenital human neuronal ceroid lipofuscinosis (CLN10)

Mutation site		Structural Features			Experimental Method - Thermal		
Protein sequence P07339	Protein structure 1lya:D	SS element	Solvent accessibility	Torsion angles (φ, ψ)	Overall Stability	Torsion	Predicted ΔΔG (kcal/mol)
Phe229Ile	Phe165Ile	Sheet	0.0%	-151.5°, 149.0°	Destabilising	Unfavourable	-5.48
Tyr383Cys	Tyr329Cys	Sheet	7.02%	-120.8°, 110.5°	Destabilising	Favourable	-11.37

2.2 Adult-onset neuronal ceroid lipofuscinosis – Type B Kufs disease: Cathepsin F (CTSF, CLN13)

Mutations in the cathepsin F gene cause the adult-onset neuronal ceroid lipofuscinosis – Type B Kufs disease (OMIM 603539) [2,9].

Very recently, genome-wide linkage mapping of two families with recessive Type B Kufs disease and exome sequencing identified homozygous and compound heterozygous missense mutations in cathepsin F within a single region on chromosome 11 [16]. In total, five rare or novel variants were detected and multiple lines of evidence indicate that cathepsin F variants are indeed pathogenic mutations due to missense mutation or frameshift [16].

These mutations affected exons 5, 7, 12 and 13 [16]. A nucleotide change c.954delC lead to a frameshift and subsequent nonsense mutation with a protein change p.(Ser319Leufs*27) resulting in a C-terminus deletion [11,16]. Missense mutations lead to p.(Tyr231Cys), p.(Gln321Arg), p.(Gly458Ala), p.(Ser480Leu), with predicted functional effects probably damaging [11,16]. Mutations p.(Gln321Arg), p.(Gly458Ala) and p.(Ser480Leu) were indicated on the X-ray crystal structure of human cathepsin F [8] (Gln51Arg, Gly182Ala and Ser208Leu according to 1m6d:A numbering) (Figure 2). These mutations affect secondary structure elements (α-helix, β-sheet, other) thus resulting in an overall destabilizing effect on cathepsin F, with an either favorable or unfavorable torsion angles and stability change (ΔΔG) values of -4.74, 0.64 and -4.02 kcal/mol, respectively (Table 2). The impact of single amino acid replacements on protein stability due to thermal denaturation was assessed on the 3D structure of cathepsin F (1m6d:A) [8] using the Cologne University Protein Stability Analysis Tool – CUPSAT [15].

Table 2. *Effect on human cathepsin F structure of point mutations corresponding to the allelic variants found in Kufs disease – Type B (CLN13)*

Mutation site		Structural Features			Experimental Method - Thermal		
Protein sequence Q9UBX1	Protein structure 1m6d:A	SS element	Solvent accessibility	Torsion angles (φ, ψ)	Overall Stability	Torsion	Predicted ΔΔG (kcal/mol)
Gln321Arg	Gln51Arg	Helix	0.0%	-60.0°, -38.9°	Destabilising	Favourable	-4.74
Gly458Ala	Gly182Ala	Other (turns, coils, etc.)	17.79%	56.5°, -145.7°	Destabilising	Unfavourable	0.64
Ser480Leu	Ser208Leu	Sheet	0.0%	-157.4°, 148.1°	Destabilising	Unfavourable	-4.02

Very recently, we showed that the N-terminally truncated forms of human cathepsin F accumulate in aggresome-like inclusions and predicted the aggregate-prone regions [17].

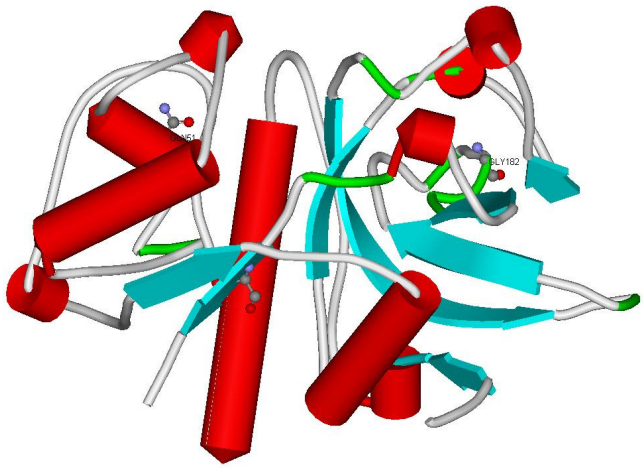


Figure 2. *Point mutations corresponding to the allelic variants found in adult-onset neuronal ceroid lipofuscinosis (CLN13) are shown on the 3D structure of human cathepsin F (1m6d:A).*

3 CONCLUSION

From 14 genetically distinct human lysosomal storage disorders namely, neuronal ceroid lipofuscinosis (NCLs) only two involve cathepsins. The aspartic cathepsin D and the cysteine cathepsin F are involved in the congenital and adult-onset neuronal ceroid lipofuscinosis, thus resulting in loss-of-function mutations that affect the structure, stability and function of the enzyme.

Acknowledgements

This work was supported by grants from the Slovenian Research Agency - ARRS awarded to Profs. Boris Turk (P1-0140), Robert Zorec (J3-4051) and Marko Kreft (J3-4146).

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NEREDUKTIBILNOST IZKUSTVA: ZAKAJ BI MORALI V KOGNITIVNI ZNANOSTI PREUČEVATI IZKUSTVO?

Toma Strle
Univerza v Ljubljani
Pedagoška fakulteta
Kardeljeva ploščad 16, 1000 Ljubljana, Slovenija
Tel: +386 1 5892 327
e-mail: toma.strle@pef.uni-lj.si

POVZETEK

Nevrofenomenološki program, ki ga Varela (2013) ponuja kot rešitev težkega problema zavesti (Chalmers, 2013), predstavlja dober metodološki predlog raziskovanja izkustva, po drugi strani pa so njegove zahteve za sistematično raziskovanja izkustva premočna. Ne glede na to in ne glede na nekatere druge težave, s katerimi se soočajo prvo- in drugoosebne metode, pa postaja vedno bolj jasno, da je uporaba le teh v kognitivni znanosti močno potrebna. Slednje bom prikazal na primeru nekaterih raziskav in teorij iz širšega področja preučevanja odločanja.

1 UVOD: TEŽKI PROBLEM ZAVESTI

Chalmers (2013) v svojem članku »Kaj pomeni soočiti se s problemom zavesti?«[1] probleme zavesti razdeli na lahke in težke. Lahki problemi so tisti, za katere se zdi, da jih vsaj načeloma lahko rešimo z uporabo standardnih metod kognitivne znanosti. A Chalmers (2013) upravičeno trdi, da čeprav bi razložili mehanizme in procese, ki omogočajo različne kognitivne funkcije (lahki problemi), bi se še vedno lahko vprašali, »[z]akaj vso to procesiranje informacij ne poteka »v temi«, prosto vsakršnega notranjega občutka?« (Chalmers, 2013, pogl. 3), brez prisotnosti zavestnega izkustva. Poleg procesiranja informacij obstaja tudi subjektivni aspekt izkušnje, ta »kako je biti« (Nagel, 1974), nek subjektiven način, na katerega se svet prikazuje tistemu, ki ga izkuša. Ne le, da težki problem zavesti ostaja vseskozi nerazrešen, ampak kognitivna znanost z uporabo standardnih metod preučevanja »izkustva« (npr. s kvantitativnimi vprašalniki) ali korelatov izkustva (npr. z metodami, ki jih uporablja nevroznanost), le tega sploh ne raziskuje ali pa ga raziskuje le »površno«. Da bi podal temelj »bolj natančnega« raziskovanja izkustva je Varela (2013) predlagal zanimivo rešitev težkega problema zavesti: program nevrofenomenologije, ki je »osnovan na *iskanju vzajemnih omejitev* med poljem pojavov, razkritem v izkustvu, in sopripadajočim poljem pojavov, uveljavljenem v kognitivni znanosti.« (Varela, 2013, pogl. IV). Nevrofenomenologija vsebuje tri bistvene elemente: a) nereduktibilnost zavestnega izkustva, b) nujnost uporabe sistematičnih prvoosebnih pristopov pri raziskovanju izkustva (fenomenologija[2]) in c) združevanje prvo- in tretjeosebnih pristopov pri raziskovanju zavesti in duševnosti na splošno (nevrofenomenologija).

V prispevku[3] bom najprej bom predstavil trditev, da Varela poskuša težki problem zavesti reševati na metodološko-epistemološki ravni (ne reši pa težkega problema zavesti na ontološki ravni) in poskusil pokazati, da za preučevanje izkustva potrebujemo ustrezne metode in ustrezno raven znanja in razumevanja (a). Nadalje bom na kratko predstavil fenomenologijo (po Vareli, 2013), ki naj bi šele omogočala sistematično raziskovanje izkustva (b). Čeprav je po mojem mnenju Varelina zahteva po fenomenološki redukciji premočna, pa se strinjam z osnovno idejo Varele, da mora kognitivna znanost v svoje raziskovanje zavesti in duševnih pojavov, ki se na zavest/izkustvo navezujejo, vključiti boljše (in bolj sistematične) metode preučevanja izkustva. Le tako bomo duševnost razumeli bolj celostno, omogočili pogoje za medsebojno omejevanje prvo- in tretjeosebnih pristopov (c) in se morda bolj približali izkustvu, ki tvori bistven del duševnosti.

2 O KAKŠNI VRSTI NEREDUKTIBILNOSTI IZKUSTVA LAHKO GOVORIMO?

V kontekstu vprašanja (ne)reduktibilnosti izkustva Lutz in Thompson (2003) razlikujeta težek problem zavesti od problema razlagalne vrzeli (Levine, 1983). Težek problem zavesti je po njunem mnenju metafizično vprašanje o tem, kakšno mesto ima izkustvo v naravi. Problem razlagalne vrzeli pa pojmujeta kot »epistemološki in metodološki problem, kako povezati prvoosebne fenomenološke in

[1] Vsi prevodi navedkov iz člankov Chalmers (2013 [1995]) in Varela (2013 [1996]) so delo Sebastjana Vörösa. Prevodi člankov bodo izdani v naslednji številki revije Analiza.

[2] Ko uporabljam izraz fenomenologija, se nanašam na empirično in ne na Husserlovo fenomenologijo.

[3] Prispevek se delno naslanja na moj članek, ki bo objavljen v reviji Analiza (Strle, 2013)

tretjeosebne kognitivno-nevroznanstvene opise izkustva« (Lutz in Thompson, 2003, 47). Iz tega vidika Varelinega (2013) predloga rešitve težkega problema zavesti tako ne smemo razumeti kot poskus odgovora na metafizično vprašanje o ontološkem statusu zavesti, ampak kot tezo nereduktibilnosti zavesti na metodološki in epistemološki ravni.

V kontekstu raziskovanja izkustva bi metodološka redukcija (o tezi na splošno: Brigandt in Love, 2012) pomenila, da lahko izkustvo najbolj plodno raziskujemo npr. na elektro-kemični ravni ali ravni subatomskih delcev. Vendar so je težko predstavljati, kako bi izkustvo lahko najbolje preučevali le na električno-molekularni ali funkcionalni ravni možganov, brez navezave na raven izkustva. V resnici se npr. nevroznanost izkustvu (in zavesti) poskuša izogniti, vendar, bolj ali manj implicitno, izkustveno v eksperimentih in interpretacijah predpostavlja: od podajanja navodil udeležencem, spraševanja udeležencev po izkustvu, do uporabe konceptov, ki se nanašajo na raven izkustva in ne le na raven delovanja možganov (npr. pri trditvah o korelacijah).

Epistemološka redukcija (o tezi na splošno: Brigandt in Love, 2012) pa bi v kontekstu raziskovanja izkustva pomenila, da lahko znanje, ki smo ga pridobili v domeni fenomenologije (s prvo- ali drugoosebne perspektive), zreduciramo na neko nižjo raven, npr. na raven elektro-kemičnega delovanja možganov, na domeno znanja nevroznanosti. A četudi bi podali kar se da dobro razlago izkustva na tem nivoju, ta razlaga ne bi vključevala doživljajskih (prvoosebnih) stanj. Posebej trdovratna v kontekstu vprašanja epistemološke reduktibilnosti izkustva je razlagalna redukcija, ki se osredotoča na vprašanje, ali lahko lastnosti višjih ravni razložimo z lastnostmi nižjih ravni. Lahko bi predpostavili, da je izkustvo nekako možno razložiti brez navezave na doživljajska (prvoosebna) stanja, a ker razlaga izkustva predpostavlja razumevanje pojava, ki ga poskušamo razložiti, mora taka razlaga vsebovati navezavo na izkustvo, saj drugače vsaj dela pojava, ki ga poskušamo razložiti, ne bi razumeli in naša razlaga ne bi bila popolna. Morda bi, ko bi se navadili na npr. matematično razlago izkustvenega, matematično razlago razumeli (tudi na izkustveni ravni?), vendar bi naše razumevanje vedno implicitno vključevalo navezavo na (lastno) izkustvo, ki pa je že znanje »višje« ravni. Tako npr. nevrofiziološka razlaga (interpretacija rezultatov) čustev in občutkov nujno vključuje (čeprav implicitno, intuitivno) »poljudno« znanje (in razumevanje) raziskovalcev o izkustvenem, ki nikakor ne izvira le iz preučevanja nevrofizioloških substratov.

Metcalfe in Shimamura (1994) tako upravičeno kritizirata strogo tretjeosebne pristope pri raziskovanju duševnosti: »Mentalni procesi, s katerimi so novo nastali kognitivni znanstveniki začeli polniti »črno škatlo«, so bile bolj abstrakcije opazovalcev kot zavestno izkustvo posameznikov. To preučevanje duševnosti s tretjeosebnega vidika se v tem smislu ni močno razlikovalo od osnovnih pogledov behavioristov.« (Metcalfe in Shimamura, 1994, viii)« Zaradi naštetih razlogov Varela (2013) upravičeno zagovarja (metodološko in epistemološko) nereduktibilnost zavesti in uvedbo sistematičnih prvo- in drugoosebnih metod raziskovanja izkustva v znanost. Varela tako pravilno trdi, da je potrebno »proučiti konkretne možnosti za disciplinirano raziskovanje izkustva – projekta, ki leži v samem osrčju fenomenološkega navdiha –, ne da bi se ob tem pustili ustrahovati strašilu subjektivnosti.« (Varela, 2013, pogl. II)[4]

3 FENOMENOLOGIJA IN FENOMENOLOŠKA REDUKCIJA

Fenomenologija predstavlja metodološko pot, ki v nasprotju z objektivističnim, zunanjim pristopom znanosti, ne zavrača subjektivnega značaja izkustva. Varela opiše fenomenologijo kot »*posebno obliko refleksije* ali drže do naše zmožnosti biti zavestni.« (Varela, 2013, pogl. II) Čeprav vsaka refleksija razkriva mnogotero zavestnih vsebin, pa naivna oz. naravna drža, ki smo jo navajeni, po Vareli nevedno predpostavlja »vrsto sprejetih prepričanj o naravi izkuševalca in njegovih intendiranih predmetov.« (Varela, 2013, pogl. II) in s tem »zastira« vpogled v izkustveno. Po drugi strani fenomenološka drža, katere temelj je fenomenološka redukcija (FR), po Vareli omogoča drugačen, lahko bi rekli bolj odprt, natančen in »pravilen« vpogled v doživljanje in strukturo izkustva. FR predstavlja poseben način, kako biti zavesten, način, kako pristopati do sveta in izkustva in sestoji iz štirih osnovnih delov: reduktivne drže, intimnosti z izkustvom, veščine poročanja o izkustvu, neprekinjenega učenja in vztrajnega usposabljanja v FR (na tem mestu bom na kratko opredelil le prvi in zadnji element). Prvi del predstavlja sposobnost spremembe drže do izkustvenega iz naivne, naravne drže v reduktivno držo. Reduktivna drža pomeni suspenzijo prepričanj o tem, kar izkušamo. Je postavljanje v oklepaj »vnaprejšnjega strukturiranja, ki tvori vseprisotno ozadje našega vsakdana …« (Varela, 2013, pogl. II). Reduktivna drža nam omogoča zaznati »avtomatične miselne vzorce, jim pustiti, da odplujejo, in refleksijo usmeriti nazaj k njihovemu viru.« (Varela, 2013, pogl. II) Takšna drža do izkustvenega je tako bistveno drugačna od drže nekritične introspekcije, ki po Vareli predpostavlja, da je opazovanje izkustva le pogled navznoter (naravna drža introspekcije ima prav tako za posledico, da so poročila o izkustvenem obremenjena in »obložena« s teorijo in vnaprejšnjimi prepričanji). Zadnji in bistven element, ki prejšnje tri šele omogoči, je neprekinjeno učenje in vztrajno usposabljanje (podobno trdijo tudi mnoge meditativne tradicije) v treh vidikih FR. Po Vareli je med površnim opazovanjem zavesti in disciplineranim gojenjem veščine v FR ogromna razlika: brez slednje je sistematično raziskovanje izkustva nemogoče: »Narava »težkosti« je predrugačena v dveh ozirih: (1) težko je vaditi in stabilizirati nove metode, s

[4] V ozadju je tukaj ostra kritika strogega ločevanja med subjektivnim in objektivnim. Več o tej pomembni diskusiji v Varela, 2013; Varela in Shear, 1999; Varela, Thompson in Rosch, 1991).

katerimi naj bi raziskovali izkustvo; (2) težko je spremeniti navade znanosti in jo pripraviti, da sprejme nova orodja, potrebna za transformacijo narave raziskovanja duha...« (Varela, 2013, pogl. IV)

Gojenje štirih elementov FR po Vareli (2013) predstavlja pogoj možnosti sistematičnega raziskovanja izkustva. Po eni strani je to dobro zamišljen ideal raziskovalnega programa, po drugi strani pa menim, da ta ideal predstavlja premočne zahteve za sistematično raziskovanje izkustva. Metoda DVI, ki ne dosega Varelinega ideala, je npr. že podala nekaj pomembnih uvidov v to, kakšni fenomeni se nam kažejo v izkustvu (Heavey in Hurlburt, 2008), poglobila naše razumevanje občutkov (Heavey, Hurlburt in Lefforge, 2012), ipd. Prav tako metoda »poglobljenega« intervjuja, ki sicer bolj, a ne docela, sledi Varelinemu programu, predstavlja plodno metodo za raziskovanje izkustva (npr. Petitmengin, 2006; 2007).

Čeprav se metoda FR (in delno tudi druge prvo- in drugoosebne metode, glede na njihovo specifiko) sooča z nekaterimi težavami – kako npr. vemo, da je nekdo dovolj vešč sistematičnega doseganja stabilnega stanja redukcije, koliko in kakšen trening potrebujemo za doseganje FR, ali želimo pridobiti podatke o izkustvu od oseb, ki so v samoopazovanju in poročanju vešče ali od oseb, ki niso, ipd. – pa bi bilo osnovno trditev Varele, da moramo raziskovanje izkustva vzeti resno in posledično razvijati boljše in boljše metode raziskovanja izkustva (kot npr. za raziskovanje možganov počne nevroznanost), nesmiselno zavreči. Prav nasprotno menim, da je uporaba in razvijanje različnih dobro premišljenih in sistematičnih prvo- in drugoosebnih metod zelo koristna, saj omogoča primerjavo rezultatov in tako medsebojno »omejevanje« že med različnimi prvoosebnimi pristopi raziskovanja izkustva in posledično razumevanje dinamike izkustvenega iz različnih vidikov, ki ga lahko potem primerjamo in usklajujemo s tretjeosebnimi opisi. Tretje osebne metode o duševnosti sicer podajajo pomembne ugotovitve, vendar menim, da moramo za celostno razlago in razumevanje duševnosti bolj sistematično preučevati tudi izkustveno.

4 NEZAVEDNO RAZMIŠLJANJE ALI ZAVESTNO PREUDARJANJE?

Dober primer tega, kako neupoštevanje prvoosebnih podatkov vodi do napačnih hipotez o tem, kako deluje odločanje, je »odkritje« efekta preudarjanja brez pozornosti(Dijksterhuis et al., 2006), ki naj bi pokazal na prednost nezavednega odločanja pred zavestnim, preudarnim odločanjem v kontekstu kompleksnih izbir[5]. V enem izmed eksperimentov so udeleženci izbirali med štirimi avtomobili. V enem pogoju so udeleženci prebrali opis avtomobilov, od katerih je imel vsak štiri lastnosti (enostavna izbira), v drugem dvanajst (kompleksna izbira). Po tem so eni skupini naročili, da naj pred izbiro avtomobila o izbiri razmišljajo štiri minute (pogoj zavestnega razmišljanja s pozornostjo na izbiro), druga skupina udeležencev pa je bila štiri minute zamotena z reševanjem anagramov (pogoj nezavednega razmišljanja brez pozornosti na izbiro). Obema skupinama udeležencev so rekli, da jih bodo po teh štirih minutah prosili, naj izberejo najboljši avto (z največ pozitivnimi lastnostmi). Izkazalo se je, da so udeleženci v pogoju nezavednega razmišljanja izbirali boljše avtomobile, ko so imeli le ti dvanajst lastnosti, kot udeleženci, ki so o izbiri razmišljali zavestno (pozornost naj bi imeli usmerjeno na izbiro). Avtorji so zaključili, da »v takih primerih bi moralo posamezniku koristiti, da zavestno premišljuje o enostavnih zadevah, razmišljanje o bolj kompleksnih zadevah pa prepusti nezavednemu.« (Dijksterhuis et al., 2006, 1007). Waroquier et al. (2010) pa so v svoji raziskavi pokazali, da so nekateri izsledki in interpretacija prej opisane študije, napačni. Pokazali so (o tem so povprašali udeležence!), da je približno 70% udeležencev že v predstavitveni fazi, preden so jih razdelili v skupini zavestnega in nezavednega razmišljanja o izbiri, že izbralo produkt, ki se jim je zdel najbolj privlačen. S tem pa je neveljavna tudi trditev, da je nezavedno premišljevanje o kompleksnih izbirah vodilo v boljše izbire kot zavestno premišljevanje o izbirah, saj različna pogoja v večini nista imela vpliva na izbiro, saj se je izbira zgodila že prej. Prav tako je treba poudariti, da moramo biti pri sklepanju iz relativno enostavnih odločitvenih situacij – ki nimajo resnih posledic za udeležence – na bolj kompleksne in situacije, s katerimi se ljudje soočajo v (realnem) svetu, zelo previdni.

Raziskave, kjer je nujno razlikovanje med tem ali udeleženci zavestno preudarjajo o svojih izbirah ali ne, oz. kjer morajo raziskovalci presojati o tem ali se udeleženci nekega pojava zavedajo ali ne, potrebujemo neko metodo, s katero bomo to lahko preverili – upoštevati moramo prvoosebna poročila udeležencev, ki nam močno olajšajo in omogočijo bolj verodostojno interpretacijo rezultatov. Čeprav Waroquier et al. (2010) niso uporabili bolj sistematične metode za pridobivanje prvoosebnih podatkov, pa se zdi, da so sistematične drugoosebne metode in izurjenost raziskovalcev v pridobivanju verbalnih poročil (Froese et al., 2011) kot ustvarjene za boljše razumevanje načina razmišljanja v kontekstu odločanja.

5 TEST KOGNITIVNE REFLEKSIJE

Na podobne težave kot v zgoraj opisanem eksperimentu (Dijksterhuis et al., 2006) naletimo tudi v kontekstu teorij dvojnega procesiranja (TDP), ki kognitivne procese delijo na dva tipa. Procesi tipa 1 so hitri, avtomatični, nezavedni, kontekstualizirani, ipd., procesi tipa 2 so počasni, kontrolirani, zavestni, dekontekstualizirani, ipd. (Evans, 2008). TDP v kontekstu presojanja in odločanja ponavadi predpostavljajo, da so intuitivni in nezavedni procesi tisti, ki vodijo naše odločitve (in še to v »napačne« ali »neoptimalne«), preudarnim, (refleksivnim) in zavestnim procesom pa se ponavadi pripisuje majhno vlogo (in še to npr. le za racionalizacije in konfabulacije) (npr. Evan, 2010). Sicer je res, da raziskave odločanja in presojanja kažejo, da smo kot odločevalci in presojevalci omejeni, vendar

[5] Ta primer omenjajo tudi Froese et al. (2011).

raziskavam manjka boljša metoda, s katero bi lahko dobili boljši vpogled v dinamiko zavestnih (npr. miselnih) procesov v kontekstu odločanja in tudi drugje. Posebej vprašljive so lahko interpretacije rezultatov, ki so pridobljeni s kvantitativnimi metodami, a se implicitno ali eksplicitno nanašajo na izkustvo. Frederick (2005) je razvil t. i. test kognitivne refleksije (TKR) v katerem iz odgovorov na tri enostavna vprašanja poskuša sklepati na to, v kolikšni meri ljudje hitre intuitivne, impulzivne odgovore, ki jih izzovejo vprašanja[6] (ki so namerno tako zastavljena), sprejmemo brez zavestnega preudarka (refleksije) o svojem odgovoru. Izkaže se, da tudi š tudenti najboljših univerz (MIT) test rešijo relativno slabo (glede na enostavnost vprašanj), »povprečni« udeleženci pa še veliko slabše. Test kognitivne refleksije je po mojem mnenju dober primer kvantitativnega pridobivanja podatkov o duševnosti, kjer pravzaprav ne vemo, kako udeleženci v resnici rešujejo nalogo in kakšne sposobnosti za to uporabljaj. O tem sklepamo le posredno in če je to naše edino »orodje«, ki vodi naše presoje in interpretacije, se lahko znajdemo z napačno predstavo o tem, kako delujejo zavestni kognitivni procesi (trditev o tem, da npr. o »nalogah« velikokrat ne preudarjamo zavestno, že vključuje razlago, ki je na ravni izkustva in ne npr. na ravni vedenja). Na vprašanje, kako udeleženci razmišljajo o podobnih nalogah, bi lahko bolje odgovorili s preučevanjem izkustvene dinamike razmišljanja udeležencev, ki bi ga potem lahko primerjali s tretjeosebnimi podatki.

6 ZAKLJUČEK

Čeprav ostaja v kontekstu raziskovanja izkustva veliko odprtih vprašanj, menim, da je nujno, da sistematično raziskovanje izkustva postane sprejet del raziskovanja duševnosti v kognitivni znanosti. Če izkustva ne bomo poskusili raziskati bolj sistematično, »se bo uganka o položaju, ki ga zavest zaseda v znanosti in svetu, vedno znova vračala in bo bodisi pojasnjena le navidezno bodisi bo v luči tega, kar vemo, proglašena za prezahtevno.« (Varela, 2013, pogl. IV)

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[6] Eno izmed vprašanj se glasi: »Kij in žogica staneta 1,10 dolarjev. Kij stane 1 dolar več kot žogica. Koliko centov stane žogica?« (Frederick, 2005, 26).

Novel Framework for Investigating Learning-Preferences and Personality Traits: The Augmented VAS[k]

Vladan Sutanovac
University of Vienna
|MEi:CogSci|
Vienna, Austria
vladan.sh@gmail.com

ABSTRACT

Primary goal of the following paper is to provide an in depth overview of the research, and its empirical implications, concerning the functionality, significance, role, and implications of the augmented VAS[k] model in facilitation and furtherance of the general understanding of higher-level cognitive faculties* and individual-specific microcosm. This includes the revision of parent and related concepts and models - more contemporary and attested adaptations included, for the purpose of broadening and further advancing the aforementioned insights and conceptual constructs, as well as for laying foundations for a novel multi-dimensional model.

*In the context of VAS[k], the term (higher-level) cognitive faculties is an umbrella term encompassing cognition per se, communicative and learning preferences

1 INTRODUCTION

Upon a more closer introspection of one's inner self each I[1] becomes aware that it/he/she is endowed with a microcosm of innumerable subtleties. A microcosm which is the embodiment of the I's genuine specificity and, in its own right, I's uniqueness. What such an introspection also gives rise to is the notion of constituency (belonging) – symbolising I's adjunction to the living entity (i.e. world) whose macrocosm I inhabits and, by partaking in it, contributes to its universal wholeness. In order to be able to address all the grandeur of such an omnipresent entity and establish a unifying bond with it, as well as establish a meaningful relationships with other I's, I needs, concurrently, a communicative tool which offers copious modes of expression, i.e. a *Lingua*. Equipped with such a tool, what is made available is a broad spectrum of means/components to articulate and successfully convey to other I's emotions, thoughts, feelings and all that resides in their deepest unconsciousness. Furthermore, unique inherent Nature is that which gives birth and permeates each and every Individual, making it one of a kind. Hence, it could be hypothesised/put forth that, in terms of communicative preferences, there exist many different types of people, who prefer one MC [mode of communication]/SCP [system of communicative preferences] to another. Remaining on the same theoretical plane, it can be further hypothesised that individual MCs/SCPs are, in fact, also the mirror image of different inherent individual-specific microcosms (i.e. personalities). Consequently, such distinct inherent microcosms and different personal communicative preferences contain the potential to cause a veritable mental whirlwind, threatening to hinder the birth of a motive-guided thought and disrupt its growth into a full-fledged comprehensible entity - successful communication.

Bearing the aforesaid in mind, the goal of the augmented VAS[k] model is to provide a sturdy basis for a more comprehensive and profounder understanding of the fundamental nature of our own SCP and those of the people we come in touch with on a daily basis, as well as the complex inherent individual microcosms, and serve as a potential key-means/component in our attempt to transcend the ever present void of conflicts and misunderstandings.

2 BACKGROUND

Many scholars and scientific researchers today, whose field of interest to a certain extent overlaps with the research microcosm focused on cognitive multisensoriness (multiple intelligence in particular), individual learning styles and communicative preferences, would without a doubt argue that this is too brief a time span for a field to become widely accepted by the scientific community, let alone be regarded a valid research microcosm in terms of prolificacy. However, time span of a research paradigm need not and should not exclusively be the sole measure of its validity. Instead another dimension should also be taken into consideration, i.e. the qualia it brings forth by constantly revising the paradigm foundations within which it develops and by arriving at novel conclusions and theoretical constructs.

In this sense, the recent years have seen the rise in the number of empirical research performed not only in the area of multiple intelligence and linguistic education (Kolb 1976, 1984; Titone 1983; Dunn, Dunn & Price 1989; Flemming and Mills 1992, 2001; Torresan 2010), but also

[1] The conceptual term I/I's is used here to replace the conventional term individual(s) - embodies the *exclusive* and communicatively egocentric individual ***Geist***, prior to reaching the *Individual* phase

in areas quite closely related to the aforementioned one, (educational) psychology primarily (Gardner 1983, 2000; Jackson 2002; Sternberg 2003). Such theoretical constructs and models as Jackson's and Sternberg's, which take its substance from psychology and merge it with the discoveries made in the domain of linguistic education, represent a crucial step toward the advancement of the available unidimensional[2] models. Furthermore, by introducing a second dimension, i.e. by accounting for the specific personality traits, an improved multidimensional model such as the multisensory augmented VAS[k] can offer a much profounder analysis of an individual (learner) and significantly more complete image of the microcosm each cognitive preference represents. Yet, this cannot be successfully achieved unless a sturdy connection between these two crucial dimensions is established. In this sense, not only the theoretical constructs and models from the field of linguistic education play a vital role but, equally, those regarded as the corner stones of a broad field of psychology (Cattell, 1957, 1993; Tupes & Christal, 1961/1992; Norman, 1963; Digman & Takemoto-Chock, 1981; Costa & McCrae, 1992) as well.

By merging the two highly enticing and insightful microcosms – cognitive and psychological, a novel research plane comes into existence, forming a prolific niche for further exploration of the multisensory nature of our cognitive faculties and individual-specific microcosm - the key components for the formation of a unique complete macrocosm, i.e. a full-fledged living entity, the *Individual*.

Being in possession of such profound knowledge is crucial, for it advances the theoretical foundation and increases the empirical strength and validity of a model.

With such a conceptual dimension etched in the very foundation, fortified with the empirical basis (see Chapter 3), the augmented VAS[k] model seeks to provide a novel perspective, and establish itself as an indispensable tool for further research into the cognitive and psychological nature of an Individual.

2.2. How we communicate determines who we are

In the light of what has been said so far, it may be deduced that our communicative preferences mold not only our individuality, but also our psychological/mental configuration. Following this trajectory, it can be argued that all I's can, on an initial level, be placed in three basic individuality-realms, pertaining to the three basic types of MC/SCP, that being Auds (f. Audio), Visios (f. Visual) and Symps (f. Kinesthetic).

[2] The concept refers to singularity of the models in terms of the number of phenomena they account for – *learning preference* only

2.2.1. Auds

The basic characteristic of people belonging to this group is that their frame of reference spans the plane of what they hear and think. As far as input processing and output production are concerned, it can be said that they resemble computers in being more data-centered. This further implies that their emotional side is not at the forefront, making their most prominent trait the dependency upon facts and figures rather than emotions when it comes to decision making. The linguistic features that determine them include the use of audio and thought-based terms, such as: "Hear me out…, I think you should…, sounds good to me, It does ring a bell…, I am paying attention to what you are saying" etc. What they prefer are the exact terms, without embellishments, since their area of expertise is that of pure facts. Once given the facts they are likely to arrive at their own conclusions, without relying on others. Among the things they are interested in the most are primarily studies scientific in nature (mathematics, physics, computing etc.). As children they are keen on solving logical problems and puzzles, calculating and measuring activities. Furthermore their love of the technical extends to other spheres as well – they savor paintings, photos, music, and books that are technical in nature. Consequently this also affects and determines the emotional side of their personality: any display of emotions comes as something rather difficult and awkward. Thus they feel discomfort when touched without permission or invitation. When an audio tells you something, he/she expects you to accept it as valid until told otherwise..

2.2.2. Visios

Completely opposite to the previously discussed group, visuals are individuals whose frame of reference is based on what they perceive visually (i.e. what they see). In order to be able to fully comprehend notions, they first need to "paint a picture" of it in their minds. It is essential for them to be familiar with all the details, down to the minute ones, so they can set the entire stage. When it comes to describing things, they opt for word images. As a result of this preference, phrases commonly used by visuals include: "I can just picture it…, I see the point…, that looks good to me…, I am all ears…, I have my eye on you…" etc. Even when engaging in other activities, such as listening to music or reading a book, they actually see pictures of it in their minds – the words "the forest" will invoke pictures of a landscape teeming with tall trees, wild life, and the birds' singing. When it comes to emotions, visuals express them using word images as well – "I am so angry I feel like a volcano about to explode …, I am so sad I feel like crying a river…, I am so happy I could jump over the moon". They need to be shown emotions by both deeds and words, and on a daily basis; anything that is not seen does not exist. Visuals, in short, need to see it both literally and with their mental eye in order to believe it.

2.2.3. Symps[kinesthets]

The final group of people consists of individuals whose principal frame of reference is emotions-determined, i.e. people who rely completely on how something makes them feel. In stereotypical terms, they are described as sensitive, "touchy-feely" individuals. From a linguistic point of view, their primary choice are words directly illustrating feelings: "I am happy…, I am furious…, I am miserable…, This is beautiful…, It is neat". Their favorite activities include group activities (role-playing and the like). The emotional side of their lives is extremely emphasized, enabling them to not only sense other people's feelings more acutely than individuals belonging to the other two realms/groups, but also empathize with them. From a more practical, i.e. everyday life point of view, the differences between the afore-mentioned groups can be illustrated by the following example:

In the exemplary situation of purchasing a book – An Aud wants to know how old it is, how many pages does the book have, rating and all other related facts. A Visio wants to see the book inside and out, book font, all the illustrations etc. A Symp for e.g. wants to take it in his/her hands to see how it feels.

3 RESEARCH DESIGN

In terms of content, the overview is going to include a succinct description of the method.

Phase: Task > Attitudinal close-ended questionnaire

Aim: by analysing the given answers, reveal which of the three groups – auds, visios, symps , the study participants belong to

1. Phase: Task > Description of a social situation referring to a script (*E. Lojek, 1998: xx):

- giving directions to a person/tourist unable to find his/her way in an unfamiliar town

Aim: acquire additional empirical data to support the questionnaire results. By choosing a certain set of information, provided in the script, when completing the situation related task, study participants reveal their cognitive/communicative preferences

2. Phase — VAS[k] types personality profiling via personality models: Big Five Personality Model/Test

Aim: determine specific personality traits of each VAS[k] type

4 EMPIRICAL VALIDATION AND RESULTS

Initial research study was envisaged as a qualitative study - included 10 participants. The primary reason for this was the intention to get as profounder insights as possible and obtain subtler results through direct contact with the study participants which would be much more difficult, perhaps even impossible, if the number had been greater. Advantage of such an approach is that the examiner is given an opportunity not only to observe the participant through his/her linguistic behavior and comments, but also observe his extra linguistic behavior which is also highly insightful, especially in terms of specific behavioral patterns and readily observable personality traits.

What have the initial two research phases revealed is that, even at this level (lesser participants), it is possible to 'extract' all three multisensory variables. Pursuant to this, it may be argued that this provides evidence for the existence of multisensoriness of the higher-level cognitive faculties, making it a significant component of the cognitive makeup of each individual.

On the other hand, what the results also revealed is that it is rarely the case an individual is, in fact, highly mono-sensory (3 participants only). However, after the completion of the second task, what was the case is that the sensory preference most prevalent[3] among the three did determine the chosen mode of communication, i.e. the manner in which the message (instructions) was conveyed, in the majority of cases. Although the number of participants is, perhaps, not ideal for making straightforward assertions and conclusions at this stage of research, this is certainly an essential aspect worth investigating further and on a large-scale participant population.

5 CONCLUSION

The aim of this paper was, first and foremost, to thoroughly investigate theoretical hypotheses and constructs concerning the higher-level cognitive faculties (multiple intelligence, in particular), and their empirical application in the form of various types of VAK models. By gaining valuable theoretical and empirical insights (through experimentation) what was made possible was the setting of important foundations for conceptual redefining and advancement of the VAK model in terms of dimensional augmentation. What the results of the research revealed is the existence of specific multisensory cognitive patterns and individual-specific psychological traits. They, to a significant degree, affect the way in which an individual thinks, perceives reality it is a part of and communicates its experience of this very same reality to others, as well as the choice of natural language specific for an individual.

On the other hand, what the research also revealed is that a crude and exclusive categorisation might not be an ideal

[3] Specific (sensory) preference was considered *prevalent* if its value was P =*p(x)*> p2^p3

approach to take. One of the reasons for this is the extremely low number of mono-sensory participants. The other, the fact that even those participants were not completely mono-sensory, but exhibited sensory preferences belonging to the remaining two categories as well. Still, this should by no means be regarded as an unavoidable obstacle but, quite the contrary, motivate further exploration of the dimensionality of VAS[k] types for the purpose of improving the model and increasing its empirical validity.

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DELICATE FOOD-WAVES: A PHENOMENOLOGICAL APPROACH TO FOOD-RELATED EXPERIENCES

Fransisca Hok-Eng Tan
University of Vienna, Austria
Universitaetsstrasse 7 A-1010 Wien, Austria
e-mail: fransisca.hok-eng.tan@univie.ac.at

ABSTRACT

Facing our ways of consumption it suggests itself that we are far ahead the basic rationale of food being solely for purposes of nourishing and fuelling the body. Nevertheless, it seems that in science it is presented only few and far between that there is more to it than nutrition. Accordingly, instead of looking through a micronutrient lens of explaining mechanisms, an experiential approach towards understanding food-related experiences shall illuminate the process rather than only the content of lived experience. This paper introduces an idiographic (within-person) mapping of food-related experiences and explores a potential framework for experiential data analysis and visualization heading towards a nomothetic direction. Envisioning this, though being still a long way off, shall highlight the promising approach of using methods of phenomenology to extend the current construction and account of food in research.

1 ON BEING DELICATE

Food Matters. It is "for nourishing, for fuelling the body, for building bones, teeth and muscle" (Lupton, 1996), but there is more to it than just nutrition. It is common to find concepts such as *food cravings* related to issues of obesity, depression, addiction or compulsion (Pelchat, 2002). Exemplary assessments include arbitrary rating scales, speed of consumption, physiological arousal or saliva secretion (McVay et al, 2012; Svaldi et al, 2010; Weingarten 1990). But on second thought this will evoke curiosity on how we actually define and operationalize hypothetical constructs that are hardly directly measurable. Being *delicate* is not just meant as denoting enjoyable food, likewise it hints at the sensitive subject matter of experience. Our thoughts, feelings, sensations and perceptions are tender to confabulations. Thus, illuminating the gap between lived experiences and what we usually label »thoughts«, and the construction of food and contemporary integration in science will be challenging but of vital relevance for the exploration of strategies for experiential data analysis and visualization.

2 STATE OF THE ART RESEARCH

Current research seems to set a focus on obesity as dominant public health issue and disorders such as binge eating (which was added in 2013 to the Diagnostic and Statistical Manual of Mental Disorders V). This resonates a rather negative connotation of matters of food. These investigated phenomena tend to use a mechanical approach to the human body (Guthman, 2012), i.e. by presuming the relevance of the energy balance model and thus focusing on caloric intake relative to expenditure, genetic predispositions (Gard & Wright, 2005) and such. Reviewing literature on phenomenological approaches to food-related experiences left me with a disturbingly mingled feeling of being in two minds. On the one hand there is a low tide of studies that problematize experiential advances and on the other a overwhelming flood tide of findings with a clear health impact, coined by buzzwords such as obesity epidemic and a weight loss culture (Glenn, 2013; Bidgood & Buckroyd, 2005 or Green, Larkin & Sullivan, 2009). Phenomenological approaches are applied to very delimited phenomena such as concrete symptoms in eating disorders (Thomas et al, 2011) and thus implement a strong connection to predefined indicator variables and underlying assumptions. Consequently a predominant mindset of something being of erroneous character crystallizes. Therefore the proposal of this paper, to use methods of phenomenology for investigating the structures of subjective experiences and consciousness, is of foremost importance. It is about revealing underlying constructs, rather than reproducing common conceptions available in the realms involving food and health in the multifarious disciplines in science.

3 A PHENOMENOLOGICAL APPROACH

This research is constructing against the grain and delimiting itself from prior hypothesis. Instead of spotting gaps in existent theories it intends to problematize the account of food in science. This problematization as advocated by Freire (1970) sets the general methodological proposal of posing questions to challenge assumptions and deconstruct the phenomena. The specific method implemented was drawn from the Descriptive Experience Sampling (DES) by Russel Hurlburt (2006), a method for investigating random samples of inner experience in participants' natural environments. All co-researchers were trained to give their reports according to DES, thus getting familiar with the strengths of this phenomenological application prior to the actual data acquisition. One vital modification was necessary to allow the directed sampling of food-related experiences in the following. Thus, co-researchers were instructed to

document the onset of an experience involving food. This focus means a subject-driven selection and is connected to their awareness of this experience. To delimit from confabulation and artificial elaboration the focus on the onset was of high importance as well as the explicit avoidance of using biased concepts such as »food-cravings« by the researcher prior and during the period of data acquisition. Conclusively, this research included in-depth interviews with a set of 5 individuals without any diagnosed disorders related to food (due to the assumed proneness of patients with food-related disorders to report on their problematic relation to food). Each co-researcher was asked to document his/her food-related thoughts over a period of 24 hours. These samples were then discussed during in-depth interviews of max. 90 minutes (due to concentration and accuracy of reporting) and this overall procedure was repeated three times for every co-researcher. The explicatory interviews were transcribed and analyzed using open coding in grounded theory and the abstracted codes and categories visualized for each co-researcher. These structured illustrations serve as *idiographic* (Allport, 1937) map depicting food-related concepts significant to a co-researchers experience with the potential impact to render great value for individuals (i.e. with a problematic relation to food). Only in further course a higher purpose of developing strategies to analyze this phenomenal data is challenged, thus holding out to a nomothetic view. An early attempt to do so is proposed by the framework *food-waves,* which explores a first approach for analysis, structuring and visualization of phenomenal data. Evidently the two discrete products are complementary for gaining vital but different types of understandings.

4 IDIOGRAPHIC MAPPING OF FOOD-RELATED EXPERIENCES

We perceive the world around us as real, solid, tangible; we see, hear, smell, taste and touch things out there. But how close is the image of the world that we experience and create in our minds to the actual momentary descriptions that we give? And to what degree is it a perceived or embodied one, a product of cognition and emotion? Examples for discussing *how* we experience are modalities such as inner speech (McCarthy, 2011), mental imagery (Thompson, 2007) or concrete process categories such as colors or items visually popping out and drawing attention. Yet, people are rarely capable to state with certainty how they experience their daily life. Thus, the experiential data collected in in-depth interviews for this research allowed a first attempt to draw visual maps of aspects decisive for food-related experiences by deriving experiential concepts, categories and modalities formative to the several cases. The following selection of findings will illustrate a range of associated characteristics and modalities, offering a very reduced illustration of the structure and texture of reported incidents. (A full overview of the categories and according idiographic visual maps would unfortunately exceed the scope of this paper.) Starting from experiential reports a case-specific analysis and pattern finding is pursued by grouping codes to core concepts. These were structured into visual maps for reasons of structuring and build the basis for the case-descriptions. Following I will discuss one case in more detail and then append significant divergences to other co-researchers.

In line with the distinctive statement »I constantly think about food« one co-researcher was characterized as the ***Food-Lover*** and volunteered for participation due to her self-attributed mindset that food-related thoughts take up a great deal of daily thoughts and experiences. She reported to be indecisive about her relation to food, sometimes thinking it to be "unhealthy" as well as considering the evaluation by close persons that advance the opinion that she is thinking too much about food. The discussed samples showed that 54% of food related experiences were initiated by *external input* and were either of visual nature, an olfactory trigger or actual food intake involved at the onset. Food-related experiences arising in thought and without any external aspect reported to be of importance, occurred in 46% of the samples. The concept of *check & decide* involved several types of modalities in 30% of the samples and was either of *bodily* or *emotional* nature but always experienced in correspondence to mental images. Her reports on *missing* showed to be an *emotional desire* or *want* that were mostly abstract as drawn from the reports occurring in 39% of the samples. Whereas a *wish* occurred in 30% of the samples, described as the co-researchers strong feeling of *wanting* something and was mostly located in the chest area. A *cognitive* notion to *push away* was the controlled disruption of negative food-related thoughts by engaging in active *cognitive* distraction from an *emotional* feeling. Reported Modalities included *informed knowing* (77%), *unsymbolized thinking* (31%), *emotions* (100%), *mental imagery of concrete locations or situations* (100%), *mouth sensations* (77%) or *memories* (77%). Overall the active engagement in *mental imagery* is interpreted as a vital act of creating extensive thought processes that are distinct for the participant's way of experiencing daily life. Food related experiences seem to be consciously lived and showed a positive connotation and detailed elaboration, but with a critical integration and with a shift to a negative connotation due to cognitive reflection. This idiographic mapping gives a picture of probable modalities characteristic to this individual. Consequently, by highlighting the differences and similarities to other co-researchers I hope to bring about a broader topology of food related experiences.

Thus, comparing to ***the Neutral*** (with the mindset »food is food«) a strong *bodily* impact was discovered. Percepts such as *taste* and *mouth feeling* were manifest in all reported samples, and included concrete *awareness* of aspects such as *chewing, texture, tongue, teeth, palatine or throat*. She evidently showed a *bodily* consciousness regarding food-related experiences, opposed to a *cognitive* expression that seems to be a competing modality. Distinct to this co-researcher, ***the Anti-Foodie*** showed a majority of *perceptive* categories being of importance to food-related experiences. These were described in concepts of *blankness & awareness* (40%), *browsing & soft-eye* (40%), *visual popping in/out/up* (40%). His samples mostly involved situations of concrete food-related decisions, tasks and routines that are perceived as chore or labor with a rather negative connotation. The

integration seems to be excelled by *cognitive* tasks that need not be disrupted by *emotional* or *bodily* desires.
In contrary to that, ***the Conscious*** (characterized as thinking »There is a value to every food.«) echoes a positive value of food with a clear *emotional* access. The importance of *feelings* exhibited in reports discussing emotional *switches & flashes*, often giving the nudge to alert the co-researcher about the occurrence of a food-related thought. An overall *blend* and high awareness of *self* and *environment* was illustrated during the interviews. A comparison between subject points at the *cognitive* integration being subject-driven in this case, rather than triggered by external percepts as shows to be predominant with the ***Food-Lover***.
The fifth and final co-researcher had a counterintuitive attitude towards food. Although describing to love food in line with the observation to show a very high appreciation of food he reported to rarely think about food. Being labeled as ***the Unconscious*****,** his reports showed the relevance of abstract cognitive concepts such as *hunger* (75%), *time* (50%) and *anticipation (75%)*, whereas typical modalities and process categories were *mental imagery* (58%) with a focus of visualizing, *simulating* (25%) visual and spatial characteristics (of situations) and *knowing* (58%).
Examining this short excerpt of results shows the richness and divergence of the manifold of descriptors that illustrate a co-researchers experience. Seeing that, this unknown realm of possibilities offers a strong indicator for the need of a framework for experiential data analysis.

5 FOOD-WAVES. EXPLORING A FRAMEWORK FOR EXPERIENTIAL DATA ANALYSIS AND VISUALIZATION

So far so good there is promising prospects for the extracted categories. But more than only hinting at the individual significances there is the wish to systematically analyze the phenomenal data to get a glimpse at the big picture. Adopting the idea of waves as denoting an oscillation that travels through space and matter accompanied by energy transfer, I want to introduce the framework *food-waves* that explores food-related experiences as amplification of internal and external perception, cognition & emotion. This shall emphasize that our experience is more than the percepts, the evident aspects of the content, of *what* happens in a situation. Following Hurlburt's argument in his work with patients with disturbances of affect it is a promising prospect to highlight the process of feeling and thinking, in sharp contrast to the most contemporary cognitive theories of psychiatric disorder that rather posit content categories as the cause for a disorder (Hurlburt, 1993).
Thus, instead of being content with the content of experience, and therefore the meaning and interpretation given in the interviews, it is aspired to get a grasp at *how* we sense (external and internal) cues and integrate them bodily, emotionally and cognitive wise. Exploring ways to structure the experiential data for analysis resulted in an early approach of the visualized framework *food-waves* (as depicted in Figure 1). The example shows categories of one particular co-researcher according to three groups that currently proposed to guide the early stages of analysis. The first one is *perception* (as the external percepts and internal bodily cues, mainly visceral sensations), followed by *mood & emotion* (ranging from less specific valences to concrete topics and specific emotions and affect). The final group of characteristics focuses on *cognition*, covering process categories (such as attention, memory, awareness, visual imagery) and content categories (including subjective concepts that are rather unattended in the residual structure). It is subject to further exploration and offers a first stage for deriving a data-driven strategy for experiential data analysis and visualization. Nevertheless, fragments of the proposed framework need further exploration due to the complexity and dimensions clearly exceeding a 2-dimensional account, as well as alignment with present theories. Let alone the aspect of emotions raise a manifold of promising theories to be considered, starting from the selection of a definition for emotion (e.g. Plutchik, 1962), features of emotion (e.g. de Sousa, 2010) or the consideration of more concrete applications, such as contrasting the use of perceptual vs. cognitive mental verbs in recalling of emotional past (O'Kearney, 2006).

The potential classes of constructs (*perception, emotion, cognition*) envision the quest to explore ways to a structured manner of analyzing food-related experiences, guided by, but clearly not limited to the offered framework.
Though suggesting these kinds of quantifiers seem to lead to counterintuitive restrictions, this proposal is still contemplated as allowing individual case-based constructs and thus fostering a data-driven work-in-progress. While considering the categories as basic building blocks in line with the framework we strive for continuous refinement and extension. The higher aspiration for this first framework at hand lies in the systematic analysis of experiential data, approximating a promising access to this data by the asset of visualization. Suppose that the frequency of the *food-wave* could give information on a subjects experienced density of details or modalities and the amplitude offering the intensity or relevance of these peaks, one could easily spot case-based commonalities or identify typicality's and significances in the experiential data.

6 FUTURE OUTLOOK AND OTHER AREAS OF RESEARCH

Assuming that I have been able to act unbiased and predominantly bracket out prior concepts, I hope to have offered a first glimpse on some characteristics of inner experience. Nonetheless, intentions to draw clear conclusions from the data require further extensive research. The anecdotes of content and process categories outlined give critical footage to the understanding of how people experience and conceptualize food. By collecting this phenomenal data we are able to identify significances and patterns of subjective experience and might even direct commonalities between subjects in the future. This could be decisive to our understanding of experiences that shape normal to erroneous integration of food. To achieve this, there is the need for further engagement in both collecting experiential data and finding novel approaches to analyze the data. Vital to mark here is the strong explorative character of this research, with the proposed framework being an early

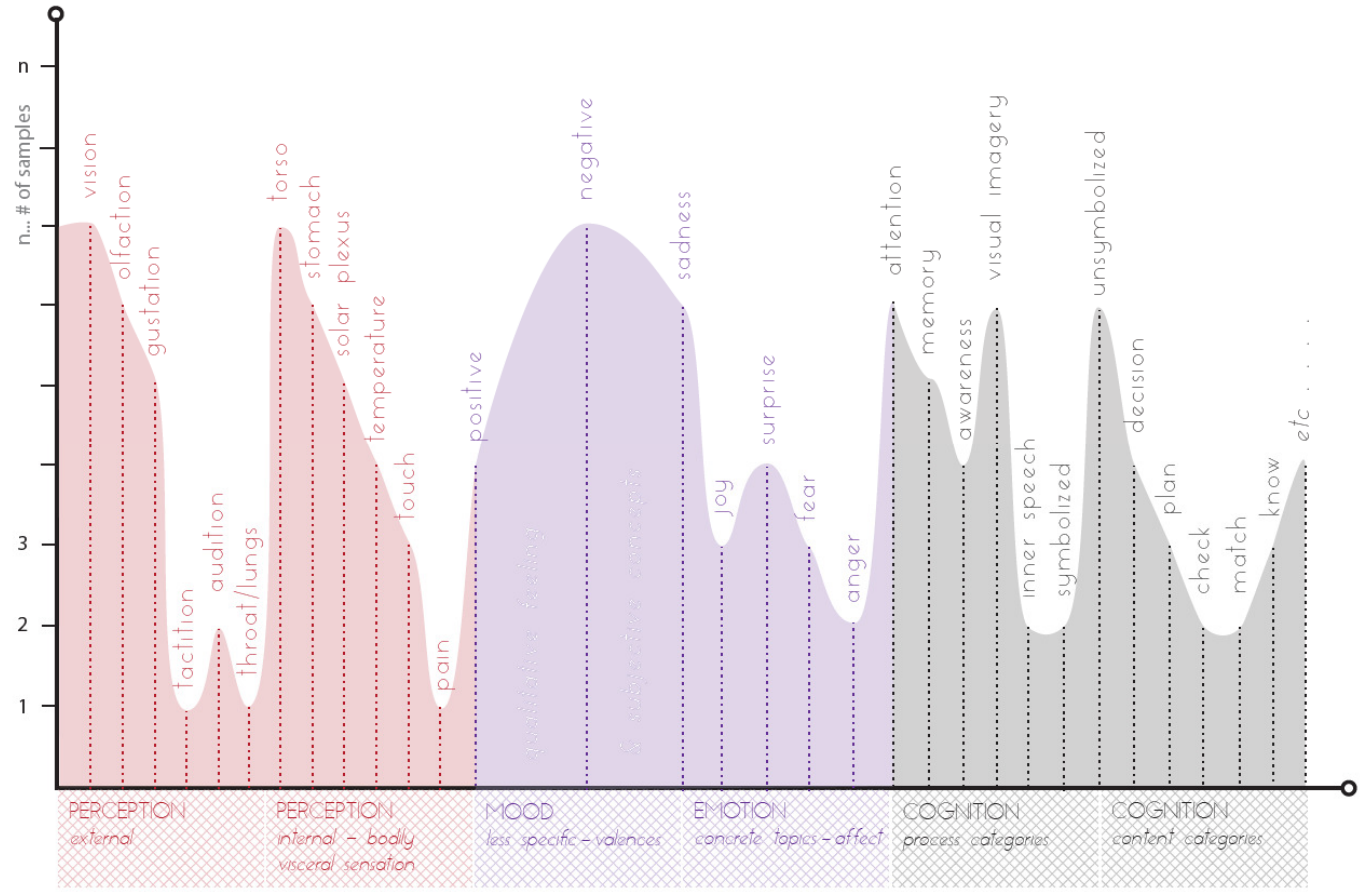


Figure 1: *Food-Waves Example for the Food-Lover.*

attempt to structure and visualize food-related experiences. Facing the need and great potential for interdisciplinary work for this underpinning I see promising collaborations with researchers coming from anthropology, etiology, ecology, gestaltism or aesthetics, to only name a few, and I remain with the uttermost hope for much more research to come.

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KOGNITIVNA ANALIZA RAVNOTEŽNOSTNIH METAFOR V SHAKESPEAROVEM RIHARDU II.

Borut Trpin
Oddelek za filozofijo
Filozofska fakulteta Ljubljana
Aškerčeva cesta 2, 1000 Ljubljana, Slovenija
e-mail: borut.trpin@gmail.com

IZVLEČEK

V prispevku predstavljam svojo kognitivno analizo metafor v Shakespearovi drami *Rihard II*. Najprej predstavim glavne kognitivne teorije metafor, ki jih nato apliciram na interpretacijo drame. Ugotovil sem, da političen uspeh Riharda II. metaforično razumemo preko utelešenega občutka ravnotežja. Shema ravnotežja je prisotna v večini metafor v drami: bodisi posredno prek nasprotij ali pa kar neposredno z omembo ravnotežja. Prav to omogoča svežo interpretacijo drame.

1 KOGNITIVEN PRISTOP K RAZISKOVANJU METAFORE

Za tradicionalne teorije metafore je značilno, da metaforo opredeljujejo kot jezikovni pojav in ne kot stvar misli (Lakoff, 1998: 273). Kognitivna teorija metafore področje metafor bistveno razširi iz književnosti na naše vsakdanje mišljenje. To izkazuje že naslov prelomnega dela na tem področju, leta 1980 izdana knjiga Lakoffa in Johnsona *Metafore, po katerih živimo* [The Metaphors We Live By]. Metafora jima ne pomeni več posamezne metafore, ampak širši sistem razumevanja nekega področja s strukturami drugega. Ugotavljata, da je naš "običajen pojmovni sistem po svoji naravi temeljno metaforičen." (Johnson in Lakoff, [1980] 2003: 3). To pomeni, da se metafore sicer zunanje izražajo v jeziku, vendar ne kot jezikovni okras, marveč kot vrh ledene gore našega pojmovnega sistema. Jezik je le "pomemben vir evidence o tem, kakšen je sistem" (prav tam). Do razumevanja in tvorjenja metafor pride večinoma nezavedno, avtomatično. Podrobno opazovanje jezika, v katerem se metafore najpogosteje javno izražajo, nam pokaže, da so povsem dobesedni stavki razmeroma redki. Ena izmed analiz je npr. pokazala, da govorci na televizijski pogovorni oddaji uporabijo unikatno metaforo na vsakih 25 besed (Bowdle in Gentner, 2005: 193). Metafore so tako pogoste, da se nam zdijo povsem naravne in jih niti ne prepoznamo več kot metafore.

2 KLASIČNA KOGNITIVNA TEORIJA METAFORE

Glavni kognitivni teoriji metafore sta klasična kognitivna teorija metafore (KKTM) in teorija spajanja. Poimenovanje KKTM ni splošno uveljavljeno, ga pa predlagam zaradi neenotnosti v imenovanju te teorije ter zaradi zgodovinske in vsebinske predhodnosti KKTM pred drugimi kognitivnimi teorijami metafore.

Najbolj prepoznaven znak, da nekdo razpravlja o metafori s stališča KKTM so MALE VELIKE ČRKE. To formalno sredstvo omogoča, da ločimo med metaforo in posameznimi metaforičnimi izrazi.

Metafora zaobsega cel sklop izrazov, ki temeljijo na razumevanju ciljnega področja v strukturah izvirnega (oz. tipičen zapis: CILJNO PODROČJE JE IZVORNO PODROČJE). Bistvo kognitivne metafore je torej v tem, da "razumemo in izkusimo eno stvar v načinu delovanja druge" (Johnson in Lakoff, [1980] 2003: 5). Metafore delujejo sistematično kot "preslikave (v matematičnem smislu) s področja vira [...] na področje cilja" (Lakoff, 1998: 276).

Podrobneje se je osnovanju pomena (posledično tudi metafor) v telesnih izkušnjah posvetil Johnson, ki uvaja termin shema podobe [image schema]. Gre za "dinamičen vzorec, ki deluje kot nekakšna abstraktna struktura podobe in tako poveže velik razpon različnih izkušenj, ki izkazujejo isto ponavljajočo strukturo" (Johnson, 1987: 2). Sheme podobe obstajajo "v našem razumevanju" (prav tam: 23). Pomembno je, da ločimo sheme podob od konkretnih podob, saj sheme naše mentalne podobe šele organizirajo na bolj splošni ravni.

Sheme podob se razvijejo kot nekakšen predkonceptualni aparat že pri dojenčkih preko telesnih izkustev, šele kasneje pa jih uporabimo tudi za dojemanje pojmov (Mandler, cit. po Kimmel, 2009: 160). Eksperimenti so potrdili, da so sheme podob odgovorne za protosintezo abstraktnih pojmov preko prostorskih in senzimotoričnih izkustev (Gibbs, cit. po Kimmel, 2009: 160). Sheme podob so v kognitivni literarni vedi doživele dober sprejem, saj se uporabljajo za razlago poezije, razlago osredinjenja naracije okrog posamezne teme v dramah in romanih, predvsem pa za razlago metafor.

3 TEORIJA KONCEPTUALNEGA SPAJANJA

Teorija konceptualnega spajanja [blending theory] je prvotno nastala kot del razlage procesov razumevanja in tvorjenja pomena. Teorijo sta začela razvijati Giles Fauconnier in Mark Turner v zgodnjih devetdesetih letih. Za izhodišče sta vzela predhodno teorijo mentalnih prostorov (kot idealiziranih kognitivnih modelov, ki delujejo pri razumevanju manjših delov informacij), ki jo je v osemdesetih razvil Fauconnier. Izpopolnjeno teorijo sta Fauconnier in Turner nato predstavila v delu *Način, kako razmišljamo* [The Way We Think], ki velja za najvplivnejšo formulacijo njune teorije.

Spajanje je večinoma nezaveden proces, čeprav deluje v vseh vidikih človeškega življenja (Fauconnier in Turner, 2002: 18). Poleg vpliva na teorijo metafor je pomembno tudi za razlago (rezultatov) ustvarjalnosti. Teorija sicer ne služi kot popolna razlaga ustvarjalnosti, saj ni deterministična in ne more opisati, kakšni spoji sledijo iz določenih vhodnih prostorov. Lahko pa učinkovito razloži, kako so spoji nastali.

Novost teorije glede na KKTM je, da preslikave delujejo večsmerno, tudi nazaj iz spoja v vhodni prostor. Turner poudarja, da že najbolj banalne misli ustvarjajo kompleksna konceptualna omrežja (Hogan, 2003: 112, tudi Fauconnier in Turner, 2002: 54). V literarni vedi se ta teorija pogosto uporablja za razlago metafor. Metafora spoji dva ali več vhodnih prostorov v prostor spoja. Proces je za razliko od KKTM, ki pozna le direktno preslikavo iz področja vira na področje cilja, posreden in večsmeren.

Prednost teorije spajanja je, da vključi tudi določene vidike, ki jim KKTM običajno pripisuje manjši pomen. Tak primer so čustva in njihov vpliv na to, katere povezave se v spoju ustvarijo (Turner, 1996: 79-80).

4 INTERPRETACIJA RIHARDA II. S KOGNITIVNO TEORIJO METAFORE

V interpretaciji Shakespearove drame *Rihard II.* sem se osredotočil na kognitivno analizo metafor. Moje izhodišče je bilo, da se preko celotnega dela na bistvenih mestih razvija (mega)metafora POLITIČEN USPEH JE RAVNOTEŽJE. Političen uspeh (ciljno področje) tako razumemo preko telesnega občutja ravnotežja (izvirno področje).

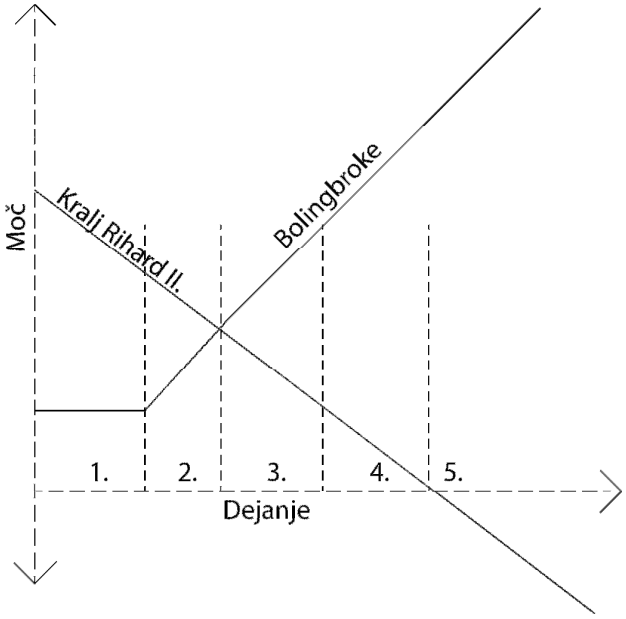
4.1 Ravnovesje moči na ravni dejanj

Shemo ravnotežja političnega uspeha zaznamo tako na ravni metafor kot na ravni vsebine (padec Riharda in vzpon Bolingbroka). Rihard II. v prvem dejanju nastopa kot močan kralj, ki vlada razmeroma odločno. V drugem dejanju že začne izgubljati podpornike, Bolingbroke pa začne svoj uporni pohod. Ravnovesje je sicer še približno enakomerno nagnjeno tako v korist Riharda kot Bolingbroka.

V tretjem dejanju je kralj dokončno in nezaustavljivo premagan. Vrne se v Anglijo, vendar izgubi še zadnje podpornike. Ko se sooči z upornim bratrancem, ga iz strahu podpre v vseh zahtevah, samoiniciativno pa ponudi še svojo odstavitev. Tehtnica se tako popolnoma nagne v Bolingbrokovo korist.

V četrtem dejanju Rihardova moč pade še nižje, saj je dokončno odstavljen, Bolingbroke pa zanj odredi zapor. Prizor odstavitve kralja je bil v času nastanka zaradi svoje subverzivnosti cenzuriran. Bolingbroke s tem postane novi kralj Henrik IV., ravnovesje pa je ravno obratno od začetnega.

Čeprav je v začetku petega dejanja Rihard že brez moči, na koncu izgubi še svoje življenje. V zaporu ga skušajo zastrupiti. V samoobrambi sicer ubije slugo in še enega izmed morilcev, vendar na koncu umre. Ravnovesje, ki je bilo v četrtem dejanju obratno začetnemu, tako v petem dejanju Riharda II. dokončno izbriše in za edinega vladarja postavi kralja Henrika IV. Njegova zgodba se nato nadaljuje v Shakespearovih dramah Henrik IV. - prvi in drugi del ter Henrik V.



Shema 1: *Ravnovesje politične moči v Rihardu II.*

4.2 Megametafora

Metafore (tudi metonimije in primere), ki se pojavljajo v *Rihardu II*., so si strukturno zelo sorodne. V izredno veliki meri gradijo na dvojnosti nasprotnih elementov. Prav to je ključno za shemo podobe dvostranskega ravnotežja (po principu gugalnice). Tako so prisotne različne metafore, ki gradijo na razliki med nebesi in zemljo, dvigom in padcem, vročim in mrzlim, zasebnim in političnim, nizkim in visokim družbenim slojem, polnim in praznim, sladkim in grenkim itd. Strukturna sorodnost metafor omogoča, da posamezne metafore razumemo kot gradnike megametafore POLITIČEN USPEH JE RAVNOTEŽJE. Omenjene metafore (pa tudi drugi tropi, ki gradijo na nasprotjih) se na shemo podobe ravnotežja navezujejo posredno, nekaj metafor pa tudi neposredno. To je ključno za razumevanje dejstva, da

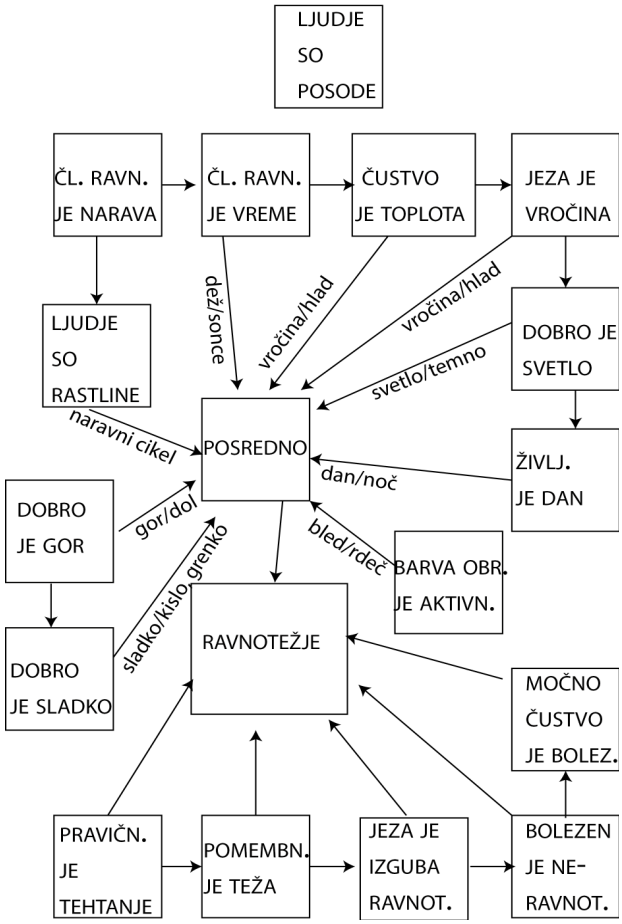
nam je *Rihard II.* kljub poetičnemu jeziku takoj razumljiv kot drama ravnotežja oblasti.

4.3 Razvoj megametafore v prvem dejanju

Za predstavo, kako se megametafora POLITIČEN USPEH JE RAVNOTEŽJE razvija preko celotne drame, natančneje poglejmo prvo dejanje. V svoji analizi sem v prvem dejanju odkril petnajst pomembnejših metafor. Metafore sem razvsrtil v dve skupini:
1. metafore, ki so na ravnotežje vezane posredno preko nasprotij (zgornja polovica v Shemi 2),
2. metafore, ki neposredno omenjajo ravnotežje (spodnja polovica Sheme 2).
Izmed petnajstih metafor samo dve nista niti posredno vezani na shemo ravnotežja. To kaže, da je princip ravnotežja v ozadju res izrazito prisoten.
Primer metafore, ki se na ravnotežje veže le posredno, a je v drami izredno pogosta, je JEZA JE VROČINA oz. splošnejše ČUSTVO JE TOPLOTA. Mowbray, ki v svojem zagovoru pred kraljem ni tako vročekrven kot njegov nasprotnik Bolingbroke, reče: "Ne mislite, da mi je srce hladno,/ ker bom hladan v besedah." (Shakespeare, 1971: 104) in nekaj vrstic kasneje: "The blood is hot that must be cool'd for this" (Shakespeare, 1988: 1040) [dob.: Kri je vroča in se mora ohladiti]. Kognitivno razumevanje metafor nam omogoča, da se ne osredotočamo samo na posamezne metaforične izraze. To je v primeru Shakespeara še posebej pomembno. Avtor namreč besede, s katerimi izgrajuje ključne metafore (in ključna mesta za razvoj pripovedi) pogosto "obdeluje" tudi kasneje - jih sprevrača, postavlja v posebne kontekste, izvaja besedne igre (lahko tudi med več osebami). Hlad, ki ga Mowbray npr. omenja na začetku svoje dvajset-vrstične replike, nato proti koncu ponovno uporabi v grožnji, da bo svojega nasprotnika ubil, "pa če bi moral peš tja na ledene rebri samih Alp" (Shakespeare, 1971: 105). Prav ravnotežje med vročim in hladnim se kasneje izkaže za zelo pomembno in se večkrat ponovi v različnih kombinacijah, večinoma kot presoja upravičenosti ravnanj in čustvene vpletenosti.
Poglejmo še metaforo PRAVICA JE TEHTANJE, ki je preko tehtanja oz. majanja neposredno povezana z ravnotežjem. Metafora je zanimiva tudi zato, ker je v naši kulturi še vedno zelo razširjena (npr. podoba Pravičnosti, ki tehta z zavezanimi očmi). Rihard metaforo izrazi v izjavi, da v svoji sodbi ne bo pristranski: "[N]obena, še tak ozka krvna zveza / z mojim kraljevskim rodom ne omaje / moje pravičnosti nikomur v prid" (Shakespeare, 1971: 106).
Kljub temu se nobena izmed metafor ne nanaša na politični uspeh, saj je v prvem dejanju Rihardov položaj še popolnoma neogrožen. Metafore v tem dejanju že gradijo na izvornem področju megametafore (RAVNOTEŽJE), ne dosežejo pa še njenega ciljnega področja (POLITIČNI USPEH).

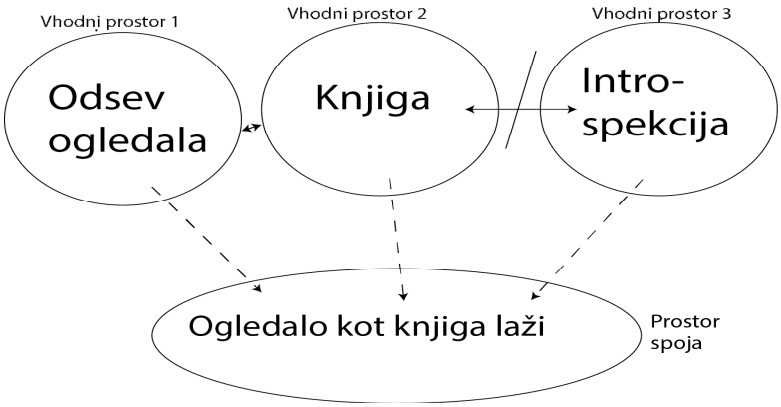
4.4 Teorija spajanja kot interpretativno orodje

Na primeru Rihardove odstavitve v četrtem dejanju poglejmo, kako lahko uporabimo teorijo spajanja za boljše razumevanje metafor in nove interpretativne možnosti. Najbolj pretresljiv del odstavitve je, ko Rihard zahteva



Shema 2: *Družinske podobnosti metafor prvega dejanja Riharda II. in (ne)porednost povezave s shemo ravnotežja.*

ogledalo (metafora OGLEDALO JE ŽIVLJENJEPIS) (Shakespeare, 1971: 169). Ogledalo najprej označi za knjigo ("knjig[a], kjer je vsak moj greh zapisan"). V ogledalu nato prepozna isti obraz, kot ga je imel za časa vladanja ("Nič globljih gub? /…/ Steklo, hinavsko […]"), zato ogledalo v afektu razbije.
Rihard ob tem ustvari poseben spoj. Vhodni prostor 1 je prostor knjige (življenjepisa), vhodni prostor 2 ogledalo in njegov odsev, vhodni prostor 3 pa introspekcijsko dojemanje samega sebe. V spoju Rihard razume ogledalo kot knjigo laži. Odsev ogledala, ki ga bere kot knjigo o svojem življenju, je namreč v protislovju z njegovim dojemanjem samega sebe. S tem metaforično pokaže, da je zanj njegov notranji svet pomembnejši od politične realnosti. To je nakazal že ob samem odstopu krone: "[L]ahko mi vzameš moč, sijaj, okras,/ bridkosti ne: njen kralj ostanem jaz" (prav tam).
Ogledalo torej preko podobe knjige metaforično kaže na kontrast med notranjostjo in zunanjostjo (glej: Shema 3).



Shema 3: *Metafora ogledala kot knjige laži s stališča teorije spajanja.*

9 ZAKLJUČEK

Na nekaj ilustrativnih primerih smo pokazali, kako nam kognitivna teorija metafor omogoča svež pristop k interpretaciji *Riharda II.* Megametafora se sicer najbolj izrazito pojavlja v tretjem in četrtem dejanju, v katerih uporni Bolingbroke premaga kralja Riharda. Obdobje menjave oblasti namreč najizraziteje razkrije ravnotežje, ki je v ozadju vsake vladavine.

Omenimo tudi, da so nasprotja, ki se posredno vežejo na shemo ravnotežja, v večini vzeta iz prostorske orientacije (predvsem gor/dol, tudi blizu/daleč, ne pa levo/desno kot je v uporabi ob današnji politiki), vizualne zaznave (svetlo/temno, dan/noč) in okusa (sladko/kislo). Prisotna so tudi druga nasprotja (npr. taktilna, številčna), vendar pa so prav našteta nasprotja ključna. Da imajo prostorske in vizualne zaznave prednost ni pretirano čudno, saj je obvladovanje prostora ena izmed najpomembnejših človeških zaznav, podobno je z vizualnimi zaznavami. Bolj zanimivo je, da Shakespeare metafore večkrat gradi na okusu kot pa npr. na sluhu, ki običajno velja za drugi najpomembnejši čut.

Shakespeare svoje metafore gradi predvsem na zelo jasnih izvornih področjih, ki s svojo slikovitostjo tudi čustveno obarvajo naše branje in tako dosežejo večji učinek. Trdim, da lahko s tem razložimo, zakaj tako pogosto uporablja metafore, ki gradijo na občutju sladkega oz. kislega. Ko preberemo, da je nekaj sladko oz. kislo, to razumemo prek nezavedne simulacije občutka okusa (prim. Gibbs in Matlock, 2008: 164; tudi Feldman, cit. po Lakoff, 2008: 19), okus sladkega pa sproži ugodje. Ugodje sicer sproži tudi harmonična glasba, vendar ne tako neposredno.

Posebej je potrebno izpostaviti tudi ravnotežje, ki gradi na cikličnosti (leto, dan/noč, rastline), ki je zanimivo predvsem zaradi ireverzibilnosti. Cikličnost temelji na tem, da vedno pride nov obrat, nov krog in nov začetek in kot taka ni tragična. Je pa cikličnost tragična za kralja Riharda, saj pomeni, da njegova oblast ni večna in da se je njegov cikel zaključil.

Kognitivna analiza metafor nam torej omogoča svež pristop k interpretaciji literarnega dela. Presenetljivo je, da se spoznanj kognitivne znanosti v literarni vedi ne uporablja v večji meri, "čeprav gre za eno izmed najbolj zanimivih in potencialno daljnosežnih področij intelektualnega razvoja v dvajsetem stoletju" (Crane in Richardson, 1999: 124).

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ENABLING PSYCHOTHERAPEUTIC SPACES

Klemen Trupej
Mei:CogSci interdisciplinary master programme in Cognitive Science
Faculty of Education, University of Ljubljana
Kardeljeva ploščad 16, SI-1000 Ljubljana
Tel: +386 31 306 305
E-mail: klemen@trupej.si

ABSTRACT

The relationship between healing potential and design in psychotherapeutic spaces has been the focus of many research studies. They determined that patients are responding to different settings in a way that affects the therapeutic process and its outcome.
Beautiful rooms are described as attractive, pretty and comfortable, while in ugly rooms patients were more likely to complain of monotony, fatigue and headache and showed irritability and hostility [1].
Several studies have also shown more specific effects on a patient's well being during therapy. For example, seeing the personal memorabilia of the therapists was shown to lead to better self-disclosure in patients, the display of a large number of credentials was concluded as a positive impact factor on judgments about therapists' qualifications [2], specific lighting, decoration and interior design were also studied and concluded as important elements in psychotherapeutic spaces [1].
The problem with the majority of the studies conducted is that although it is known how specific physical properties affect patients and therapists, we are unsure about the outcomes when different features are combined. Although they were tested (on e.g. beautiful vs. ugly [1], soft vs. hard [2]) it could be different for every patient and therapist, as there are different preferences. To obtain better or completely new results it is important to discover the core processes, which can later be transformed into a physical space as an innovative enabler of new knowledge. In this study, the enabling space paradigm is used, which focuses on the identification of core processes and patterns that define specific environments [3].

1 INTRODUCTION

How physical setting is important in psychotherapy is also suggested by the environmental docility hypothesis, which suggests that the less competent the individual is, the greater the impact of environmental factors on that individual [4]. Consequently, physical space is an important factor, especially when considering patients with high feelings of insecurity and anxiety [5]. In designing a new space, the identification of core processes that define psychotherapy is an obligatory step. Firstly, this is because every element that is not carefully chosen (as can be seen in the next part), can trigger unpleasant emotions or lead to a specific state and possibly slow down the process of the therapy. Secondly, for the identification of an enabler (new physical property), it is essential to know what has to be enabled and in what way. This research is based on qualitative interviews from therapists and patients, where basic qualities and patterns were discovered.

2 METHODS

Qualities and patterns were researched using qualitative interviews. 12 interviews with patients, which were 21:19 minutes long on average and 7 interviews with psychotherapists, which were 44:50 minutes long on average, were conducted. In those interviews patients and psychotherapists were asked about the psychotherapeutic branch they are following, the basic qualities they need and both their relation to physical settings and to the process of psychotherapy. Interviews were based on previously conducted questionnaires, but these were not used rigorously. Thus, participants lead the conversation and more information, which could lead to innovation, was gathered.

3 FINDINGS

3.1 Fundamental quality

Based on observation and quotes from the therapists and patients, trust is proposed as a basic quality (core process) that is needed in psychotherapy and which can later be regarded as a fundamental part of enabling space. It was concluded that patients develop trust if cognitive, emotional and physical spaces provide them with safety, privacy, acceptance and understanding. How trust emerges and is affected by different factors is explained in the following sections.

3.2 Trust from feeling safe and having privacy

Based on quotes from therapists and patients it was noted that patients lose their feeling of safety if they are

distracted. Although some of the therapists argued that any distraction could also be a material to work with, patients confirmed the contrary. When something stood out, this was either related to privacy or space alone; they became distracted, unintentionally or intentionally, to escape from their feelings.

The main distractor was if they felt afraid at one point that somebody was listening to them. The reasons for this were: if they heard somebody walking outside the office or on the balcony, if they were waiting for therapy and in the meantime they met other people, if the windows were opened and others could hear them, etc.

Patients also mentioned other distractors like the therapist's mobile phone ringing, the clock ticking or not working at all, figurines or other elements, that they could become engrossed in, dry flowers, the changed position of things, religious elements, unfinished or poorly finished things in the room, odors and diplomas. Distractors mainly affected their feelings of safety and understanding and thus trust. As one patient said:

> *"It is hard enough to begin, so if you are distracted, you have to begin again. That is just uncomfortable."*

It is rare, but some therapists also left the room during the therapy, or allowed others to come in (if they were working in a clinic). That was reported by two patients. That again affected their feeling of safety, as both patients felt that they were not important to the therapist.

I also experienced the issue of how distractors can affect the feeling of trust when I was invited to a therapeutic session at the Sigmund Freud University in Vienna. During the therapy I was constantly hearing voices from another room, and at one point it became so intense because one person in that room had started to scream. It felt uncomfortable, because we all thought something was wrong. The patient also said that she feels very uncomfortable when she hears something like that.

In the room where I observed the therapeutic process, there were toys scatterered everywhere, children's pictures and tents, many chairs and other places to sit. The room was too big and messy; I felt lost inside and got distracted easily. During the therapy I was observing a patient and I noticed her looking at the pictures and toys numerous times. Although she was talking fluently, she seemed to pay attention to those things. The thing that bothered me the most was that the therapist was taking notes during the therapy. She was constantly writing something, and it seemed very disrespectful to the patient.

To make the patient feel like he/she can trust the therapist, the therapist should consider enhancing their feeling of safety and privacy. This is related to both the therapist and also the physical space. Therapists can convey that they care and bring forth trust by appearing to be genuine, that they respect the client's process and by demonstrating faith and expertise in the therapeutic process [6].

3.3 Trust from feeling accepted and understood

There are different ways to make the patient feel accepted and understood. The most important thing that was recognized from the interviews is to make them feel that they are the only important person in this therapy. Also, it is important for them to be able to trust the person they are talking to. Most of the patients who I interviewed had great experiences with their therapist. However, some of them mentioned that they had met the therapist's family members or that they had therapy at the therapist's home. Although they said this did not bother them, this does not fit with the basic needs they mentioned. Also, there is a problem of transference, which according to one therapist could be morally wrong to patients.

Notably, the feeling of acceptance comes from the therapist's self-disclosure (personal and via memorabilia). What kind of self-disclosure and in what circumstances therapists talk about their personal things is personal choice, as there are very different opinions on this topic [6]. In my research all of the interviewed therapists agreed that their personal issues and things do not have a place in therapy. Also, most patients agreed with this. One of them said:

> *"If I had a male therapist, I am sure transference would occur and I would only pay attention to those personal things and I would ask myself at home about his personality."*

Two of them said they liked the personal things in the office.

> *"I am happy if I see that he has some family life. That shows me that the person is real, and it speeds up things for me... I trust this person faster",*

one of them said. Because personal things can have a great impact on a patient, it is suggested that the therapists remove them from the office. It is also suggested that therapists should consider having their office in a business building rather than at home. This could also enhance the feeling of privacy as patients can "be lost" in a building and become one of the other people.

3.4 Physical space findings

Psychotherapeutic physical space was the topic where I noted the most differences between the opinions of the patients and therapists. Interestingly, the clock was one of the things that almost all of the patients and therapists talked about. Some of them said the clock bothered them and that it just represents another form of pressure or distractor to them, while others said that they need a clock to know when they should stop talking. For therapists, it is important to have a clock, although some patients mentioned that they felt like they were bored when the therapist checked the time. I think this is an interesting topic, which should be researched further (for example, one of the patients suggested that the

clock should be on his left hand side so he can decide whether to look at it).

Most of the patients mentioned that they would like to feel like the therapy is taking place at their home. This would bring them relaxation, acceptance, trust and thus better self-disclosure. Feeling like they are at home means different things to them. This could be that they can have a cup of tea or coffee, that there are flowers there, some things are made from wood and that there are comfortable chairs, pleasant lighting and big windows. As many therapists said, what for one patient represents homeliness, can be a distractor for another. Based on patients' reaction to distractors, I think that many of the elements which represent homeliness to them could just be a way for them to feel accepted.

When asked about position, most of the patients felt comfortable sitting (or lying) and they did not want to change that (sitting provides them with safety), while some of them mentioned that they would like to lie down from time to time or just walk around the room. Gestalts' theory supports the explanation that conflicts can only be resolved when somebody is moving their body while talking. Psychoanalysis is the only branch used by those who I interviewed, where moving is not an option.

On the whole the patients and therapists sit on chairs. There is rarely a sofa for both of them. For both parties it is important for them to feel comfortable and relaxed, as this brings them better self-disclosure. I found it interesting when one therapist said that there should be no difference between a therapist's and a patient's chair or sofa. This is because the patient could then feel different and consequently unsafe. The safety of the patients is also considered by having distance between the patients and therapists. They should have enough personal space, which they own in the therapeutic session.

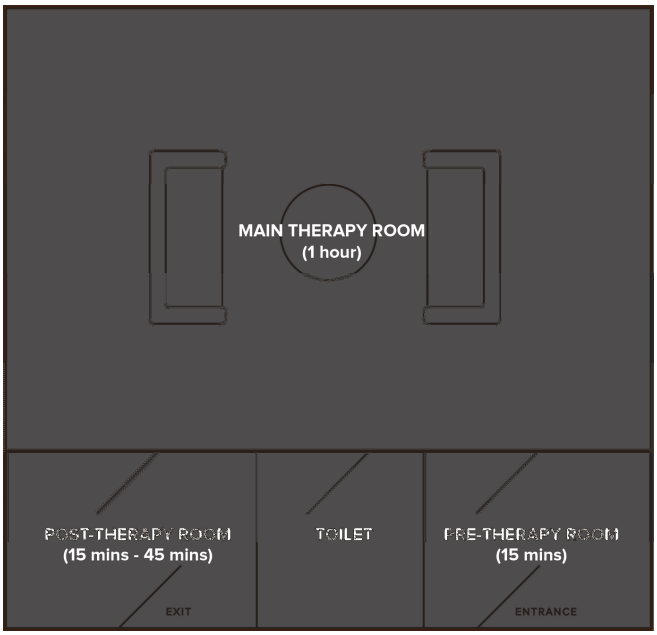
Regarding the therapists' wishes about space, most of them said that they want to feel safe. This has two meanings for them, one is that they are sure that nobody will enter the room, and the other is that they know that there is somebody who can help if a patient becomes too aggressive. When asked about their private space in the office, they said that they do not need a separate space, as for most of them a table and computer is sufficient. Some patients said that this space should be separated, but most of them were happy with the current state.

4 FINDINGS CONVERTED TO PHYSICAL SPACE

Based on the findings, the design of the psychotherapeutic space is proposed to contain four rooms (Figure 1). When patients come to therapy, they first enter the pre-therapy room where they can relax and prepare for the therapy. This room acts as an enabler in a way that patients have time to think about what they will be talking about and time to shift their attention to the therapy (as they mostly come directly from work or their studies).

After the pre-therapy room they enter the main therapy room. To ensure the patient is not distracted during the therapy, it is suggested that the room should be as clear as possible (a "blank canvas", as one therapist mentioned).

Figure 1: *Plan for proposed division of space and duration of usage.*



This means no unnecessary elements that they could become engrossed in (from statues, flowers to paintings). Instead of achieving warmth with these elements, the Japanese concept of wabi-sabi could be considered. It was found that objects and environments that embody natural elements, simplicity, and subtle imperfection achieve a deeper, more meaningful aesthetic [7]. Organic forms and natural materials (like wooden floors or walls) can lead to this effect. If therapists do not find that a very clean room is suitable for them, they can use anthropomorphic objects, as it is known that people have a tendency to favor objects with contours over objects with sharp angles or points, which is known as contour bias [8]. Regarding odors in the room, I propose not to have them, as they can be very powerful cues for the recall of very old and emotional autobiographical memories [9] and can be another distractor.

For the chairs or sofas, I propose not to use very expensive material or anything that looks unusual, as this could elicit the feeling of unsafety in the patients. It is best that the patients and therapists have an equal sitting element, so there is no distinction between them. Sofas should be comfortable and light coloured. To enhance the feeling of safety, there should be some space between the therapist and the patient. A table between them could be an option, and here the therapist should also consider the above-mentioned contour bias. The distance would give the patient and the therapist private space, which would allow both of them to feel safe. In an investigation of seating arrangements and lighting conditions, researchers found that counselor-client interactions were enhanced by a moderate interpersonal

distance, as opposed to an extremely close or distant proximity [10].

When considering lighting, the room should have big windows for maximum natural light and artificial lighting should be soft, as there are higher levels of self-disclosure and trust in rooms with soft lighting [1, 11].

For the spatial layout I propose that therapists choose rooms with enough space. Regarding ceiling height, it is known that people prefer high ceilings to low ceilings [7]. Nevertheless, it was more specifically researched that ceiling height could influence how people approach problem solving. Lower ceilings promote concrete and detail-oriented thinking, while high ceilings encourage more abstract thinking and creativity [12], which is known as the cathedral effect. Therefore, therapists should choose rooms with lower ceilings, as psychotherapy is oriented towards more concrete and detailed thinking.

After the main therapy room patients enter the post-therapy room, where they have time for reflection. This room consists of chairs, tables and paper for them to write on. For each of the rooms (the pre- and post-therapy rooms), patients have the option to use them if they want, but it has been suggested that this should not be obligatory.

5 CONCLUSION

This research suggests the ways in which therapists can build offices that would act as enablers of trust and other qualities that are connected to this (safety, privacy, acceptance and understanding). The way newly proposed space affects patients needs to be further researched, but it is suggested that the possible implications of a new space on therapy could be: to increase well being and trust in patients and therapists (especially at the beginning of the therapy), to make patients more focused, to make the therapy more pleasurable and overall to shorten the duration of the psychotherapy.

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ZAVEST, UM IN DUH: TRI RAVNI ČLOVEŠKE KOGNICIJE

Andrej Ule
Odd. za filozofijo
Filozofska fakulteta, UL
Aškerčeva 2, 1000 Ljubljana
Tel. +386 1 241 1102; Fax: +386 1 4259 337
e-mail: andrej.ule@guest.arnes.si

POVZETEK

Predstavim tri pomembne pojme oz. stvarnosti, ki zajemajo kognitivne pojave in jih pogosto mešamo med seboj: zavest, um in duh. Predstavljajo pa tri ravni človeške kognicije: individualno-doživljajsko, individualno-miselno in nad individualno-miselno raven. Pojem zavesti v grobem zajema budno duševno življenje ljudi. Pojem uma zajema zmožnost in dejavnost zavestnega dojemanja in razumevanja določenih vsebin ali predmetov človeške dejavnosti. Razlikujem objektivni in osebni duh ter objektivizacijo duha v stvaritvah kulture, glede morebitnih kozmičnih ali nadkozmičnih dimenzij duha pa sem zadržan, čeprav nekatere interpretacije kvantne fizike in sodobne kozmologije nakazujejo tudi tovrstne dimenzije.

Ključne besede: zavest, um, duh, pojmovno mišljenje, objektivni duh, osebni duh.

ABSTRACT

Summary: Consciousness, mind and spirit: Three levels of human cognition

I present three important concepts and realities that encompass cognitive phenomena and are often (if wrongly) used as synonyms: consciousness, mind and spirit. They present three levels of human cognition: individual-experiential, individual-mental and trans-individual-mental level. Simply put: the concept of consciousness pertains to the waking mental life of a human being, while the concept of mind pertains to the ability and activity of conscious comprehension and understanding of certain contents and objects of human activity. I distinguish between the objective, personal spirit and the objectification of the spirit in creations of human culture; I am, however, slightly sceptical of eventual cosmic or super-cosmic dimensions of the spirit, though some interpretations of quantum physics and modern cosmology indicate such dimensions as well.

Kew words: consciousness, mind, spirit, conceptual thought, objective spirit, personal spirit.

Ta svoj tekst posvečam opredelitvi pomembnih pojmov, ki se vsi tako ali drugače tičejo kognicije, vsaj v širšem smislu. Zavest, um in duh po mojem mnenju predstavljajo tri osnovne, vendar različne ravni človeške kognicije: individualno-doživljajsko, individualno-miselno in nadindividualno-miselno raven, ki jih ne moremo reducirati na eno od njih.

1 ZAVEST

Ta pojem v grobem zajema budno duševno življenje ljudi. V slovenščini imamo na žalost v glavnem le en izraz, ki opredeljuje budno duševno življenje ljudi in to je »zavest«, čeprav gre v resnici za sklop več pojavov, stanj in procesov, ki so medsebojno povezani z ohlapno mrežo podobnosti in delno skupnih lastnosti. V angleščini poznamo vsaj dva izraza, npr. consciousness, awareness, sense ki izražajo razne trajnejše vidike in moduse zavesti, kar je ugodneje za morebitno natančnejšo pojmovno razlikovanje.

Pojem zavesti primarno zajema individualno budno duševno življenje ljudi, včasih pa ga, bolj ko ne v prenesenem pomenu, uporabljamo tudi za ne in nadindividualno početje ljudi, npr. kolektivna, družbena, nacionalna ipd. zavest. V tem tekstu se bom omejil na primarno vsebinsko jedro, tj. na individualno budno duševno življenje ljudi. Dejansko pa zajema trojico procesov: zavedanje čutno danih predmetov in z njimi vezanih občutkov, zavedanje lastnih »afektov«, tj. čustev, strasti in hotenj ter zavedanje svojih misli.

Razlikujem čisto doživljajski in predmetni ali tudi vsebinski vidik (moment) zavesti. Prvi sovpada nekako z angleško awareness, drugi s consciousness. »Preostaja« še vsaj en pomemben vidik, namreč *samozavedanje*. Nekateri avtorji namreč menijo, da vsaka dejanska zavest kakega bitja vključuje tudi neko njegovo elementarno zavedanje samega sebe. Pojem samozavedanja je zopet izjemno kompleksen in se vanj za sedaj ne bom vtikal, menim pa, da moramo razlikovati med elementarnim, nemiselnim doživljanjem samega sebe v času budnosti in bolj elaboriranimi *kognitivnimi* oblikami samozavedanja. V tem smislu razlikujem *čisto doživljajski*, *predmetni* in *samo-ovedni* vidik (moment) zavesti. Čisto doživljajski vidik je osnovni, na njem pa se gradita tako predmetni kot samo-ovedni vidik zavesti. Poudarjam še, da sta predmetni in samo-ovedni vidik relativno neodvisna drug od drugega, kajti bitje, ki

doživlja samega sebe, še ne jemlje nujno samega sebe kot predmet svoje zavesti, to se zgodi šele, če se »vključi« miselna dejavnost. Podobno bitje, ki se zaveda kakega predmeta, še ni nujno bitje, ki ob tem doživlja samega sebe. To se zgodi šele tedaj, če ta predmet dojema kot »svoj« predmet, tj. če se nanaša na njegov jaz.

Nekateri vidni teoretiki zavesti se kar odpovedujejo definiranju zavesti in se zadovoljijo le z naštevanjem nekaterih bistvenih značilnosti zavesti (Blackmore, 2005, Chalmers, 2010). Blackmorjeva in Chalmers se v svojem opisu zavesti naslanjata na znameniti sestavek Thomasa Nagela »Kako je biti netopir« (1979) in pojmujeta zavest kot »fenomenalno« zavest, tj. kot način »bivanja kot ...«.

To samoomejevanje v pojmovanju zavesti je sicer modro početje, vendar pa navedene »kvalitete« zavesti opredeljujejo le neintencionalni, čisto doživljajski, ne pa tudi predmetni in samo-ovedni vidik zavesti.

Razprava o tem, kateri vidik zavesti je primaren za sleherno zavest je še vedno odprta, vendar imam sam za osnovnega doživljajski vidik, čeprav sta vsaj v primeru zavesti odraslega človeka prisotna tudi oba ostala vidika, sta celo bistveno pomembna za kompetentno človeško življenje.

2 UM

Pojem uma je še bolj kot pojem zavesti nabit z raznimi zgodovinsko in kulturno pogojenimi opredelitvami in razlikovanji, vendar sam s tem pojmom zajemam človeško *zmožnost in dejavnost zavestnega dojemanja in razumevanja določenih vsebin ali predmetov človeške dejavnosti*. V njem nekako združujem tradicionalni *razum* (intelekt) in *um* (ratio). pojem »uma« uporabljam za vse človeške intelektualne spoznavne zmožnosti in to brez vnaprejšnjih normativnih pričakovanj, npr. zahteve po *racionalnosti* mišljenja in govora (Ule, 2001). Res pa je, da lahko in moramo razlikovati med raznimi oblikami in ravnmi mišljenja, npr. med *predstavnim*, *pojmovnim* in *intuitivnim mišljenjem* in v tem smislu lahko govorimo o treh ravneh ali modusih uma: predstavni, pojmovni in intuitivni um.

Predstavno mišljenje gradi na subjektivnih domnevah, pogledih in vrednotenjih mislečega subjekta, ki so nastali v določenih situacijah in pogosto neupravičeno posplošuje svoje »domisleke« na vse ljudi in različne situacije. Takšno mišljenje je pogosto uspešno na ravni vsakdanjega sveta, ob tihi predpostavki, da tudi drugi ljudje okrog nas razmišljajo, čutijo in vrednotijo svet in življenjske situacije podobno kot mi sami. Se pa seveda hitro zruši, če ta predpostavka ne drži več in se soočimo z dovolj »različnimi« ljudmi od nas, ki od nas terjajo priznanje »njihovih« pogledov. V grški antiki so se te situacije ovedli npr. sofisti in hitro zašli v nevzdržne relativizme, ki jih je skušal preseči Sokrat s svojo pojmovno dialektiko.

Pojmovno mišljenje skuša preseči omejitve vsakdanjega predstavnega mišljenja z naslonitvijo na pojme kot nekakšne miselno objektivne entitete. Za Sokrata so pojmi predstavljali miselna dojetja bistev stvari, to pa pomeni uvid v nujne in potrebne (zadostne) lastnosti stvari. Nujne lastnosti so tiste, brez katerih neka stvar določene vrste ne bi bila to, kar je, potrebne pa so tiste, ki nujno implicirajo, da gre za stvar določene vrste. Verbalno povzetje nujnih in potrebnih lastnosti stvari predstavlja definicijo pojma. Pojem kake stvari spoznamo, ko poznamo njegovo definicijo. Sokratsko pojmovanje pojmov se veže na bistva, ta pa pripadajo vrstam stvari, ne pa posameznim stvarem, zato pri njem ni pojmov in s tem tudi ne objektivnih spoznanj posameznih stvari.

Novoveška filozofija in moderna znanost sta povsem spodjedli »sokratsko« pojmovanje pojma in pojmovnega mišljenja, nista pa ovrgla same zahteve po pojmovnem mišljenju, ki zagotavlja spoznavno (in tudi vrednotno) objektivnost v nasprotju s predstavnim mišljenjem. Nov je bil vsekakor odpor zoper razne absolutizme in apriorizme, predvsem seveda zoper religiozne in politične apriorizme, ki naj bi določali, kaj je v kaki filozofiji in znanosti objektivno, vredno ali resnično in kaj ne.

Sodobna pojmovanja pojmov in pojmovnega mišljenja gradi na *obvladanju pravil* za uporabo pojmovnih izrazov v smiselnih stavkih in različnih kontekstih. Pojmi so torej nekaj ne-zasebnega, intersubjektivnega. Pripadajo *objektivni sferi smislov in pomenov*, ne pa imenom, stavkom in seveda tudi ne predstavam. Objektivnost pojmov in njihovo načelno razliko od predstav je zlasti poudarjal Gottlob Frege v svojih tezah o duhovni objektivnosti misli, vendar je on objektivnost pojmov in misli videl v povsem nadsubjektni in neempirični sferi čistih smislov, kar pojmovno mišljenje zopet vrača v platonistične vode (Frege, 2001). Za razliko od Fregeja miselno objektivnost vidim v intersubjektivni praksi sledenja pravil smiselnega govora in smiselnega ravnanja (Ule, 2001).

Ludwig Wittgenstein je opozoril še na eno vrsto pojmov, ki je izrecno odvisna od značilnih primerkov in tipičnih lastnosti. Ti pojmi ustrezajo zelo širokim vrstam pojavov oz. predmetnosti, ki jih niti v načelu ne moremo zajeti v kako skupno definicijsko jedro. Pri njih se moramo zadovoljiti le z navedbo podvrst in zanje lahko zopet podamo nekatere značilne primerke ali/in tipične lastnosti pripadnikov teh podvrst. Te podvrste se prepletajo med seboj nekako tako, kot so si delno podobni in delno različni člani iste družine. Wittgenstein pravi takšnim pojmom *družinski pojmi* (Wittgenstein, 1984, par. 65-72).

Poznavanje pojma nas nujno privede k resničnim *protidejstvenim (kontrafaktičnim) stavkom* tipa »Če bi bilo A, bi bilo B«, ki jih ne moremo reducirati na pogojne stavke v indikativu (tipa »Če je (ni)…., potem je (ni) …«) in dodatne pogoje, razen če ti pogoji zopet ne vsebujejo protidejstvenih stavkov. Vendar pa že samo dejstvo, da protidejstveni stavki govore o nedejanskih, a možnih situacijah in predmetih, kaže na to, da presegamo območje dejstvenosti in se gibljemo v območju možnega, zgolj pojmovnega, celo apriornega (Stalnaker, 1968, Lewis, 1973).

Intuitivno mišljenje je nadgradnja pojmovnega mišljenja z opažanjem (zrenjem), ki vsaj delno presega čutno zaznavo in omogoča hipne, domnevno nemislne *uvide* v določeno problematiko. Lahko poteka na elementarni,

»predracionalni« ravni, npr. v zgodnjem razvoju otroške inteligence ali v primerih zožene zavesti ali na nadmiselni ravni (do)umevanja sintetičnih in celostnih uvidov v problematiko (Gladwell, 2007). Vtis o povsem nemiselni oz. vsaj povsem nepojmovni naravi intuitivnega mišljenja je večinoma napačen, kajti razen v primerih zgodnjega otroškega »umevanja« ali preseganja običajne zavesti v raznih transih, mističnih doživetjih ipd. imamo vedno opravka s prikrito dejavnostjo mišljenja, ki teče v ozadju ali je omogočilo intuitivne uvide.

Višje razvito intuitivno mišljenje je podobno zaznavi v toliko, ker nas naredi za intelektualno pozorne za določene abstrakte ideje, podobno kot nas čutna zaznava naredi pozorne za določene čutne predmete okrog nas (Chudnoff, 2013).

Pomembno je upoštevati, da ti uvidi ne predstavljajo nekakšne neposredne resnice, prav nasprotno, so šele predlogi za razumne domneve o tem, kar razmišljamo. Intuitivno mišljenje sicer presega moč pojmovne analize, kar se tiče celovitosti uvida v problematiko, toda ne dosega moči pojmovnega mišljenja, kar se tiče izdelanosti misli. Zato je intuitivno mišljenje toliko bolj vredno in zanesljivo, kolikor več »analitičnega« pojmovnega mišljenja mu je predhajalo. Zato *je za umsko delovanje človeka pojmovno mišljenje centralno,* ker le v njem lahko pridemo do jasno artikuliranih vsebin umske dejavnosti.

3 DUH

V sodobni filozofiji, zlasti še v kognitivni filozofiji in kognitivni znanosti se pogosto medsebojno mešajo pojmi zavesti, duševnosti (mentalnosti), uma in duha. Angleži imajo za vse to »vsepokrivajoči« izraz »mind«, ki je prav zaradi te svoje univerzalnosti povsem neprevedljiv v slovenščino in tudi v kake druge evropske jezike. Moderni duhovni individualizem zožuje duhovne pojave človeškega življenja na skupek mnogih individualnih vedenj, kognicij, vrednotenj in razumevanj in ob tem zanemarjajo inherentno nadosebne, objektivne pomene, resnice in vrednote. Mislim, da takšno razumevanje človeka vodi k napačnemu samorazumevanju posameznika, prav tako v napačno razumevanje družbenih pojavov in močno prispeva k sedanji krizi človeškega sveta (Ule, 2011a).

Pojem duha zajema tako *individualne kot nadindividualne (intersubjektive, nadsubjektivne) potenciale za kompetentno delovanje ljudi v svojem življenjskem svetu*, pa tudi *udejanjanje teh potencialov* v zavestih in umih posameznikov in v »duhovnih stvaritvah« ljudi skozi človeško zgodovino. Duha tako ne moremo zožiti na zavest ali umske delovanje posameznikov, duh je nujno nadindividualen, ga pa lahko delno ozaveščamo in osmišljamo.

Pri tem se želim izogniti tako subjektivističnim redukcijam duha na kognitivne funkcije posameznika kot tudi metafizičnim postvaritvam duha. Nasprotujem tudi pozitivistični težnji, ki se v splošnem želi rešiti vprašanja duha, češ da gre za zastarel metafizični pojem, zunaj znanstvene sfere. Kot je znano, je najbolj obsežno in zaključeno teorijo duha postavil Hegel. Najbolj inovativni del Heglove teorije duha je njegov pojem objektivnega duha, ki zajema objektivnost človeških dosežkov tako v polju družbenega kot kulturnega življenja, npr. v moralnosti, pravu in državi.

Nekateri pomembni filozofi 19. in 20. stoletja so poprijeli in preoblikovali te Heglove zamisli v duhu historicizma ali fenomenologije (Dilthay, Simmel, Cassirer, Hartman). Sam sledim nekaterim reformulacijam pojma objektivnega duha, kot jih je podal fenomenolog Nicolai Hartmann v svoji knjigi *Problem duhovne biti* (Das Problem des geistgen Seins) (1933) in jih dopolnjujem s svojimi uvidi. Tako kot Hegel je tudi Hartmann zavrnil izenačevanje duha z zavestjo ali umom, čeprav sta ta dva povezana z duhom. »Duhovnost« človeške zavesti se kaže najprej v njeni odprtosti v *svet* in ne zgolj v neko okolje. Ljudje potrebujemo neko skupno »duhovno sfero«, v katero rastemo in to toliko bolj intenzivno in široko, kolikor bolj smo družbeno odgovorni in kulturno ozaveščeni. Ta sfera je več kot le goli skupek posameznikov, ki se družbeno in kulturno udejanjajo, tudi ni zgolj neka abstrakcija njihovih posamičnih zavesti ali umov, temveč svojska stvarnost, v kateri ljudje živimo prav tako kot v snovnem svetu. Zgolj zavest ločuje ljudi med seboj, šele duh jih lahko povezuje, pravi Hartmann (1934: 61). Vendar po Hartmannu duhovna stvarnost ni neodvisna od narave ali celo ontološko primarna, kot je bilo za tradicionalno metafiziko in tudi za Hegla, temveč se lahko razvije in ohranja le na podlagi materialne stvarnosti, v kateri živimo ljudje kot živa bitja.

Objektivni duh pa ni kak »nezavedni« ali »nadzavedni« duh. Hartmanovo pojmovanje duha ima vsekakor svoje prednosti in slabosti. Prednosti so v njeni »nemetafizičnosti«, izogibanju subjektivizmu in postvarjanju duha, slabosti pa so, da ni uspel pokazati, kaj pomeni relativna samostojnost (objektivnega) duha nasproti posameznikom oz. »osebnim duhovom«. Mislim, da to slabost lahko vsaj delno zapolnimo s pomočjo nekaterih zamisli poznega Wittgensteina.

Wittgensteinov pojem, ki je soroden Hartmannovemu pojmu objektivnega duha je pojem »življenjske oblike« iz *Filozofskih raziskav* (1984). Wittgenstein meni, da v sledenju pravil, ki regulirajo naš govor, mišljenje in početje, postanemo vpleteni v mrežo raznih dejavnosti, ki vzete skupaj tvorijo neko celoto, ki ji Wittgenstein pravi »oblika življenja« (Die Lebensform). Življenjska oblika običajno pripada določeni skupnosti ljudi s sorodno kulturo, govorico, običaji ipd. Ona omogoča članom te skupnost medsebojno ujemanje njihovih dejanj, pomenov govornih izrazov in dejanj in enako ali podobno sledenje določenih pravil. Zato lahko vsaka javna raba kakega pravila podlega kritiki tistih, ki si delijo enako življenjsko obliko. Življenjska oblika je nekaj, »kar je sprejeto, dano« (Wittgenstein, 1984, XI: 572). Naš govor, misli, namere so del človeških življenjskih oblik, pri tem pa je jezik njihov bistveni sestavni del.

Menim, da pojav nadosebnega pomena, veljavnosti in resnice določenih predstav, pojmov, trditev, dejanj in človeških proizvodov sloni na mreži *bazičnih pravil*, ki jih »slepo« in na zelo podoben ali celo enak način sledijo vsi

člani določene skupnosti, ki si delijo skupno obliko življenja. »Slepo« sledenje pravilu pomeni, da poteka nedvomno in brez posebnega razmisleka o tem, ali prav ali ne-prav sledimo pravilu. Vsa druga pravila, ki jim ljudje sledijo v raznih situacijah v okviru iste življenjske oblike, lahko pojasnimo ali določimo s pomočjo kombinacij bazičnih pravil.

Poudarjam pa, da tudi slepo sledenje pravilom pri posameznikih ni zgolj njihova individualna praksa, temveč je *skupnostna* praksa, kajti nastala je na podlagi medsebojnega uvežbavanja in učenja sledenja pravil v skupinah ljudi, tako da vsak od njih doseže takšno trdnost v obvladanju pravil, da »ne dvomi več«, kako jih uporabiti v elementarnih situacijah njihove rabe.

Postavljam tezo, da *dinamična celota pravil, načinov govora in razumevanja ljudi v danih med- in nadosebnih situacijah človeškega življenja* predstavlja *temeljno obliko objektivnega duha* ljudi, ki si delijo isto življenjsko situacijo (Ule, 2011a: 97). Ta pojem objektivnega duha je torej situacijsko in kontekstualno opredeljen in ga ne moremo brez nadaljnjega posplošiti nad dano življenjsko situacijo. Jedro objektivnega duha neke situacije vidim v celoti implicitnih, pogosto nezavednih predpostavk razumevanja, smiselnega odzivanja na situacijo in v implicitnih konsekvencah tega razumevanja in odzivanja. Poenostavljeno rečeno ta celota predstavlja »objektivni duh dane socialne situacije«. Višje in kompleksnejše oblike objektivnega duha nastopajo pri bolj kompleksnih in trajnejših oblikah socialnih situacij, npr. v socialnih institucijah, v medijih, v obsežnih procesih komuniciranja (npr. v množičnih medijih) ipd.

Vsak »primerek« objektivnega duha je nekaj različnega od zavedanja tega primerka pri posameznikih in od njihovega umevanja tega primerka. Takšno zavedanje predstavlja sestavino *osebnega duha* (Hartmann) pri tem posamezniku. To pa zato, ker je vsak primerek objektivnega duha le latentno, potencialno prisoten v doživljanju, mišljenju, govoru in ravnanju ljudi, medtem ko je zavedanje in umevanje nekaj aktualnega. Podobno kot Hartmann tudi sam govorim o »*objektiviziranem duhu*« tedaj, ko je aktualizacija duha povezana s kakim javnim in opredmetenim izrazom duha, npr. v kakem umetniškem ali znanstvenem izdelku.

Seveda potrebujemo nek »medij«, ki ohranja ali prenaša transpersonalni potencial objektivnega duha v zavest in um posameznikov in v družbo in to tudi brez konkretnih objektivizacij duha. Tu je uporaben pojem »institucij smisla« kot temeljnih nosilcev objektivnega duha, ki jih je predlagal Vincent Descombes (1966, 2001). Socialne institucije imajo svoje lastno življenje in nam dopuščajo, da mislimo in odločamo o nečem tudi tedaj, ko tega ne moremo storiti zgolj v svojih glavah ali celo v več glavah. Podobne koncepte najdemo tudi pri konceptih mentalnih institucij, družbeno povnanjenega duha in razširjenega duha Gallager, Crisafi (2009, 2010, Clark, Chalmers, 1998).

Sem pa zadržan glede domnev o kozmičnem oz. celo nadkozmičnem duhu. Te domneve so nepreverljive z znanstvenega stališča, pogosto izrecno metafizične. Vendar niso povsem neracionalne, kajti je nekaj kazalcev, ki dopuščajo vsaj razumno spekulacijo o tovrstnih duhovnih dimenzijah. Nekatere interpretacije kvantne fizike npr. dopuščajo ali celo terjajo obstoj nekakšnih »kozmičnih opazovalcev« (enega ali več), ki nenehno »lomijo« holistični kozmični kvantni potencial, ki ga formalno predstavlja združena valovna funkcija vseh fizičnih dogajanj v kozmosu (npr. Wigner, 1962, Bohm, 1980, Polkinhorne, 1984, Squires, 1986).

V knjigi *Mind in Nature* (Ule, 2012) in sestavku o kvantnnomehanskih modelih duha (Ule, 2011) sem v svojem poglavju o duhu v fizični stvarnosti razvil nekaj začetnih idej o zavesti kot polju potencialnosti in njenem aktualiziranju skozi razne oblike pozornosti doživljajskih akterjev na tok svojih doživljajev, kar vsaj formalno gledano lahko primerjamo z določenimi vidiki kvantnomehanske potencialnosti in njene aktualizacije v fizikalnih opazovanjih. Vendar pa zgolj zavest in um posameznika nista dovolj za polno razvitje te ideje, potrebujemo upoštevanje *dosegljivega znanja* subjekta o tem, kako je z njim v svetu, ki si ga deli z drugimi ljudmi. Tu gre za izrazito *duhovno domeno*, točneje za objektivni duh situacij, ki jih doživlja posameznik in si jih deli z drugimi ljudmi, s katerimi interagira.

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MYSTICISM, COGNITIVE SCIENCE AND CONSCIOUSNESS: WHY IT IS IMPORTANT FOR COGNITIVE SCIENTISTS TO READ LAO ZI, DOGEN AND ST. JOHN OF THE CROSS?

Sebastjan Vörös, PhD
Department of Philosophy, Faculty of Arts
Aškerčeva 2, 1000 Ljubljana, Slovenia
e-mail: sebastjan.voros@gmail.com

ABSTRACT

The article considers how mysticism, defined as a set of practices, beliefs, values etc. developed within a given religious tradition to help the practitioner realize the experiential and existential transformations associated with mystical experiences, could enter into a dialogue with cognitive science. I focus on two broad areas where this exchange could prove particularly fruitful: *phenomenological research* (mysticism as a repository of unique and valuable phenomenological material and of practical know-how for rigorous phenomenological analysis) and some *pressing theoretical conundrums* (the problem of the self and the hard problem of consciousness). It is argued that, contrary to popular belief, mysticism has a lot to offer to cognitive science, especially as a way of grounding its findings in the lived experience and thereby demystifying some of its (unknowingly) self-imposed (abstract, rational) puzzles.

KEYWORDS: mysticism, cognitive science, consciousness, phenomenology, the self, hard problem

1 MYSTICISM AND COGNITIVE SCIENCE: STRANGE BEDFELLOWS?

The main goal of this article is to consider the possibility of a dialogue between two seemingly very different approaches to consciousness, namely that of mysticism and that of modern cognitive science. Our main thesis will be that not only is such a dialogue possible but might actually prove beneficial for both parties. To demonstrate this, we will briefly sketch the main points where this exchange could take place and provide reasons why insights developed in mystical traditions might be of interest for cognitive scientists. But before we proceed, two things need to be mentioned: (i) this paper makes no pretence of being a comprehensive study of the suggested "points of contact"; it is merely a preliminary sketch intended to provide food for additional thought, no more no less; (ii) as the conference itself is aimed primarily at current developments in cognitive science, our sketch will be asymmetrical, focusing on what mysticism can offer cognitive science, and not so much on what cognitive science can offer mysticism.

Although considerable effort has been expanded towards introducing the insights of mystical traditions into mainstream cognitive science (cf. Forman, 1998; Shear and Jevning, 1999; Lancaster, 2005), the topic is still likely to raise many an eyebrow: some might feel inclined to label it as unscientific and therefore ill-suited for what is basically supposed to be a *scientific* conference. To alleviate these worries, a few preliminary remarks would be in order. First of all, it is important to delineate how mysticism is to be understood in our discussion. The word itself has a complex history, which we can't go into at this point (but see Vörös, 2013: ch. 1, for a more detailed presentation), and is usually associated with a wide variety of phenomena: "religious experience, mythology, miracles, schizophrenia, hallucinations, trances, altered states of consciousness, alleged psychic powers such as levitation, visions, parapsychology, and in general anything considered irrational, unintelligible, or occult" (Jones, 1993: 1). It is important to note, however, that this ordinary or "folk" understanding of the term is in stark contrast to how it is used in academic circles, particularly in religious studies and philosophy of religion. There, the term is ordinarily associated with a particular *set of trans-confessional and trans-cultural experiences* that are said to possess a *unique set of phenomenological characteristics* and are capable of instigating *a profound existential transformation in the life of a mystic*.[1] In order to get a better understanding of what mysticism stands for, it is therefore necessary to get a better understanding the main characteristics of these so-called mystical experiences.

We will do this in two steps. First, it is essential to consider what mystical experiences *are not*. Experiences that are frequently associated with mystical experiences, but shouldn't be confused with them are: visions, auditions, locutions, trances, ecstasies, paranormal phenomena (Zaehner, 1980; Stace, 1960). Although these experiences

[1] I'm fully aware that such a claim is all but trivial. In the study of mysticism two general positions have been established: *perennialism* claiming that there exists a phenomenological core of mystical experiences that is identical across cultures, traditions etc, and *constructivism* claiming that no such core exists and that all experiences are culturally constructed. Limited space prevents us from entering into these interesting debates, so we will simply assume the validity of a weak perennialist positions that has been argued for at length elsewhere (cf. Vörös, 2013, esp. ch. 1).

can and *do* occur on the "mystical path", they don't qualify as mystical in the strict sense.[2] This brings us to the second step of our preliminary exposition: if mystical experiences are not to be confused with visions, auditions etc., then what *are* they? Several portrayals of mystical experiences have been made, and although they differ in particularities, they all agree on general features. The most prominent characteristic of "mystical experiences proper" seems to be *the breakdown of the subject-object dichotomy*, i.e. of the sense of *my* being separated from *the world*. This breakdown (where both "ego" and "the world" are extinguished or transcended) is normally associated with the experience of *oneness* and/or *nothingness*, and entails a radical transformation of one's being.

For lack of space, I'm unable to go into a more detailed phenomenological analysis of mystical experiences (see Vörös, ch. 1 and ch. 3, for a more detailed account), but suffice it to say that the term seems to be covering a *whole spectrum of experiences* distinguished by how this S-O breakdown is realized. On the one end of the spectrum, there are experiences of absolute nothingness/oneness, i.e. experiences emptied of all phenomenological content (sensations, thoughts, volitions, emotions etc.) in which nothing but pure oneness/nothingness is present; and on the other end of the spectrum we find experiences where this nothingness/oneness is present *in* and *through* phenomenological content. Between these two extremes lie experiences in which nothingness/oneness is present to a greater or lesser degree. I will refer to the first type of experience as the (experience of) *transcendental (introvertive) Oneness-Nothingness* (TON; corresponding approximately to Forman's Pure Consciousness Event), and to the second type as the (experience of) *lived (extrovertive) Oneness-Nothingness* (LON; corresponding approximately to Forman's Unitive Mystical State). It seems that most mystical traditions (*contra* Stace, *pro* Forman) put greater value on LON seeing it as the pinnacle of their spiritual/religious/existential striving.

Now that we have a general (albeit admittedly very sketchy) understanding of mystical experiences it is time to consider how they are related to mysticism in general. In the context of the article, mysticism will be understood as the *general platform* where mystical experiences are developed, i.e. as a set of different practices, beliefs, values etc. (characteristic of a religious tradition in which the whole process takes place) that help the practitioner realize the experiential and existential transformations associated with mystical experiences. Although individual practices etc. may differ from one religio-cultural context to another, they bring about the same type of experience. Particularly important, and in need of special mention in this context, are *meditative/contemplative practices* that are normally deemed to be essential in the overall process.

[2] Mystics tend to interpret them differently: most frequently, they are perceived as hindrances and thus something to be avoided or at least ignored; occasionally, however, they are depicted as helpful, but tricky and potentially dangerous guides on one's spiritual path. Either way, they are distinguished from mystical experiences *as such*.

2 LIFTING THE VEIL: IN SEARCH FOR THE COMMON GROUND

Armed with the basic overview of mysticism and mystical experience, we are now in a position to move on to the central part of our discussion and draw an outline of the possibilities for establishing a potentially fruitful and mutually enriching dialogue between mysticism and cognitive science in the field of consciousness studies. This outline will consist of two major parts: in the first part, we will try to elucidate how mysticism can contribute to current phenomenological research, while in the second part, we will see how it can help cognitive scientists confront two theoretical conundrums that are pestering modern cognitive science: the problem of the self and the hard problem.

2.1 Phenomenological research

The first area where mysticism could contribute significantly is *phenomenological research*. In recent years, the importance of phenomenology in cognitive science has steadily increased and it has become obvious that it is indispensable in the study of consciousness: "For consciousness is essentially an *interior* phenomenon, something we experience *as* subjectivity. Thus if we weren't able to identify the subjective phenomena of consciousness directly, [...], we would have no way to know which externally observable phenomena were relevant to what phenomena of consciousness, or in what ways" (Shear and Jevning, 1999: 189). I see at least two possible ways how mysticism could contribute to phenomenological research.

(a) EXPERIENTIAL DOMAIN

Mystical accounts (written or oral) abound in descriptions of unique experiential states (i.e. mystical states) that are (i) normally not present in our ordinary lives and (ii) exhibit surprising phenomenological similarities across cultural and religious traditions. It would seem, then, that they provide precious material for the study of the utmost recesses of consciousness that are unreachable for most people. But why should this, aside from sheer intellectual curiosity, matter? There seem to be at least two good reasons for pursuing the study of mysticism. The first reason is best exemplified by drawing a parallel with *pathological experiences*, i.e. experiences that accompany specific physiological or psychological disorders. It is an established fact that the scalpel of a disease can be, albeit possibly limited to very few, extremely useful in revealing the normal functioning of our mind-body; and it seems plausible to assume that extraordinary experiential states that *not* abnormal (there are actually good grounds for calling them *hyper*normal) would be equally if not even more revealing. In words of Robert Forman (1998): "From the *pathology* of a very few we have learned a great deal about the relationship of one side of the brain to the other, of two kinds of knowing, of information storage and retrieval, of impulse control etc. Indeed it is common practice to take data about a few unusual individuals and generalize it to the many. Here again we are studying the data of a few. But rather than the pathological,

we will be studying people […] who are not 'pathological' but unusually self-actualized" (363–4).

Another reason for the study of mystical experiences relates to the possibility that they provide the more "fundamental" mode of experiencing, i.e. a mode that underlies our ordinary (waking) consciousness. This is probably best seen in TON, a state of consciousness characterized by absolute absence of all phenomenological content (also called "pure consciousness [event]"). Just as a biologist tries to understand a complex biological phenomenon (e.g. a living organism) by looking at its simplest form (e.g. *E. Coli*), so a cognitive scientist studying consciousness might learn a lot about the phenomenon under scrutiny by looking at its most rudimentary representatives. And since TON, unlike our everyday consciousness which is a "an enormously complex stew of thoughts, feelings, sensations, wants, snatches of song, pains, drives, daydreams", is characterized by a state of absolute stillness in which one "neither thinks nor perceives any mental or sensory content" and is therefore completely "perception- and thought-free" (*ibid.*: 360-1), it seems to be the perfect candidate for the job. Moreover, mystics claim that mystical experience actually lifts an (experiential) veil and reveal that our ordinary (dual) way of perceiving things is actually *secondary and derivative*, i.e. superimposed on a more rudimentary (non-dual) experiential mode. If this were true – and it is a hypothesis that cannot be discarded on *a priori* grounds –, it would mean that studying mystical experiences (in all their guises) provides crucial insights into "the ground, structure and dynamics of consciousness" (Shear and Jevning, 1999: 190).

However, not only mystical experiences as such, but also *accompanying* experiences (visions, trances etc.) can turn out to be of immense value. Brian Lancaster (2005) has argued convincingly that the study of Jewish, Taoist and Buddhist mysticism can provide valuable insights for cognitive scientists, as these traditions contain rich phenomenological descriptions and practical means of how to experientially access what is normally referred to as "preconscious" or "preattentive" cognitive processes. Moreover, texts such as the Buddhist *Abhidharma* contain detailed phenomenological accounts of different conscious states and could therefore be highly useful in charting the territory of consciousness. Also, several authors (e.g. Clarke, 2010; Ciglenečki and Škodlar, 2013) have pointed out phenomenological similarities between states encountered on a mystical journey and in certain pathological conditions (esp. psychosis). Since mystics are capable of successfully mastering phenomena that overwhelm psychotics (hallucinations, ego-death etc.) a better understanding of processes involved on a mystical path can have not only theoretical (clearer understanding of how such phenomena occur) but also practical implications (ways of preventing and/or alleviating such occurrences in psychotic patients).

(b) PRACTICAL DOMAIN

This last remark brings us to the next domain in which phenomenological research could be coupled, and thereby enriched, with mystical traditions. Several authors have pointed out the need for a skilful application of improved practical methods that would enable a more rigorous and systematic approach to the study of human experience. Shear and Jevning (1999) thus point to a "significant asymmetry" present in the current neurophysiological approaches to consciousness: "For while their objective side employs sophisticated scientific methodologies […] their subjective side typically uses mere everyday sorts of introspection […] The need for systematic first-person methodologies here is thus starkly apparent" (109). Similarly, Francisco Varela (1996) calls out for "a systematic exploration of the only link between mind and consciousness that seems both obvious and natural: *the structure of human experience itself*" and emphasizes the need for examining "the concrete possibilities of a disciplined examination of experience" (330, 335).

Rich and multifarious meditative/contemplative practices developed in different mystical traditions seem to be particularly useful in this regard in that they provide "a repository of contemplative and phenomenological expertise" and thus constitute practical know-how for obtaining "precise and detailed first-person accounts of experience" (Thompson, 2008: 216, 228). Contemplative mental training "cultivates a capacity for sustained, attentive awareness of the moment-to-moment flux of experience" (*ibid.*: 229) and can thereby improve our overall understanding of the phenomenological domain. Note that the diversity of approaches in different traditions is not a hindrance, but an added value, since a given tradition "may have gleaned some valuable knowledge or developed some practice that is not found elsewhere" (Lutz et al. 2007: 498-9). Although such practices may induce phenomenologically identical experiences, they may differ significantly in their inner dynamics, i.e. ways how they bring them about, and each tradition could therefore offer unique insights into the structure and dynamics of consciousness.

2.2 Specific theoretical conundrums

In addition to phenomenological research, mysticism could also engage in a fruitful exchange with cognitive science in addressing certain theoretical puzzles that have persistently pestered the study of consciousness. Although several such problems exist, we will focus on two that are particularly pressing, i.e. the problem of the self and the hard problem.

(a) THE PROBLEM OF THE SELF

It has long been recognized that the notion of a unified, discrete, (semi-)autonomous entity called "the self" is highly problematic: "On the one hand, even a cursory attention to experience shows us that our experience is always changing and, furthermore, is always dependent on a particular situation. […] Yet most of us are convinced of our identities: we have a personality, memories and recollections, and plans and anticipations, which seem to come together in […] a center from which we survey the world, the ground on which we stand" (Varela, Thomson and Rosch, 1991: 59). The currently predominant attitude in cognitive science seems to be that this elusive "ego"/"self" is a *beneficial illusion*, a *useful construct* with no independent existence. In words of Daniel Dennett (1991): "But the strangest and most

wonderful constructions in the whole animal world are the amazing, intricate constructions made by the primate, *Homo sapiens*. Each normal individual of this species makes a *self*. Out of its brain it spins a web of words and deeds, and, like the other creatures, it doesn't have to know what it is doing; it just does it" (416).

The idea is that mental life in its entirety consists of nothing but subpersonal mental processes, and that the sense of self is merely a useful superimposition on this array of unconscious events. The main problem with this view, however, is that it seems to contradict our everyday experience: although there might be good scientific reasons to claim that there are no egos/selves (i.e. that all there exists are unconscious mental [neural?] processes), there seem to be even more persuasive phenomenological reasons that such entities do in fact exist, i.e. despite the fact that recent scientific studies seem to indicate that there are no unified selves, *I* still have *the feeling* of being such a self.

Mystical traditions based on meditative/contemplative practices concur with scientific claims about the non-existence of unified selves, but on different grounds: they claim that "an untrained mind is inevitably deluded over the real nature of mind and consciousness" and that it takes strenuous mental discipline in order for the "elements previously obscured (preconscious) [to] enter the clarity of consciousness" (Lancaster, 2005: 249, 253). In other words, mystical traditions claim that it is not only possible to *think* (reflect) on the non-existence of the self, but to actually make it *a living experience*. TON and LON are examples of conscious ego-less states, i.e. experiential states not referring/belonging to any self, and thus provide a phenomenological counterpart of scientific findings with potentially valuable insights into the true nature and origin of the (sense of) self (how and why it emerges, is it possible to live without it etc.). This is the reason why Varela, Thomson and Rosch (1991) proclaim the question of the self as "the meeting ground" of (cognitive) science, philosophy and meditative/contemplative traditions: "[A]ll reflective traditions in human history […] have challenged the naïve sense of the self" (59). And it is our contention that they have done so in different, yet mutually enlightening ways.

(b) THE HARD PROBLEM: DE-MYSTIFYING CONSCIOUSNESS WITH MYSTICISM?

Another important area where mystical traditions could prove of value is the so-called "hard problem of consciousness". Chalmers (1995) explains: "The really hard problem of consciousness is the problem of experience. When we think and perceive, there is a whir of information-processing, but there is also a subjective aspect. […] This subjective aspect is experience. […] It is undeniable that some organisms are subjects of experience. But the question of how it is that these systems are subjects of experience is perplexing. Why is it that when our cognitive systems engage in visual and auditory information-processing, we have visual or auditory experience: the quality of deep blue, the sensation of middle C" (201)? At the bottom of the hard problem lies the notorious "explanatory gap" (Levine, 1983) between *subjective, phenomenal* and *objective, physiological* aspects of consciousness.

Several solutions have been proposed throughout the years, but none of them met with unanimous agreement. One of the suggestions (cf. Varela, Thompson and Rosch, 1991) maintains that the problem cannot be solved by a set of conceptual/theoretical "fixes", but demands a radical (existential) reorientation of our attitude towards it. In other words, the hard problem is not so much an intellectual, as it is an *experiential-existential* question: it is dependent on a specific (dualistic) manner of experiencing. More precisely: "From Descartes on, the guiding question in Western philosophy has been whether body and mind are one or two distinct substances (properties, levels of description etc.) and what the ontological relationship between the is. […] We are suggesting that Descartes' conclusion that he was a thinking thing was the product of his question, and that question was a product of specific practices – those of disembodied, unmindful [i.e. rational, abstract] reflection. […] [But] theoretical reflection need not be mindless and disembodied […] the mind-body relation or modality is not simply fixed and given but can be fundamentally changed" (28).

In other words, the hard question is a *practical* question: by applying a set of skills/methods that can change our manner of experiencing it is possible to change ("answer away") the nature of the problem: the problem remains problematic only as long as it is *experientially* persuasive, as long as our way of experiencing presents it as a problem. "[T]he mind-body issue is not simply a theoretical speculation but is originally a practical, lived experience, involving the mustering of one's whole mind and body. The theoretical is only a reflection on this lived experience" (Yuasa in *ibid.*: 30).

It was mentioned that mystical traditions, by cultivating a specific set of practical know-how, can induce radical transformations in our general way of experiencing. This is especially prominent in LON where the subjective and the objective are experienced non-dualistically, as "oneness in duality, duality in oneness". In this state, the mind and the body are said to be working as an integrated whole, so the hard problem doesn't even arise. This, however, introduces an intriguing turn into our discussion. We started off by fearing that mysticism was something too elusive, too out-of-worldly to be of interest to cognitive science; now, in the face of the hard problem, it seems that it is cognitive science that might be too abstract, too out-of-worldly (not rooted in concrete, lived experience) and therefore incapable of seeing that the problems pestering it are the creations of (abstract, disembodied) premises it endorses and derivative on the lived experience. Could it be that the greatest gift that mysticism could give to cognitive science is to save it from some of its own ghosts – and thus demystify it?

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Zbornik 16. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2013

Proceedings of the 16th International Multiconference

INFORMATION SOCIETY – IS 2013

Kognitonika

Cognitonics

Uredila / Edited by

Vladimir A. Fomichov, Olga S. Fomichova

http://is.ijs.si

7. in 8. oktober 2013 / October 7th and 8th 2013
Ljubljana, Slovenia

PREFACE

THIRD INTERNATIONAL CONFERENCE ON COGNITONICS – THE SCIENCE ABOUT THE HUMAN BEING IN THE DIGITAL WORLD (COGNIT 2013)

During the last decade many scholars at various international and national conferences, in the books and papers have said and written about serious distortions in the development of the personality (first of all, in the system of moral values) and national cultures caused by stormy development of information and communication technologies (ICT) and globalization processes.

The conviction that it is not only necessary but also *possible* to make something constructive and significant for compensating these distortions has underlain the elaboration of the foundations of a new scientific discipline called Cognitonics (see free of charge the selected papers on Cognitonics on the Social Science Research Network (SSRN) at http://ssrn.com/author=1871348, in the Special Issue on the Human Being in the Digital World of Informatica. An International Journal of Computing and Informatics (Slovenia), 2012, Vol. 36, No. 2, pp. 119-130, www.informatica.si/vol36.htm#No2, and in the Proceedings of the Second International Conference on Cognitonics (Slovenia, Ljubljana, 10-11 October 2011) - a subconference of the 14th International Multiconference Information Society, Jozef Stefan Institute, Ljubljana, Slovenia; http://is.ijs.si/is/is2011/zborniki.asp?lang=eng; Proceedings A, Section "Cognitonics").

Cognitonics, first of all, aims (a) at explicating the distortions in the perception of the world caused by the information society and globalization and (b) at coping with these distortions in different fields by means of elaborating systemic solutions for compensating the negative implications of the kind for the personality and society, in particular, for creating cognitive-cultural preconditions of the harmonic development of the personality in the information society and for ensuring the successful development of national cultures and national languages.

The birth of Cognitonics was stimulated by the ideas of Philosophy, Cognitive Linguistics, Artificial Intelligence theory, Web Science, Applied Linguistics, Art theory, Cognitive Psychology, and Cognitive Biology.

To follow high moral standards is important not only for people. The studies carried out in different countries during last decade have shown that following high moral norms, decency, honesty, social responsibility are the factors positively influencing the financial success of the best big international companies, in particular, by means of forming a positive image of a company. This explains why during last decade many big international companies have developed the Codes of Business Conduct.

On the other hand, a person working in industry and possessing well-developed aesthetic feeling will not allow himself/herself a negligent attitude to the final product of his/her work. That is why following high ethical norms and possessing well-developed aesthetic feeling are the significant factors of economic development demanding more attention of the researchers.

Besides, one is able to find in the scientific literature numerous confirmations of the fact that culture peculiarities and the level of trust in the society are significant factors of economic development, and these factors are to be studed much more intensively.

That is why one of the principal objectives of Cognitonics is also looking for positive correlations between (a) following high moral norms, decency, honesty, well-developed aesthetic feeling, culture peculiarities and (b) economic development, in particular, looking for positive correlations between establishing and following the codes of business conduct by the companies and their economic success.

Two factors seem to be especially important from the standpoint of achieving the goals of Cognitonics:
- information and communication technologies have been developing extremely quickly and have been expanding unusually broadly, they penetrate not only every office and laboratory but also every school class and every family;
- it is necessary and promising to use the power of modern ICT in order to very quickly and broadly disseminate the elaborated effective methods of compensating the negative distortions in the development of the personality and of national cultures in information society.

The goal of the conference is to combine the efforts of the scholars from numerous scientific fields and educators in order to establish a new synergy aimed at ensuring the harmonic, well-balanced development of the personality, national cultures, and national economics in the modern information society and, as a consequence, to compensate a number of broadly observed negative distortions (one of most severe distortions is commercialization of moral values).

From the standpoint of educational practice, Cognitonics proposes an answer to the following question: what precious ideas and images accumulated by the mankind, at what age, and in what a way are to be inscribed into the conceptual picture of the world of a person in order to harmonize his/her intellectual and spiritually-coloured emotional development and to contribute to the successful development of national cultures and national economics?

Cognitonics formulates a new, large-scale goal for the software industry and Web science: to develop a new generation of culture-oriented computer programs and online courses (in the collaboration with educators, linguists, art historians, psychologists) - the computer programs and online courses intended for supporting and developing positively-oriented creativity, cognitive-emotional sphere, the appreciation of the roots of the national cultures, the awareness of the integrity of the cultural space in the information society, and for supporting and developing symbolic information processing and linguistic skills, associative and reasoning abilities of children and university students.

The Program Committee has accepted for the conference 18 papers from 14 countries located on three continents: Asia (India, Japan), Europe (Croatia, Cyprus, Finland, Great Britain, Greece, Italy, Poland, Romania, Russia, Slovenia, Sweden), and North America (Mexico). These papers were prepared by 32 researchers.

The editors would like to thank the authors of the papers for their contributions and the members of the Program Committee for their precious comments ensuring the high quality of the accepted papers and making the reading as well the editing of this section a rewarding activity.

Vladimir Fomichov and Olga Fomichova

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REMEMBRANCE OF THINGS PAST, A RESEARCH HYPOTHESIS

Angela Christofidou
Cyprus Centre of the International Theatre Institute
38 Regaena Street, 1010, Nicosia, Cyprus
Tel: + 357 99286185; fax: + 357 22680822
e-mail: ccoiti@cytanet.com.cy

ABSTRACT

The goal of this study is to assess the hypothesis that the technologies humans use in the digital age have an impact on the behavior, the memory system, and the mental processes of the new generations.

Is the excessive use of internet changing the way we think? Are we loosing our ability of deep thinking and learning? Is our memory threatened? Socrates at the Platonic *Phaedrus* was complaining that writing kills the memory and the intellect. The paper gives the examples of the studies that question the memory system of people today. Then a set of examples supports the argument that arts and art education are linked with cognitive development. The essential role of memory in our way of thinking and in the development of our intelligence and creativity reflects our ability of communicating with our environment. This hypothesis argues that art education which is greatly ignored could be equilibrium to the damage caused by the internet. The Re-thinking Education strategy of the European Commission for the time being only focuses on a mismatch of the skills acquired at schools with employability, with no reference to the character development of the people. UNESCO is guiding the global debate on education. Scholars working in cognitive science should enter this dialogue. The proposition of this hypothesis is that the policy and decision makers responsible for the strategies implied concerning the future should cooperate with researchers and scientists who are specializing in the change of human capacity of learning and thinking caused by the information technologies. In this way they will have a more clear idea for what kind of people they are designing the strategy which will manage their future. While the accelerating rhythm of the human brain's and behavior's transformation will be as miscalculated as the climate change, future generations will not only have difficulty in writing Remembrance of Things Past but even in reading it.

1 THEY GAVE US AN OCEAN OF INFORMATION AND THEY CALLED IT KNOWLEDGE

There was no preparation done. Technology rapidly developed and you grew up swimming in an ocean of information. They called it democratization of knowledge but you had no idea what to do with it. Unlike your parents who were unlucky enough to grow up in a house without internet, you didn't know how to stand in a distant from information and judge it. Who cares anyway, in this ocean you have 3000 friends who like your posts. You stay awake all night and you forget to go out. You sit still for hours. For days.

Formal and informal education is still responsible for the intellectual and emotional development of the young student. This responsibility includes a sufficient knowledge of human beings. The educator should never ignore any side of human nature and its development in a rapidly changing environment. The educator is expected to cultivate a human being that the society believes could prevail. But any education system should be expected to cultivate the ideal man [1]. The educator should give the young student of all ages the ability to stand in a distant from information and knowledge and judge it. Knowledge is unlimited, but man is finite. But the educator is not the only one who carries this responsibility on his shoulders. On all levels of governance, decision makers have the power of changing the social and educational systems, in relevance to the changes of their time. But they have to possess sufficient knowledge of man and his nature also. And when the rhythm of changes becomes too fast for them to follow, they should consult experts. And at this digital age, the experts who can efficiently consult the decision makers are the scholars working in cognitive science. But while educators and decision makers slowly proceed in their dialogue with the young student, a faster tutor takes over and while the messages are endlessly flowing in the youth's brain,

he/she sits still, for no act is needed for passively watching electronic idols [2].

2 THE SHALLOWS

In his book "The Shallows: What the Internet is Doing to Our Brains" [3], Nicholas Carr explains how the technologies we use to find, store and share information can literally reroute our neural pathways. The scattered, multitasky way we use the internet with the many interruptions result in the losing of the ability to move the information from the working/short term memory into the long term memory where we can retrieve, contemplate and re-enact it. We are losing the ability of deep thinking and learning. We are losing the ability to write and even read a long book, or melody. The transfer of information from sensory to long term memory is governed by two control processes: the pattern recognition and attention. In cognitive psychology it is established that the more we analyze the material for meaning, the better we recall it. The process of information at a deeper level reinforces long term memory that is linked to critical thinking. Memory is a necessity to communicate with others. Memory is communication.

Charles M. Dorn explains that "Memory is linked to thought and emotion and affects what you can think about and thus how you can solve problems and make decisions [4]. Sternberg believed that to have a complete theory of intelligence, it must address three aspects of intelligence: its internal components, the relation of these components to experience and its external effects. The internal components consist of three processes used in thinking: performance components, knowledge acquisition components and metacomponents. Performance components are the processes of perceived stimuli, holding information in short-term memory, comparing values, retrieving material from long-term memory, and calculating sums and differences. Knowledge acquisition components are processes used to gain and store new information; metacomponents are the processes that control performance and the knowledge acquisition components that organize and set up the problem. According to Steinmberg, meta-components also determine the problem-solving strategies, the value of the problem, what performance components to use, that needs to be known, and how to evaluate a situation".

C. Shawn Green and Daphne Bavelier made an interesting discovery: "Dopamine is of particular interest because it is thought to play a role in a wide range of human behavior including pleasure, addiction and learning. For instance, most drugs of addiction produce pleasure by increasing the amount of dopamine in the brain. Using a form of brain imaging (Positron Emission Tomography or PET) the researchers were able to determine whether playing a video game increased the amount of dopamine released by the brain. A massive increase in the amount of dopamine released in the brain was indeed observed during video game play, in particular in areas thought to control reward and learning. The level of increase was remarkable, being comparable to that observed when amphetamines are injected intravenously" [5]. That could lead to faster learning the research concluded but what about addiction? Freud's attempts to use cocaine and the disastrous results come to mind.

"Mass media submit to a great extent the idea of stress. Anxiety in a digestible form becomes a second nature, a habit" [6]. This was written in 1966, and in 2000 the BBC News announced that researchers at Yale University have discovered that long-term use of anti-depressants is linked to the development of new cells – or neurons – in an area of the brain known as the hippocampus [7]. And in USA today they use prozac "curing" young students.

This is a question shadowed by a dangerous answer.

3 BIOLOGICALLY USEFUL IS NOT ENOUGH

Colorful art, full of sounds and movement should be considered the most useful lesson of all; beyond biological precondition, there is this need to justify life. Art without any obvious cause, offers a life lesson and in the most hostile times seems to offer an answer to a difficult question.

A three-year study at seven major universities across the United States found strong links between arts education and cognitive development [8].

The study was the result of research by cognitive neuroscientists from seven leading universities across the United States. The research was led by Dr. Michael S. Gazzaniga of the University of California at Santa Barbara. "A life-affirming dimension is opening up in neuroscience," said Dr. Gazzaniga, "to discover how the performance and appreciation of the arts enlarge cognitive capacities will be a long step forward in learning how better to learn and more enjoyably and productively to live.

The consortium's new findings and conceptual advances have clarified what now needs to be done." Participating researchers, using brain imaging studies and behavioural assessment, identified eight key points relevant to the interests of parents, students, educators, neuroscientists, and policy makers.

1. An interest in a performing art leads to a high state of motivation that produces the sustained attention necessary to improve performance and the training of attention that leads to improvement in other domains of cognition.
2. Genetic studies have begun to yield candidate genes that may help explain individual differences in interest in the arts.
3. Specific links exist between high levels of music training and the ability to manipulate information in both working and long-term memory; these links extend beyond the domain of music training.
4. In children, there appear to be specific links between the practice of music and skills in geometrical representation, though not in other forms of numerical representation.
5. Correlations exist between music training and both reading acquisition and sequence learning. One of the central predictors of early literacy, phonological awareness, is correlated with both music training and the development of a specific brain pathway.
6. Training in acting appears to lead to memory improvement through the learning of general skills for manipulating semantic information.
7. Adult self-reported interest in aesthetics is related to a temperamental factor of openness, which in turn is influenced by dopamine-related genes.
8. Learning to dance by effective observation is closely related to learning by physical practice, both in the level of achievement and also the neural substrates that support the organization of complex actions. Effective observational learning may transfer to other cognitive skills.

4 TO WATCH THEM FROWNING UNDER A MENTAL EFFORT…

When M. Lecoq de Boisbaudran first published "*The Training of the Memory in Art"* [9], he was not just proposing a method of training of the memory in art. He was analyzing the essential role of memory in our way of thinking and in the development of our intelligence and creativity.

He wrote: "The well-known name of M. Horace Vernet will occur at once to prove how much the power of any talent is multiplied by the gift of memory […] It was a remarkably interesting sight to watch their young faces, and see a look deep and thoughtful as that of some solitary sage take the place of their naturally light-hearted expressions ; to watch them frowning under a mental effort such as no other of their studies could evoke, and such as no direct exhortation could have brought them to make. […] As a general reply to other objections, let me state that it is precisely when the memory is left entirely to itself that it runs the risk of becoming disastrously overcrowded with masses of incoherent matter;
[…] Memory and imagination are so closely linked that imagination can only use what memory has to offer her, producing, like chemistry from known elements, results completely new. How much more productive then must the imagination be when nourished by a cultivated memory, for it has at its service a store of material richer both in quantity and in variety, yet absolutely precise. We may be sure then that memory training is a great stimulus to artistic creation by ministering to and reinforcing the imagination. […] memory and intelligence must always be cultivated side by side, and in such a way that the development of one encourages the development of the other.»

Education should communicate the love for the form, the passion for free expression, the consciousness that useful is not enough, that what is biologically needless is humanly essential [1].

Jeremy Rifkins spoke of a rapidly accelerating entropic juggernaut in the form of climate change. "The reason the scientists miscalculate the climate change is because they cannot calculate the accelerating rhythm of change" [10], he explained.
And while climate change and cognitive function change are being miscalculated, future generations will not only have difficulty in writing *Remembrance of Things Past* but even in reading it.

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Note. This is a philosophical text in the sense that for the philosopher it is self evident that when he gives an answer to a question, he does not do so because he is certain that he possess the right answers, "but because he feels the need to offer, not only unanswered questions, but also logically synchronized patterns of answers to facilitate an endless dialogue that began 2500 years before at Ionia." [Christofides, A, 1966 It is also an artistic text. As Mengfei Huang wrote "the growing insight that some scientists have gained in recognizing the work of artists as co-investigators of reality have led them to conclude that while their approaches differ, artists and scientists strive toward a common goal in their quest for knowledge".

ASSESSING THE POTENTIAL OF COLLABORATIVE VIDEO-GAMES TO IMPROVE EDUCATION IN LA MIXTECA REGION OF MEXICO

Paul Craig[1], Néna Roa-Seïler[1, 2], Marcela Martínez Díaz[1], Felipe Lara Rosano[3]
[1] Universidad Tecnológica de la Mixteca, Huajuapan de León, Oaxaca, Mexico
[2] Edinburgh Napier University, Edinburgh, Scotland, United Kingdom
[3] Universidad Nacional Autónoma de México, Mexico City, Mexico
e-mail: p.craig@mixteco.utm.mx, n.roa-seiler@mixteco.utm.mx, mtz_diaz.marce@hotmail.com, flararosano@gmail.com

ABSTRACT

The study presented in this paper shows how collaborative learning games can be used to improve primary education for children aged eight to ten in la Mixteca region of Mexico. We developed a series of three collaborative games to develop mathematics, language and reading skills. Each game uses elements of either Mixtec or Mexican national culture to encourage the children to identify with different sides of their identity. The children were tested before and after playing the games, observed during gaming sessions and interviewed to assess the impact of the games on their learning. Results show that educational video-games can be used to promote learning and team working skills as well as directly achieving learning objectives in mathematics.

1 INTRODUCTION

There are around one million persons of Mixtec origin (Mixtecos) living in the world today. Around 800,000 of these live in la Mixteca, a region of southern Mexico covering northern Oaxaca state as well as parts of western Guerero and southern Puebla. Around 300,000 Mixtecos live in the state of Oaxaca where they form part of a rich cultural tapestry together with large populations of other indigenous peoples such as the Zapotec, Mazateco, Chinanteco and Mixe. In all, around 48% of Oaxaca's population is indigenous, accounting for 53% of the total indigenous population of Mexico [1]. These groups have tended to survive and preserve their native culture better than other communities in Mexico due to the isolating effect of rugged mountainous terrain [2]. Since being conquered by the Spanish in the 16th century the Mixtecos have maintained a strong ethnic identity and many aspects of the mixtec culture, such as craftwork and Mixtec art, are highly visible today. The Mixtec language is also still prevalent, being spoken by around 300,000 people (normally together with Spanish as a first or second language) [3].

Despite the rich cultural heritage and resilience of the Mixtec people, they are currently faced with a variety of serious social and economic challenges. Primary education is particularly problematic with Mixtec municipalities accounting for the majority of the 80% in Oaxaca not adhering to minimum requirements set by the Mexican government [4]. Only 5% of indigenous persons in the state attain a grade beyond primary school level and over 21% of the overall state population is illiterate [4]. These problems can be attributed to a number of factors including low family income [5], disruption of family structures due to high rates of migration [4, 5] and the large percentage of the population that live in remote rural areas [2]. There is also the significant problem that many indigenous teachers have not received formal training [6] and a strong sense that the education system is not properly adapted to best serve the indigenous population. There is strong evidence that indigenous Mesoamerican peoples have a cultural disposition to collaborative learning rather than the traditional directed approach [7] and children from this background may not adapt well to the more authoritarian European-American classroom model [8]. Other factors such as the limited availability supervision and equipment, both in schools and at home, suggest that collaborative learning [9, 10] could be part of a realistic solution to improve the education of indigenous children in the state of Oaxaca.

2 METHODOLOGY

Our experiments to investigate how collaborative video-games might be used in la Mixteca involved six groups of three children aged eight to ten years. Each group spent two hours in total playing three educational videogames. Games were played on a forty-two inch multi-touch screen angled at forty-five degrees and raised between waist and head height to be ergonomically accessible. The children were observed through two-way glass with audio and video recorded throughout the sessions to give us a permanent record of results. The groups consisted of four groups all female and two groups all male.

Each child was tested immediately before, immediately after and four days after their session. The exams used for testing included three five minute sessions testing mathematics, languages and reading. The students were also asked to fill in questionnaires to provide us with more subjective information relating to how they felt about the games and working as a team. In addition to this, observations made



Figure 1: *Mixtec codices used as characters in the mathematics and languages videogames: Jaguar, eagle, muerte and mixteco.*

during the tests allowed us to assess the dynamics of the groups telling us how the students interacted and how collaboration strategies evolved.

3 VIDEOGAME DESIGN

The three educational games developed for our experiment supported the learning of mathematics, languages and reading. In order for the games to be both accessible and challenging for children with different levels of learning, we incorporated gradually increasing levels of difficulty for each game. Other key aspects of game design were cultural relevance and age appropriateness. Here we tried to ensure that the games were non-violent and did not enforce gender stereotypes while encouraging the children to identify with elements of their native Mixtec and Mexican culture.

Two of the three educational videogames developed for the project (those designed for mathematics and language learning) make use of graphics based on Mixtec codices (see figure 1). Codices are a form of colorful hieroglyphic used by the early Mixtecos to record their history. While these are no longer used today for writing, they remain a strong symbol of Mixtec culture used in logos, books and t-shirt designs. Parts of the costumes seen in the codices are also used in traditional ceremonies and festivals. The codices used in the games are the jaguar, the eagle, the muerte, and the Mixtec man. Muerte can be literally translated as death and the character used in our game represents a dead friend or relative returning to visit the living. To western eyes this might seem as a morbid character to include in a video game for young children but the Mixtecos have a somewhat different attitude to the symbolism surrounding death. Mixtecos consider the 'day of the dead', when the dead are said to return to visit their loved ones, as a happy occasion to be celebrated with bright colors and loud music.

The mathematics game developed for the project (figure 2 left) is a simple 'tower defense' type game where the students have to solve mathematical equations to fire eagles and prevent the muertes from reaching the perimeter wall of their 'tower' and draining their energy. The character of the user, the jaguar, sits at the left hand side of the screen. Below this character is a keypad and to the right a list of sums. To the right of the sums is a vertical wall and beyond the wall are the muertes. Each muerte advances slowly from right to left toward a sum and if a muerte reaches the wall it stops and begins to drain the health of the user. When the health of the user reaches zero, the game is over. In order to stop muertes reaching the wall the user can answer sums to fire eagles. The user can press on different sums to answer them using the keypad. If a sum is answered incorrectly, health is drained and if a sum is answered correctly, an eagle is fired from the wall toward the right hand side of the



Figure 2. Screenshots of the educational videogames; left mathematics, top right languages and bottom right reading.

screen. When a muerte is hit by an eagle it is pushed back away from the wall. Pushing back muertes also adds to the users score and causes the level-up bar to rise. When the level up bar is full, every sum fires an eagle to push all the muertes back and the user progresses to the next level. As the level increases, the muertes begin to speed up, and it becomes gradually more difficult to do all the sums on time to keep the muertes away from the wall.

The languages game helps students to learn the names of animals in English (figure 2 top right). This game is another 'tower defense' type game similar to that used to learn mathematics described above. However, instead of doing sums to fire eagles the students have to match words in English to their Spanish translations. When words are matched correctly eagles are fired from both words and health is drained when words are matched incorrectly. The game begins with a small number of words for more common animals such as cats and dogs. As the game advances, the difficulty level increases with a wider variety of gradually more obscure animal names. If the children are not already familiar with the names of these animals in English, they can normally find the translations out by trial and error and learn from their mistakes.

The reading game (figure 2 bottom right) aims to help the children with reading by asking them to complete a story by replacing missing verbs. Literature and authors are held in particular esteem in Mexico, and Latin America in general, with popular authors often considered as national heroes. This game encourages the children to explore the Mexican national side of their identity by using an adaptation of the short story 'Mi vida con la ola' by Mexican Nobel laureate for literature Octavio Paz.

4 RESULTS

Our experiments provided us with three types of results. Firstly, short exams taken by the students immediately before, immediately after and four days after the experiments allowed us to assess how the games contributed towards specific short-term learning objectives. In addition to these exams, the students were asked to fill in questionnaires to provide us with more subjective information relating to how the students felt about working as a team throughout the sessions. Finally, observations made during the tests allowed us to observe the dynamics of the groups and how strategies evolved during the sessions.

4.1 Exam results

Table 1 summarizes the improvement in the children's performance in the exams after the session with the educational games. Here we can see that the children's performance did not improve significantly, or deteriorated, immediately after their session with the games. This was most likely due to the children being tired and over-stimulated after playing the games for two hours. When the students were tested again, four days after the tests, there was a significant improvement in their performance. This improvement was particularly marked for mathematics where the student's performance showed an increase of 21.9%. The improvement for languages was 4.3% and the students regressed slightly in their reading (by 2.1%). In order to statistically validate our results and account for inter-sample variance, we performed a single-tailed t-test. This gave a p-value of 0.016 for the second test to indicate that it was highly likely the children's improvement was due to their exposure to the games rather than variation of the children's scores overall. The p-value for improvement in the mathematics test was 0.0018 indicating a greater probability that the children's improvement was due to their exposure to the games. The p-value for the language test was marginal at 0.20 (0.089 for the boys) indicating that there is insufficient evidence to conclude that exposure to the games caused an improvement in the children's results (using the standard p-value threshold of 0.05). Results also indicate that there is insufficient evidence to conclude that the *drop* in reading performance was due to exposure to the reading game (with a p-value of 0.38).

4.2 Questionnaire results and observations

The questionnaires filled in by students and observations made during the experiments provided us with more subjective information regarding the benefits of our educational games. The first thing we noticed was the short time the children took to learn how to play the games. On average it took around two minutes for the children to

		Improvement in performance							
		Immediately after the test				four days after the test			
		Maths	Languages	Reading	All	Maths	Languages	Reading	All
girls	%	10.00%	0.96%	0.00%	3.65%	22.08%	2.56%	1.04%	8.56%
	p-value	0.111	0.421	0.500	0.243	0.012	0.215	0.500	0.393
boys	%	9.17%	-0.64%	-25.00%	-5.49%	21.67%	7.69%	-8.33%	7.01%
	p-value	0.065	0.468	0.005	0.130	0.012	0.089	0.282	0.016
all children	%	9.7%	0.4%	-8.3%	0.6%	21.9%	4.3%	-2.1%	8.0%
	p-value	0.067	0.458	0.148	0.439	0.002	0.198	0.387	0.031

Table 1. Improvement in child performance assessed by exams administered after a session with collaborative educational games.

develop an understanding of how each game worked. During the next five or ten minutes the children would develop basic game strategies and continue developing these while playing the games. The students also developed collaboration strategies such as coordinated turn taking, task delegation and thinking aloud. In general, the boys tended to prefer the mathematics game while the girls preferred the reading game. The boys and girls also tended to use different strategies for the reading game. The girls would read larger sections of the text aloud, following the story. Boys tended to use a more direct strategy of reading individual sentences and trying to use grammatical rules to choose a word. The boys also tended to be more competitive, celebrate more when an answer was correct, and argue more over whose turn it would be to operate the interface. All of the student groups spent around about equal time playing each of the different games and tended to spend around twenty minutes or half an hour playing a game before moving on to the next. The positive feelings the children had toward the games were reflected both in observed behavior and questionnaire results. At the end of the sessions the children wanted to continue playing even after two hours. In the questionnairs the children told us they enjoyed the gaming sessions and would be very happy to use the games for future learning. The children particularly enjoyed being able to learn together with their fellow students and found the graphical nature of the games stimulating. They recognized the characters from the codices and felt this helped them relate to the games. The story used in the reading game was not familiar to the students but those who followed the text in the session expressed an interest in learning more about the story.

5 CONCLUSION

The results of the evaluation presented in this paper demonstrate the potential of collaborative games to improve the educational experience of children in la Mixteca region of Mexico. To support our study, we developed three games incorporating elements from the children's native Mixtex and Mexican national culture. These were designed to help children with mathematics, languages and reading. The children played the games during two hour sessions in groups of three.

Evaluating exam scores before and after gaming sessions showed a statistically significant improvement of over 20% in results for mathematics. Results for the languages were positive though not conclusive due to the small sample size and natural variation between student grades. While the exam results did not show an improvement for reading, a number of children involved in the study felt encouraged to develop an interest in the story presented during the game. The games also allowed the children to develop important team working skills and encouraged them to identify with different aspects of their native culture.

As an extension to this initial study we plan to annotate and further analyze recordings of our experiments in order to gain a better understanding of the processes involved when children collaborate to achieve learning objectives. This in turn should help us understand where collaborative learning is most effective and allow us to improve the design of future collaborative learning interfaces.

Acknowledgements

The authors of this paper would like to acknowledge the help of the following persons whose contributions were crucial in realizing the experiments described in this paper. Firstly, we would like to thank the teachers, students and the parents of students at Escuela Primaria Rural Benito Juárez in Acatlima Oaxaca for participating in and facilitating our experiments and tests. We would also like to thank Carlos Martinez and Mario Moreno for helping us to use the excellent UsaLab facility at the Universidad Tecnológica de la Mixteca. Also at the UTM, we would like to thank Rodolfo Palma Guzman and his team at Encargado de Taller de Metal Mécanica for the design and construction of the adjustable large screen display stands used in the experiments.

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THE DARK PATHS OF THE INTERNET

Ioanna Dagdileli
Erasmus Mundus Office, Aristotle University of Thessaloniki
University Campus, 541 24, Thessaloniki, Greece
e-mail: iodagdil@gmail.com

ABSTRACT

The Internet has grown up in a climate of absolute support. It is believed that this is absolute Democracy and absolute Equality, since all digital citizens have exactly the same rights. However, a number of phenomena force us to keep a more circumspect attitude need to be looked at. These reservations stem from three main sources. Firstly, the Internet has a dark side. As pointed out by Evgeny Morozov in his book "The Net Delusion", the capabilities of the Internet have gained progressively democratic movements like the Arab Spring, but as shown by the case of Iran, conservative forces that draw information very easily from the Internet, have benefited as well. Secondly, the Internet is also an ocean of information without any discrimination, control or priority. This obscures the important events, and mixes the major and minor news items.
In the electronic media, for example, there is no page two or page three: all are page one headlines claiming the attention of the reader. Similarly, in our personal lives, for instance the constant efforts to answer e-mails and sms or comment on the Facebook wall, in the end, result in nullification and loss of our personal capacity for reflection. Thirdly, the uncontrolled reproduction of news and "rumours" in tens of thousands of digital copies renders any attempt to rescue the "Lost Honour of Katharina Blum" effect futile, since digital news, whether true or false, with no source or center, is viral: each new recipient can be an equal transmitter. If it seems believable, ultimately, nothing can prevent a digital "witch-hunt". In the present work, an attempt is made to analyze these "dark" sides, negative aspects of the internet and to put forward a proposal to address them.

1 HOW "BIG" IS THE INTERNET?

In relation to the standard definition of "big", the internet is very big, is huge. Nowadays, internet has explosive dimensions, while it provides enormous possibilities for navigation, exploration and communication.
According to Pingdom's 2012 annual report (https://www.pingdom.com/), 51 million websites were added worldwide, reaching the 634 million mark globally, while 2.2 billion users sent 1.44 billion e-mails daily. At the same time, there were 1.2 trillion Google searches, 300 million photographs uploaded on facebook every day, and 4 billion hours of video were watched on YouTube in one month. These figures show the absolute sovereignty of the internet not only in the daily life of millions of people but also the enormous repercussions it has on both the economy and the society in general. This large number, however, does not mean that users have made use of all the possibilities that the internet provides. Research has shown that only $1/10^{th}$ of the possibilities are used by the average user, whereas a very small number of people make use of the other $9/10^{th}$. The internet is often accurately compared to an iceberg where only the tip (the one tenth) is visible at sea level and the great bulk (the nine tenths) is hidden the water reaching down to the ocean floor. As is the case with all icebergs, so too with the internet: it is the part that is hidden that is the most dangerous.
When it first appeared, one very important characteristic of the internet was that it was totally free and that everyone had access to everything, with no obstacles. It thus soon came to be considered as the most democratic means available. However, with the passing of time, it was revealed that to a certain extent, the internet plays the role of Big Brother. Take as an example, Facebook users. Their name, email address, friends, and a lot of other data are available in each user's profile, which can be used to identify and note one's political opinions, religious convictions, sexual preferences, as well as health status. This personal data may, as very often happens, be sold to any interested party and be used in numerous ways, even though companies such as Google and Microsoft go to great lengths to assure us of the opposite. The American Edward Snowden and the action taken against him by the NSA is but one characteristic example. Google has been called to clarify before the European data protection authorities about the widespread use of the personal data of users from the UK, Germany, France and Spain by September 20, 2013. Another example is the case of Instagram that announced a change to its terms of use for its popular photo-sharing service as of January 16 of this year.The change stated that usernames, likeness and photos could be bought for promotion or advertizing purposes without any compensation to its users. After the terrorist attack of September 11th, there was rapid development in the technologies and techniques of surveillance, at the same time generating enormous profits for these companies, which proceeded in the analysis of data drawn from various sources that combined pictures and recorded the behaviour of individuals. Moreover, having the possibility of processing large volumes of data, these companies also carry out

linguistic analysis of messages drawing on information that is not immediately perceptible.

It is beyond dispute that the communication networks have aided in the democratization of regimes, among others, by providing unhindered access to information for all citizens. Furthermore, the decisive role that the internet and new technologies played in the Middle East and more recent Turkish uprisings is well-known. However, besides the widely held view that they helped mobilize citizens, Morozov [1] is of the opinion that governments also use these new means of communication not only to monitor the developments of the opposition but to intervene in shaping situations as well, often that are undesirable for the member of their opposition. The relevant government services follow discussions on the internet, prohibit internet communication (as happened in Egypt and Iran), and even carry out message and text analysis in various networks, in this way gathering information about persons and tendencies that are operating in the rival camp.

In the end, the outcome of all these cases will cause many, whether out of fear or outrage, to condemn the free dissemination of information online. It is not technology which is to blame for whatever happens but rather how and for what purposes people use that technology which is responsible for events. Cyberspace too is a reflection of the society that uses it. Even if it is banned, unhealthy uses will unfortunately always find room to grow.

2 TOO MUCH INFORMATION ?

Internet offers too much easily available information. So, accessing it can eventually become addictive. The high density of personal communication has greatly increased. In the past one could make contact with a loved one through letter writing, or via the telephone, although in countries such as Greece, this was rarer due to expenses. Today, however, services such as Skype make it extremely cheap and easy to have face to face communication, while e-mails have multiplied the number of written texts. In addition, one can follow the news on the various specialized sites – which offer much more information than can be actually followed within a particular time, since the items are continually being updated even as one reads.

People also are most likely to monitor the particular news and developments related to their profession, academic interests, hobbies and political beliefs - in other words, all that is associated with all the aspects of one's life. The choice of books or super market products, banking, all types of transactions and shopping can, and to a large extent do, take place through the Internet. In short, a big part of our personal and social life is conducted online. We have become the recipients of such a volume of information that is received at such speed which is unprecedented in the entire history of mankind.

In this ocean, or more precisely in this tsunami of information, who can control the content and the meaning of all these digital sources? Does one have time for reflection?

3 DEEP WEB IS ALSO A DARK PLACE…

If dangers lurk in the various Internet uses that have been referred to here, the so-called *deep web* of the internet is just as dark a place. All who for research purposes have had to go down that road have expressed their horror. The extent of the Deep Web is immense. It is said to contain some 550 billion individual documents (as opposed to the 1 billion found on the surface Web) and more than 200,000 hidden deep sites. Of these, the 60 largest of the deep Web hidden sites contain a total of about 750 terabytes of information. These sites alone are 40 times bigger than the surface Web.

In his study for the technology magazine The Next Web (TNW), Joel Falconer (http://thenextweb.com/author/joelfalconer/) claims that he was able to very quickly and easily access sites with child pornography and pedophilia, online orders for illegal substances and drugs, as well as sites for arms trafficking and even paid assassins**.** When, however, he attempted to explore further, access was made more difficult and anonymity software systems were required.

The deep web has a black market that is known as the dark web, darknet or the invisible web. Silk Road is one of these hidden or underground websites, which appeared in 2011 and which within two years had 10,000 products for sale, all prohibited or illegal. According to a report by Forbes it is visited by 66,000 users daily and the annual transactions are over $22 million. The products that are bought and sold range from drugs such as marijuana and heroin, to fake passports and diplomas, as well as weapons and counterfeit currency. You can get advice as well on issues such as how to get rid of a corpse, how to find people to take part in your experiments, how to set up a pornographic or pedophile site, how to seduce your victims, or generally speaking, how to satisfy all kinds of appetites [2].

Two other underground online sites offering their products to any customer who is prepared to put in the extra effort to assure their tracks are covered are Black Market Reloaded and Atlantis. For quite some time now, both these sites have been targeted by law enforcement authorities worldwide. On Atlantis, besides the other products, you can also purchase the services of a hacker in order to break into the electronic codes of credit cards and personal bank accounts.

Black Market Reloaded with 8,551 public listings amasses huge profits. Reports claim that it has monthly earnings of around $400,000 and is a top market for those people who are without any moral barriers.

In addition, there are unreliable websites that provide inaccurate or false information, either due to lack of knowledge or deliberately to deceive users (hoaxes). Attackers fall into this category causing damage to the software being used through Viruses, or to the network connection through worm programs, or by misleading the user into thinking that they are performing one particular task, whereas in fact they are doing something quite different, such as installing malware (Trojan horses).

Through *phishing* techniques an Internet users' personal data (identity card number, taxation number, credit card details, bank accounts, etc.) can be stolen and used for many different purposes, often through e-mails. Even more dangerous, however, is the so-called technique of *pharming*. This is a special program that redirects the user unwittingly only to spoofed websites. If it is a bank website, for example, the attempt of the victim to conduct transactions through on-line banking results in the transfer of money to the perpetrators ("pharmers").

Yet another consequence of preoccupation with the internet is that users become alienated from the real world. Many people, seeking the security of their home and the anonymity that the internet provides, end up choosing to live in isolation, preferring online entertainment and communication without having any face-to-face personal contact. The internet can affect users both physically and psychologically. The long hours spent on online activities can lead to addictive behaviour which is accompanied by eating and sleeping disorders, musculo-skeletal conditions and migraines, symptoms of anxiety, anger, violence, isolation, reduced desire for social contact, neglect of bodily health and hygiene or lack of other interests [3]. It also affects the neurophysiology of a child's brain which becomes accustomed to the computer's quick stimuli, resulting in distractibility and difficulty in concentrating (and in this case, what happens in adolescence?). According to statistics from the Adolescent Health Unit of Greece (A.H.U), this phenomenon is rather frequent. This is particularly the case in boys who come from problematic families and generally in children with feelings of depression. More specifically, one in 100 children in Greece is in an advanced stage of addiction, 18.2% of young people experience the state before addiction, 8% of adolescents are online for over 20 hours a week, while the number of teenagers who have contacted the Adolescent Health Unit at the A. Kyriakou Children's Hospital have surpassed 50 per week. These are teenagers with severe symptoms of Internet Addiction Disorder (IAD), which nowadays is quite frequent (http://www.youth-health.gr/). Furthermore, there have been reports of young people who steal from their parents in order to go to Internet cafes, or who play truant from school because of their involvement with the Internet, as well as students who after being online for 30 hours straight were unable to remember their home address or had suffered from dehydration as a result of forgetting to drink water. There have also been the serious cases of youngsters who have committed suicide in order to become 'famous' on the pages pertaining to their death. Cyber bullying is yet another dangerous internet behaviour. It involves the intimidation of individuals or groups, which can prove difficult to deal with because the messages are repeated and cannot be restricted [4]. When the victims of cyber bullying are young children, then intense psychological problems and emotional disturbances can arise [5, 6].

Online gambling, online games and online betting are other dangerous Internet activities, because apart from the loss of money, there is the increased risk that children and adolescents will engage in such pursuits. Yet another not directly visible risk is iDoser, the first electronic drug. It belongs to the class of "acoustic drugs" having strong side effects, because it impacts directly on the brain, not only producing relaxation or stimulation but also causing lethargy and overstimulation.

The most dangerous and harsh forms of online crime, however, are child pornography and pedophilia (relative reports on The Greek and open-Line for illegal content on the Internet, Annual Report INHOPE). Some deranged people take advantage of the innocence and naivety of children by making their images available on the internet. Some even go as far as attempting to come into physical contact with the children in order to seduce and sexually exploit them [7].

Apart from dangers referred to above, the internet has yet another equally dangerous side, which became visible last year with Boston Marathon bombings. The bomb explosions during the race incited thousands of people to seek the perpetrators. This conduct has obviously been triggered by the attack attack on the Twin Towers in New York. These Internet detectives were engaged in a witch hunt. Most of the time they presented information that was based on totally racist criteria and they developed their theories on social media sites. They in fact went so far as to identify and name suspects. Such was the case with Sunil Tripathi and Salah Barhoun whose names and photographs were uploaded on the internet with incalculable consequences to themselves and their families, as well as to the prosecuting authorities. The 17 year old Salah Barhoun has stated that he now fears for his safety and Tripathi was found dead. Here, yet again is a case of "The Lost Honor of Katharina Blum" effect. Only that the sensationalism of the tabloid news in Heinrich Boll's story has today been replaced by modern social media. The unrestrained reproduction of news and 'rumors' in thousands of digital copies renders any attempt to rescue the "lost honor of Katharina Blum" futile since digital news, whether true or false, has neither source nor center; it is viral. Each new recipient can equally be a transmitter. Ultimately, nothing can prevent a "witch hunt" even a digital one especially if it seems believable to the masses.

To this list of negatives websites that promote reactionary ideologies and ideas should also be added, as well as the economic losses from digital piracy and theft. From 2003 until the end of 2010, one billion online thefts were recorded according to a survey conducted by Verizon Business, a technological company that deals exclusively with issues of security and development on behalf of Verizon Communication, an American financial giant in telecommunications (2010 Data Breach Investigations Report). An interesting point is that the majority of these technological interceptions/ are/ to a great extent carried out by trusted company employees rather than external hackers. Another internet hazard that is not directly visible is the distortion of language. In Greece the need for quick and easy communication has led to the spread of "Greeklish". Greek

letters are rendered in Latin characters, with which neither the accents nor the correct Greek spelling can be applied.

4 PRIVACY AND THE PUBLIC

In general, there is countless information about people's personal lives available on the internet. The British magazine *Wired UK* conducted an experiment to raise awareness on this issue. In January 2011, selected subscribers were sent the current issue of the magazine with personalized covers that included personal data. By this it wanted to highlight the end of privacy and to emphasize that it is easy to gather personal information on whomever one wishes. Some of the sources used by the magazine were electoral, business, land and property registers, records from taxation authorities, insurance companies and corporations, as well as social networks. The combination of all these data gave interesting results about the life, beliefs, consumer and sexual behaviour and activities of the subscribers. With the help of a team of computer whizzes, the *magician of Brussels (famous video in YouTube)* was able to achieve analogous results revealing personal data, well-kept secrets to random passers-by. A similar scandal has broken out these days in Greece with the leakage of data of 6 million Greek citizens, in other words, the country's entire economically active population. This data is invaluable as it provides a complete profile of all the citizens.

On the internet there are also services that allow users to be able to surf on websites anonymously or create a profile without making their actual location known. According to a Wall Street Journal survey, it is mainly the nation's government and secret services that are entitled to use the services of online companies. These services have grown since 2001 and the revenues of these companies have literally skyrocketed.

The anonymity that the internet offers is the biggest problem in this new communications environment. Unchecked news and rumors that are false and sometimes conflicting are relayed quickly and uncritically. Although, as is purported, the media have been democratised and have passed into the hands of many, at the same time, they have acquired so much power that they have become established and comprise a threat to citizens [8]. Today the talk is of a new colonial regime imposed by the social media as well as the widespread use of new technologies.

Many also support the opinion that amateur users of the new media are a menace to Western civilization. On the internet you will find answers to everything you are looking for, but you cannot be sure about its validity.

Lee Siegel [7] in his article 'Twitter Can't Save You' argues that while some years ago all discussion was about how to make the internet more free, today the talk is about how to put more control on it. In addition, the news items circulating on the internet are not prioritised in accordance with their significance, but rather one item is listed next to another. It is left up to the user to assess the value of each, which is not always an easy task. The indiscriminate, uncontrolled and unprioritised deluge of information, apart from obscuring significant events, mixes major news with minor. In the electronic media, for example, there is no page two or page three. All the news items comprise front page headlines, all claiming the reader's attention. Similarly, in our personal lives, the constant effort to answer e-mails and sms, to comment on the Facebook wall, to subscribe to dozens of social media, networks, sites, online services -all of which seem important- in the long-run results in nullification and the loss of our personal capacity for reflection.

5 CONCLUSION

The Internet is obviously here to stay. Its positive elements are discovered or invented daily, especially by the younger generations. This also goes for its negative points and the potential dangers. Thus, it is not an exaggeration to say that the explosive growth of the internet has both pros and cons, has created opportunities and risks, and has given rise to new possibilities along with new traps.

Apart from the human factor itself, there does not appear to be any way to benefit from the former and eliminate the latter in each of the above dualities.

Just as in our everyday perceptions, our experiences and our values are the elements that protect us against all potential risks or help us in making choices, so too are all our online activities a matter of experience, as well as culture, education and critical thought.

This thus has a direct consequence: since internet use involves education, then the role of the school and the educational system in general is central.

'Are schools ready?' and 'Are they prepared to provide such training?' are the two major questions that arise.

The answer we fear is in the negative.

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ATTEMPTING TO TRACE THE IDENTITY OF YOUTUBE USERS

Vasileios Dagdilelis[1], Stella Giossi[2]
[1]Professor, Department of Educational and Social Policy, University of Macedonia
156, Egnatia Street, 540 06 Thessaloniki, Greece
e-mail: dagdil@uom.gr
[2]Postdoctoral Researcher, Department of Educational and Social Policy, University of Macedonia
156, Egnatia Street, 540 06 Thessaloniki, Greece
e-mail: sgiosi@uom.edu.gr

ABSTRACT

The main aim of the present research is to explore some questions that often emerge during the study and analysis of the role and the social impact of some popular online services in the environments of Web 2.0. More precisely, we focus on YouTube, in order to understand the way YouTube users deal with this environment. Do they all have common characteristics? Can we detect common patterns in the behavior of YouTube users? Do YouTube and the other similar online environments reinforce new social practices? And if they do, which are they? Eventually, are these tens of millions of YouTube users a kind of a template, a precursor state, or a preamble to some (imaginary) communities?
The present research study intends to give answers to these questions through an attempt of tracing the identity of YouTube users. As it seems that the majority of social network analysts are focused on the relationships of the network individuals rather than on their characteristics as members of a digital community with a distinct networking behavior, either individualistic or sociable, this research findings can be meaningful for researchers, practitioners and professionals who are interested in this issue.

1 INTRODUCTION

Inevitably, according to our points of view, the development of Internet overpasses every expectation of the recent fifteen or better twenty years. Initially, when we talk about Internet we have to distinguish, at least, two aspects: the first concerning its spreading and the second concerning, on the one hand, the quality of the provided services and on the other hand, the way users use it and take advantage of it.
Indeed, the widespreading of Internet was followed by the appeareance of personal computers, new operational systems, new applications and new environments. The important development in networking, information technology and communications brought into light local networks located in universities, research centers and enterprises and the consequent extension of networking and the World Wide Web (WWW). The web launching and its extension were followed by the specification of a number of web eras, where different uses of web took place and are still being developed, too. The first period between 1990 to 2000 was characterized as the period of Web 1.0 (Personal Web). Then, almost in 2002, the second period appeared, that of Web 2.0 (Social Web). Since 2007 a new period has been emerged the period of Web 3.0 (Semantic Web). It seems that after the Web 3.0 period, the period of Web 4.0 is coming, where new emerging technologies and environments of virtual and augmented reality would appear [1].
As the three main components of Web 2.0 are content creation, content organizing and content sharing [1], the YouTube as a provider of video sharing services belongs to it. In parallel, the expansion of Internet has drawn the attention on its intervention in mass collaboration and the way different online communities are formulated. As the ususal type of the online communities formulation is less formal than any other type of community, we can easily say that they resemble in the loose organization communities of cafee house habitués and the regular reading public of libraries. Furthermore, they look like the followers of a football team, in other words, the fans, or those who are sold on an idea either of religious or civil content.
Nobody can deny that the evolutionary development of technology and Internet turn the interest of all, academia, researchers, practioners, professionals and policy makers on online communities, among which Wikipedia and YouTube, which can be regarded as the centers for developing communities of this type. The interest of the present research study was limited to the YouTube online communities, while its main focus was on the characteristics of the users of YouTube.

2 SOME CHARACTERISTICS OF YOUTUBE AS AN ONLINE COMMUNITY

It is true that quite often the considerable uses of a means or an invention are not easily visible from their emergence. Common and noted examples are writing, car, telephone and computer. Furthermore, the uses of these means and inventions have led to the creation of certain communities concerning each particular means, an example of which is

the community of the users of YouTube. Navigating YouTube, each visitor can easily recognize some kinds of comminties, or in some other cases examples of teamwork, that come into sight. For example, the tribute dance for Michael Jackson, the Gangstam style, the Harlem Shake are some cases of widespread movements available in YouTube videos for those interested in knowing them and mainly following them by becoming a member of this informal team.

Long-standing familiarization with existing resources in YouTube (e.g. videos, lecture presentations, accessibility to links and comments, etc) may account for the creation of imaginary communities of users having similar interests, either temporarily or permanently. It is obvious that these communities can be distinguished by any other kind of community due to their specific characteristics such as flexibility, anonymity, internet transfer and their non well-defined community borders.

These online communities are usually built around interests, friends, industries with different objectives each, while they are properly based on the relationships of every member of the community who is involved in different structures of relationships. As social network analysts mostly are focused on the characteristics of the relationships of the networked individuals rather than on their characteristics as individuals [2], the emphasis put on the identity of YouTube users as individuals rather than as solely members of a digital community shows the originality of the present research.

3 TRACING THE IDENTITY OF YOUTUBE USERS

Identity as a concept has been a subject of extensive study, especially at an organizational level [3] [4]. In terms of digital world, identity has not been thoroughly investigated. A kind of digital users identity is the one given to the students of today in the US through which students of the digital era are labeled digital natives and their educators digital immigrants [5]. More precisely, Oxford dictionary defines digital native "a person who born or brought up during the age of digital technology and is familiar with computers and the Internet from an early age" (http://oxforddictionaries.com/definition/english/digital-native) and as a consequence, he/she can adjust to the technological changes in an easier way than the people of old generations.

Also, digital immigrant is "a person who born or brought up before the widespread use of digital technology" (http://oxforddictionaries.com/definition/english/digital-immigrant) and consequently, he/she finds it difficult either to follow the rapid technological changes or to be educated to digital technology and tools.

To this direction, the present research attempts to trace the identity of the YouTube users, which is mainly based on their motives of navigation, on their attitudes towards video sharing and on their preference for being members of a digital community.

4 AN EXPERIMENTAL APPROACH

For the purpose of this research study, an improvised questionnaire was designed and distributed to graduate and postgraduate students of the University of Macedonia in Greece. The questionnaire was available to potential respondents through an email message. In this email a specific link, where the questionnaire was included, was announced. Close-ended questions were used, offering respondents a number of defined response choices by using their left mouse button to inset a tick into a box. The total number of questions was nineteen, apart from the questions concerning the demographic elements, in order the respondents feel comfortable with their engagement. A 5-point Likert scale was selected for the responses.

The way of selecting the research sample and the time spent on the whole process were the main limitations of the research. Even though this research is at its initial phase and the qualitative approach would have been likely appreciated as the most appropriate method of getting vivid and rich descriptions of the YouTube users experiences, the selected quantitative approach has revealed some qualitative characteristics.

5 FINDINGS

To sum up the main findings of the present research, the use of YouTube seemed to appear a universality as there was no serious difference between the research respondents mainly concerning their gender and education level since their responses were united and clear. A hundred percent of the respondents visited YouTube many times in a weekly basis, which indicates that YouTube navigation is part of their daily routine.

Findings revealed that the majority of YouTube users were navigating YouTube not as followers to current trends but as users being aware of its benefits, including the acquisition of updated knowledge. Also, they seemed to be socially introverted as they preferred sending interesting links to their close friends and colleagues, while they seemed not positive to any communication with the owner of the video. Also, this introduces their networked individualism which has not been yet transformed to network collaboration and networked communities creation [2]. Another finding that converges on the same point is that fifty five percent of the research respondents disagreed with sending a link and motivating the recipient to make a comment.

Almost ninety three percent of the respondents strongly disagreed that their visit to YouTube gives them the identity of being members of a virtual community in the imaginary world of the tens millions users. This can be explained by the fact that they do not feel that they belong to an imaginary world through their visiting to YouTube, but instead, they feel networked in their natural world of their generation, the digital world.

Almost half of the respondents agreed that one of their main reasons of their YouTube visit is to satisfy their curiousity. This kind of curiosity may enrich the indentity of the

YouTube users with characteristics such as eagerness for learning, the inquisitiveness of a researcher, and the interest in progressiveness.

6 CONCLUSIONS AND DISCUSSION

The findings of the present research revealed that the majority of the respondents visit YouTube quite often in a weekly basis and this, in practice, means almost every day. Therefore, their use can be characterized as systematic and continual and not as occasional and sparing. Eventually, perhaps the use of YouTube would have been transformed from a daily routine habit to a serious necessity. Another characteristic of the YouTube users is that more often they are looking for the quickest and easier way of getting information through their YouTube navigation. Also, they are less seeking for interactivity, which is considered to be the main characteristic of undergraduate or graduate students or even corporate employees, and thus, they behave in a similar way like the students enrolled in continuing education online courses [6].

The low interest of the research participants in seeking for interactivity can be explained as YouTube is concerned to be a content sharing community. In addition, through the categorization of social media suggested by Kaplan and Haenlein (2010), Youtube can be characterized as an application of social media, at a medium level with respect to social presence and media richness, and at a low level with respect to self-presentation and self disclosure [7].

Another explanation for their unwillingness to be interactive is that they are unprepared and reflect a kind of immaturity in their way of accepting YouTube as a means of socializing, networking and concequently, acting as members of a virtual community, including a specific learning community.

Indeed, it seems that YouTube users find it difficult to behave like learners or better as adult learners, under the note that the common age of the YouTube users ranges from late adolescence to late adulthood. This may happen because quite often neither YouTube video creators nor YouTube users are able to recognize the learner identity that users of this kind adopt from the moment they decide to navigate YouTube.

Therefore, a work needs to be done to this direction. As Web 2.0 puts an emphasis on user generated content and collaborative effort and it also includes new ways of interacting with web-based applications [8], it can operate as a platform for generating, consuming and sharing content, with YouTube playing a protagonistic role. As a result, YouTube can constitute a useful teaching-learning tool. Consequently, emphasis should be put on the identity of YouTube users as learners as YouTube in future is expected to be not solely a kind of social media and video sharing services provider, but also a means and vehicle of creating learning communities based on lifelong learning, self-directed learning and self-determined learning suitable to the YouTube users of tomorrow.

Conclusively, the identity of Youtube users that emerged through this empirical approach is a user who has a strong interest in learning new things, prefers networked individualism more than networked families and communities and tends to put aside the traditional way of communicating. Thus, he/she chooses to communicate and converse with others via Internet and YouTube. This strengthens the evidence of the Rainie and Wellman's work [2], where new technologies are not considered as isolating systems but, on the contrary, they are being walking into people's social lives as a new choice of communication compatible to contemporary digital era and world.

In future, new characteristics will constitute the basis on which the potential profile of YouTube users will be built. Among these characteristics may be probable to be the tendency of creating digital families, digital communities with specific objectives or simply digital groups. Nobody can deny that a surfacing of digital tribes would be likely to happen. But certainly, any kind of digital community or tribe would not be limited to a particular content, culture, religion, fanaticism or social movement. Instead, the majority of them are expected to be large, complex, free from any kind of prejudices and having a global dimension.

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THE SIGNIFICANCE OF MINDFULNESS-BASED EDUCATIONAL METHODS PROVIDED BY COGNITONICS FOR POSITIVE PSYCHOLOGY MOVEMENT

*Vladimir A. Fomichov * and Olga S. Fomichova ***

* Faculty of Business Informatics, National Research University Higher School of Economics
Kirpichnaya str. 33, 105187 Moscow, Russia;
**State Educational Centre "Dialogue of Sciences", Universitetsky prospect 5, 119296 Moscow, Russia
e-mail: vfomichov@hse.ru and vfomichov@gmail.com

ABSTRACT

The positive psychology movement was born in the 2000s, it shifts the accent from repairing weakness to the enhancement of positive qualities of the personality and preventing the problems before the moment when these problems arise. The publications on positive psychology allow to distinguish a factor being especially beneficial to well-being, this factor is called mindfulness. Cognitonics is a new scientific discipline aiming at compensating the negative shifts in the cognitive-emotional development of the personality caused by stormy progress of information and communication technologies and globalization processes. The paper sets forth the deep connections of cognitonics with the positive psychology movement. It is shown that cognitonics suggests a system of original, mindfulness-based educational methods supporting well-balanced cognitive-emotional development of the personality in modern information society, it is called the system of the methods of emotional-imaginative teaching (the EIT-system). The analysis of central ideas of the EIT-system provided the possibility to enrich developmental psychology: the basic model proposed by P.D. Zelazo (2004) considers 4 levels of consciousness development (corresponding to the age from one to four years), and this paper introduces three new levels.

1 INTRODUCTION

During the last decade many scholars at various international and national conferences, in the books and papers have said and written about serious distortions in the development of the personality (first of all, in the system of moral values) and national cultures caused by stormy development of information and communication technologies (ICT) and globalization processes.

Digital space should be subjected to the living space, digital society to the society, and there should be a balance in value between society/digital society and environment in the world's conceptual picture of the humans. The priority of the human values and spirituality in the digital epoch is obvious. The conviction that it is not only necessary but also *possible* to make something constructive and significant for compensating these distortions has underlain the elaboration of the foundations of a new scientific discipline called Cognitonics [4-7]. At the moment, the constructive core of Cognitonics is formed mainly by the Theory of Dynamic Conceptual Mappings (the DCM-theory) and the System of the Methods of Emotional-Imaginative Teaching (the EIT-system) [1-9].

The paper sets forth deep connections of the DCM-theory and the EIT-system with the positive psychology movement. This movement fulfills a shift from the accent on repairing weakness to the enhancement of positive qualities of the personality and preventing the problems before the moment when these problems arise. The publications on positive psychology allows to distinguish a factor being especially beneficial to well-being, this factor is called mindfulness. It is shown in the paper that the EIT-system provides a mindfulness-based educational programs and, as it seems, it is the first program of the kind. The analysis of central ideas and methods of the EIT-system provided the possibility to enrich developmental psychology: the basic model proposed by P.D. Zelazo [17] considers 4 levels of consciousness development (corresponding to the age from one to four years), and this paper introduces three new levels.

2 POSITIVE PSYCHOLOGY MOVEMENT AND THE CONCEPT OF MINDFULNESS AS A REACTION TO THE REALITIES OF INFORMATION SOCIETY

During the 1990s, it was possible to observe the steady growth of the number of children at school age in the developed countries encountering various social, emotional, and behavioral problems. Numerous observations provide the possibility to conjecture that, to a large extent, it was a consequence of more intensive interaction with computers at lessons and at home and of stormy Internet's expansion. Besides, the criminal films and horror films continued to negatively influence the mental state of very many children and adolescents, in particular, causing anxiety and aggression. These negative shifts became sufficiently noticeable by the beginning of the 2000s. According to [15], approximately one fifth of children and adolescents experienced problems showing their need for mental health services.

One of the consequences of this conclusion was the increased attention of the scholars to clarifying the extent of exposure to and use of media and electronic technology by very young children. A large-scale study described in [16] showed, in particular, the following alarming facts: (a) 27% of 5-6-year-old children used a computer during 50 minutes on average on a typical day; (b) more than one third of 3- to 6-year olds also have a television in their bedroom; 54% adults said that it frees up other TV in the house, that is why other family members can watch their own shows, 38% of adults indicated that it keeps the child occupied, so the parents can do things around the house.

As a principal way out in the current situation with mental health of the young generation, many psychologists indicated the importance of promoting children's social and emotional experience in schools. As a consequence, a new paradigmatic shift was observed in psychology: a shift form the accent on repairing weakness to the enhancement of positive qualities and preventing the problems before the moment when these problems arise [14]. As a result, the positive psychology movement was born, the principal objective of this movement is studying the positive features of humans development, in particular, investigating such significant traits of the person as "subjective well-being, optimism, happiness, and self-determination" [14, p. 9].
As a logical consequence, the task of promoting positive emotions in children and adolescents was posed [10]. The evidence obtained in the 2000s shows that a critical role in the success of children in school and in their social and emotional competence is played by self-regulation, in particular, by controlling attention and inhibiting aggressive reactions.
The publications on positive psychology allow to distinguish a factor being beneficial to well-being, this factor is called mindfullness [11]. According to the definition given by Schonert-Reichl and Lawlor [12], it is a way of directing attention. Generalizing a number of available definitions of this concept, mindfulness can be characterized as the ability to maximally proceed from the context while taking decisions in any situations. It is the ability of paying attention to many details while elaborating a decision but not only "mechanically" following a number of prescribed rules, etc.

3 INFORMATIONAL-AESTHETIC CONCEPTION OF DEVELOPING COGNITIVE-EMOTIONAL SPHERE OF THE LEARNERS

The analysis of scientific literature provides weighty grounds for concluding that the first educational system satisfying the criteria of a mindfulness-based program was born and well tested several years before the emergence of the term "mindfulness-based educational program". Such criteria are satisfied by the system of the methods of emotional-imaginative teaching (the EIT-system). The core of the EIT-system was elaborated by O.S. Fomichova in the first half of the 1990s and has been expanded in the second half of the 1990s and in the 2000s. This system is underpinned by our Theory of Dynamic Conceptual Mappings (the DCM-theory). This theory is stated in numerous publications both in English and Russian, starting from the paper [1]. Both the DCM-theory and the EIT-methods form a principal part of the cognitonics constructive core.
A main component of the DCM-theory is an original informational-aesthetic conception of developing the cognitive-emotional sphere of the learners: young children, teenagers, and university students. The central ideas of our conception are as follows.

1. It is important to actively develop a broad spectrum of information processing skills of the child, starting at least at the age of five. It applies, in particular, to associative abilities, the skill of integrating information from various sources, and the ability of establishing time-causal relationships between the events (see [2, 3]).

2. It is very important to combine the development of information processing skills with inscribing, in a systemic way, the feeling of beauty into the world's conceptual picture of the child. Proceeding from our experience accumulated during 23 years, we consider the following educational processes as the principal instruments of achieving this goal:

- early support and development of figurative (or metaphoric) reasoning;
- teaching young children (at the age of 5 – 6) very beautiful language constructions for expressing the impressions from the nature;
- a unified symbolic approach to teaching natural language (mother tongue and a foreign language), the language of painting and the language of dance [2-3, 5-7, 9].

3. Passing ahead the development of soul in comparison with the development of reasoning skills. A well-developed feeling of beauty plays an especially significant role in the realization of this idea. Besides, it is very important to be aware of the fact that children should have enough time for the development of soul: the time for contemplation, for imbibing the beauty of the nature, etc., i.e. children should have time for self-paced activity [7].

4. The principal cognitive precondition of successful (as concerns a long-term perspective) acquainting children with computer is the realization of the Thought-Producing Self of the child. It means that the child should know that his/her thoughts may have a high social significance, that is, be appreciated by his/her peers, by parents, grandparents, the teacher, etc. (see [4-8]). The child should be aware of this fact before the time when the adults start to systematically acquaint him/her with computer.

5. Due to mastering modern ICT: cell telephones, internet, etc., the consequences of children's negative actions may be very severe. That is why it is necessary to find the ways of much earlier socialization of children in the modern information society in order to eliminate or considerably diminish their aggressiveness and to contribute

to the awareness by children of the real scale of their misuse of ICT.

For the realization of these ideas, an interdisciplinary educational program has been developed by O.S. Fomichova. The elaborated program is intended for teaching children during twelve years, where the starting age is five to six years. The program has been personally tested in Moscow with great success by O.S. Fomichova over a period of 23 years. The total number of successfully taught students (young children and adolescents) exceeds eight hundred. The composition of the program is described in [5-7, 9].

4 BASIC STAGE: DEVELOPMENT OF CREATIVITY AND BROAD BEAUTY APPRECIATION

The foundation of educational activities aimed at achieving the objectives of our informational-aesthetic conception of developing the cognitive-emotional sphere of the learners is the first stage of supporting and developing the reasoning skills and creativity of the child. A map of cognitive trans-formations (see [5, 6] realized at this stage is presented on Figure 1. The maps reflecfting the next cognitive transformations can be found in [5].

One of the distinguishing features of our approach to this problem is that it is realized at lessons of a foreign language (FL) – English, where the mother tongue of children is Russian. The use of original analogies (being the parts of fairy-tales and thrilling stories) for teaching the English alphabet, the rules of reasoning, and the basic rules of English grammar contributes to developing associative abilities of children at the age of 5 – 6. The EIT-system provides *an environment of conceptual learning instead of a memorization-based one*. In particular, it is the principal distinguished feature of the developed original approach to teaching FL as an instrument of thinking.

Example. A difficult problem is to explain to very young children why the verbs in the 3rd person of Past Simple Tense have no ending "s", but the same verbs in the 3rd person of Present Simple Tense do have such ending ("reads" but "read", etc.). An interesting story from one of the previous lessons associates in the consciousness of the child the ending "s" with a bow. The teacher explains that her young students were in the Past babies and had no hair (were bald). Hence it was impossible to tie a bow. That is why verbs have no ending "s" in the 3rd person of Past Simple Tense. The 5-year-old students accept this explanation with great joy and remember it very well. As a result of having heard the stories of the kind, young children become aware of the fact that symbolic objects have the meanings pertaining to the real or fairy-tale life.

The interesting stories about the life of verbs and other words establish in the consciousness of the young child a mapping from the objects and situations of the real life to the domain of language entities (verbs, nouns, pronouns, etc.). That is why the consciousness of the young child receives a considerable impulse to developing the ability to establish diverse analogies.

The other reason for using the lessons of FL is that (as a 23-year-long experience has shown) young children easier learn beautiful language constructions for describing the impressions from the nature than the equivalent constructions in mother tongue (see [2, 3]). The explanation of this phenomenon is that in the first case children don't feel any contradiction with the every-day use of language.

Example. Let's consider a fragment from the home composition "The Winter Day", it was written in English by an eight-year-old Russian speaking student Polina of the third year of studies in experimental groups:

THE KINGDOM OF THE WINTER

One winter day I was sitting near the window looking at the street covered with fresh clean snow. At first time, there was nothing so remarkable in that. Nor did I think it so very much out of the way to see that falling snowflakes, snow storm, the grey cloudy sky and the noisy crows. But when afterwards in the evening going to sleep I thought it over, it occurred to me that I ought to have wondered at this. I thought that the snow storm might be a wicked magician Winter, the grey sky with running clouds – his kingdom. Every beautiful princess that refused to be his wife because he was very angry and cruel was turned by him into a crow. And then their tears he turned into the falling snowflakes. And only the coming of the kind Fairy Spring can destroy this magic.

5 A KNOWN FOUR-LEVEL MODEL OF CONSCIOUSNESS DEVELOPMENT

It seems that the model proposed by Zelazo [17] can be considered as a good working instrument for studying the development of conscious control during the first – fourth years of childhood. This model, called the Levels of consciousness (LOC) model, emerged as a result of reflecting the experimentally discovered regularities of the development of conscious control of thought, action, and emotion. The model describes four transitions from one LOC to another, higher LOC, these transitions depend on age. Let us say about the zero LOC in case of newborn babies and very young children at the age less 11 – 12 months. Zelazo [17] characterizes the consciousness of this period as minimal consciousness; it is responsible for approach and avoidance behaviour based on pleasure and pain and is present-oriented, unreflective and doesn't operate with the Self-concept.

The principal distinguished feature of LOC1 is the emergence of concepts and of the connections between the perceived objects and concepts (playing the role of labels of experienced objects). LOC1 is called by Zelazo [17] as the *level of recursive consciousness*. LOC2 emerges at the end of the second year, the essence of the transition from LOC1 to LOC2 consists in the emergence of symbolic thinking, in children's awareness of Self. The signs of LOC2 are the first use of personal pronouns by children, their self-

recognition in mirrors. Besides, children feel first self-conscious emotions, first of all, shame.

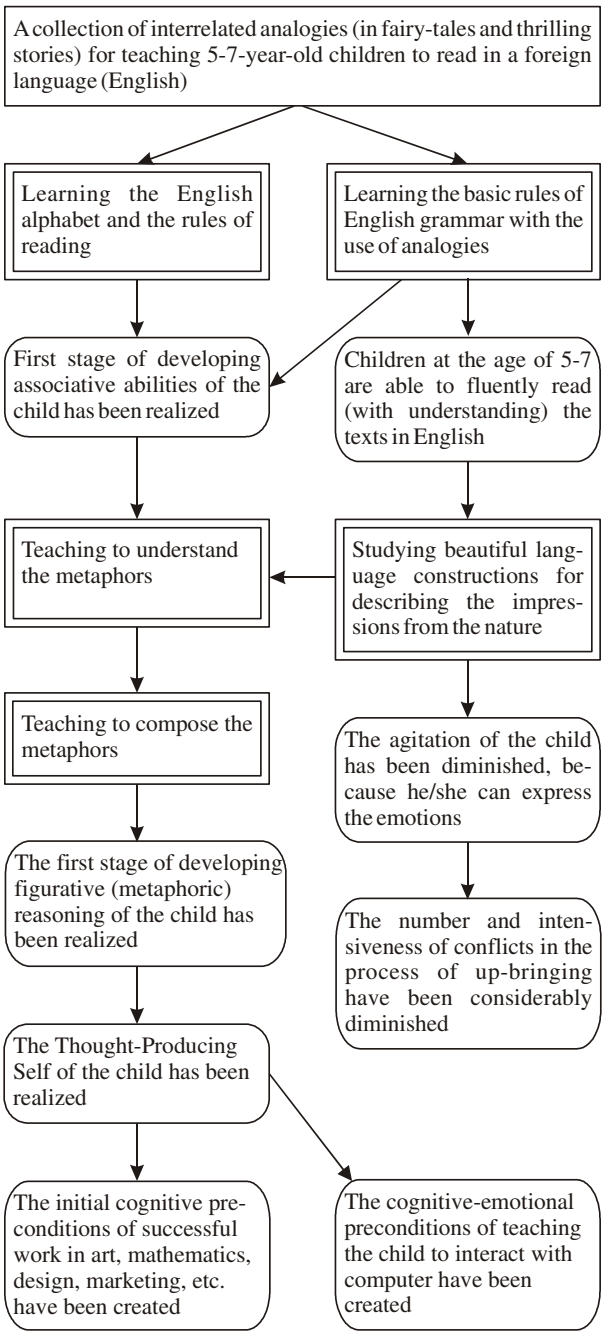


Figure 1: *A map of cognitive transformations corresponding to the basic stage of developing creativity.*

LOC3 is called by Zelazo [17] as *reflective consciousness 1*, usually this level characterizes the consciousness of three-year-olds. The manifestation of this level is the ability of children to systematically use a pair of arbitrary rules (for instance, the object of big size and of small size) for sorting the pictures representing these objects. However, the executive function of three-year-olds is still limited, it was shown by the experiments with Dimensional Change Card Sort. For being successful in this game, children must integrate two incomparable pairs of rules into a single structure. This ability characterizes the LOC4, called by Zelazo [17] as *reflective consciousness 2*. Usually, LOC4 emerges by the end of the forth year, this level is also characterized by a spectrum of meta-cognitive skills.

6 EXPANSION OF THE LEVELS OF CONSCIOUSNESS BASIC MODEL IN COGNITONICS

It seems that the broadly felt necessity of promoting children's emotional and social competence in schools and the lack in the scientific literature of rather simple solutions to this problem are the grounds for putting forward the following conjecture: the levels of consciousness model proposed by Zelazo [17] indicates only some basic stages of consciousness development. The goal of creating appropriate theoretical foundations of promoting children's emotional and social competence will lead to discovering additional, higher stages of the child's consciousness development corresponding to mature emotional and social competence of the child.

Realizing this idea, let's give a new interpretation of the methods of developing conscious control of thought, action, and emotion described in [5-6] and belonging to the System of the Methods of Emotional-Imaginative Teaching. We'll suppose that these methods underpin the transition from the level of consciousness 4 (LOC 4) to LOC 5, from LOC 5 to LOC 6, and from LOC 6 to LOC 7. The new levels LOC 5, LOC 6, and LOC 7 will be respectively called *the level of broad beauty appreciation, the level of appreciating the value of thought, and the level of enhanced awareness of social agreements and social responsibility.*

A very short, preliminary description of these levels is as follows. Reaching LOC 5 by the person means that this person possesses a well-developed feeling of beauty in various manifestations: the beauty of a thing, of an idea, of an expression, of a picture or sculpture, of the interpersonal relationships, etc. [5-7, 9].

The successful transition from LOC 5 to LOC 6 means that (a) a child is aware of the fact that his/her ideas may be socially significant, i.e. the child may be appraised by the friends or adults for the originality and beauty of his/her idea; (b) a child appreciates the value of the thoughts of other persons [5-7, 9]. Reaching LOC 7 by a person means that this person is sufficiently mature in the social sense, i.e. possesses an enhanced awareness of social agreements and social responsibility [5-7, 9].

The method of reaching LOC7 proceeds from the central idea of J.R. Searle [13] about natural language as the primary means of constructing social reality and considerably expands and works out in detail this idea.

It should be underlined that modern preschool and school educational systems in various countries encourage only a rather small proportion of children to reach the 5th - 7th levels of conscious control. But to considerably increase this proportion is vitally important for successful sociallization of children in information society. Happily, at least one broadly applicable way of solving this problem has been available since the 1990s, it is given by the EIT-system.

7 CONCLUSION: BROAD PROSPECTS OF USING THE DEVELOPED EDUCATIONAL METHODS

The EIT-system has been mainly realized at lessons of English as a foreign language for Russian-speaking children and at the lessons of poetry and literature in English, at lessons devoted to explaining the symbolic language of painting, the culture of communication, and the symbolic language of classical dance. These kinds of lessons are considered in numerous countries as highly appropriate for young children and teenagers. The carefully selected collection of texts used at lessons is provided by a number of classical, world-known fairy-tales and novels, in particular, "Snow White", "Cinderella", "Sleeping Beauty", "Pinocchio", "Pollyanna", "The Life and Adventures of Santa Claus" by L. Frank Baum, "Alice in Wonder Land" by Lewis Carroll, "The Wind in the Willows" by Kenneth Grahame, "The Hundred and One Dalmatians" by Dodie Smith, etc. That is why the EIT-system may be used (after a certain adaptation requiring a small time) in English-speaking countries and in numerous countries where the English language is learned as a second language.

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THE RISK OF POSTPONING EARLY SOCIALIZATION OF SMART YOUNG GENERATION IN MODERN INFORMATION SOCIETY

*Olga S. Fomichova * and Vladimir A. Fomichov* **
*State Educational Centre "Dialogue of Sciences", Universitetsky prospect 5, 119296 Moscow, Russia
**Faculty of Business Informatics, National Research University Higher School of Economics
Kirpichnaya str. 33, 105187 Moscow, Russia;
e-mail: vfomichov@hse.ru and vfomichov@gmail.com

ABSTRACT

The paper presents a new look at the process of education when the values of the student act like a lighthouse for the teacher at the moment of presenting material and arranging the process of education, the process of acquiring knowledge. The following new scientific statements and methods are described: (a) why the problem of secure living in modern information society demands developing and realizing the methods of much earlier socialization of children than its is usually done now; (b) why it is necessary to differentiate the methods of teaching in accordance with the values of the learners; (c) how to split young children in two groups: children with preponderance of material values and with preponderance of sublime values; (d) how to differentiate the methods of teaching for each of these groups; (e) what is cognitive engagement of the learners and how to achieve it at lessons for educational success in case of each of two values-homogeneous groups. As a result, a new psychological and educational paradigm is presented.

1 INTRODUCTION

Many scientists believe that in a relatively short time the increasing number of information technologies (IT) and the quality of IT will improve the artificial intelligence and make it mightier than the human intelligence [1].

If it happens, it means that the question of political power and the cognitive process itself which results in decision making will be considered in another way.

It is easy to assume that a person (regardless the age, spiritual maturity which includes the developed feeling of responsibility, intelligence maturity, which suggests the improved cognitive mechanisms of information processing) will be able to take power and influence the life of community, society, people all over the world due to his/her well-improved skills of using various IT. It may happen even with school children, because every new generation born in the information society (IS) is much more skillful than the previous one, and they have much more time to improve their skills, because since the early childhood it is as usual as walk and talk for all the children. Regretfully, one of tragic problems of modern IS is cyber-bullying [2].

On the other hand, the curiosity and strong aspiration to discover the digital world are underpinned by the common (for their age) desire to emulate grown-ups and become as smart and powerful as grown-ups are, or even much smarter and much more powerful in comparison with the people belonging to previous generations.

Even nowadays the teachers in various countries complain that school children are smarter and more skilful as they are. It discourages the teachers and make the relationships with school children of the kind much more complicated.

The problem looks like an iceberg, and the humans in general way may become the passengers of "Titannik", because they don't expert an iceberg on the way. This paper continues the line of the articles [3 – 5]. Metaphorically speaking, the aim of this series of publications is to propose the kind and the parameters of a manoeuvre preventing the collision of our information society with the iceberg of described sort. This manoeuvre is much earlier socialization of children than it is done now throughout the world; that is, it is a way of early and deep inscription of the notion "responsibility" into the child's conceptual picture.

The described way of early children's socialization has been elaborated under the framework of Cognitonics [4]. The constructive core of Cognitonics includes the System of the Methods of Emotional-Imaginative Teaching (the EIT-system), it is underpinned by the Theory of Dynamic Conceptual Mappings (see [3 - 5]. The ideas and methods set forth in this paper are a part of the EIT-system

This paper describes four discoveries underpinning the proposed complex method of early socialization of children in modern IS. *The first discovery* is the fundamental conclusion that young children and adolescents can be attributed to one of two groups (children with preponderance of material values and children with preponderance of sublime values), and different methods of teaching should be developed and used for achieving educational success for each of these two groups.

The second discovery is an original method of splitting young children in two groups of mentioned kinds. *The third*

discovery is two developed different practical approaches to teaching allowing to achieve educational success for each of two groups. *The fourth discovery* is the proposed notion of cognitive engagement and original methods enabling a teacher to successfully reach the goals of teaching in each of two groups by means of realizing cognitive engagement of students at lessons.

2 TWO KINDS OF VALUES IMPLY DIFFERENT METHODS OF TEACHING

Under the framework of Cognitonics new foundations of educational processes have been developed. We have added three new levels to the four levels of consciousness development considered in the model of P.D. Zelazo [5,6]. The aim is to achieve early socialization and improve the feeling of responsibility and make the person think and act in terms of public good.

The human being is brought up in the own culture and imbibes the spirit of the culture he/she is brought up. On the level of the every-day communication and acting, the culture is revealed in the answers to the following questions: *what you value, what you believe, and how you act.*

It is well known: "For where your treasure is there will your heart be also". It means that main values influence greatly the way a person perceives and processes the information, acquires knowledge, because the values emotionally colour every cognitive process.

A cognitive process includes analysis, estimation, forecast, decision making, and it is underpinned by a system of values. An educational process under the frame of Cognitonics takes into account the values of students in order to create an inspiring and creative atmosphere at the lessons. If the students share lofty ideas and sublime values, have aspiration to think and act in terms of public good and benefit to the society, then it is advisable to show, for example, the beauty of mathematical solutions and equations, the beauty and value of a thought, a metaphor, to show how one and the same idea is expressed by the language of painting ("Twilight. Moon" by I. Levitan) and natural language (the moment when Alice is dozing off in the book by Lewis Carroll "Alice in Wonderland").

If the students seek for pleasure and share the commercialized values, then their motivation is different: they take a decision here and right now without awareness of their responsibility for next generations and without gratitude to previous generations. It means that they don't consider themselves as a link between generations.

In this case it is advisable to be logical, give clear solutions to the equations, do not give the so called "additional information", do not quote poetry. E.g., while explaining mathematics, try to avoid establishing the links between various languages and natural language. The atmosphere of a lesson and the way of presenting information will meet the expectations of the audience, and the process of information processing will be successful and arise curiosity.

3 THE MAIN PARAMETERS OF THE VALUE ASSESSMENT

The process of assessment is very delicate and can't be called a precise one. The main question the students have to answer to let teachers guess the direction of their way of thinking is as follows: whether it is my cup of tea. If Yes then whether it is good for me; if Yes then it evokes emotions and becomes thought and interest provoking. In case with the young, 6-8-year old children it is helpful to listen to their answers and considerations, paying special attention to the way they put the ideas, answering the following questions:

(a) where did you spend your summer holidays; (b) what is your favourite dish cooked by your Mam or Great Mam for you; (c) what do you do when it is raining outside; (d) do you remember the gift Santa Claus presented you with last Christmas? (e) Do you have free time; (f) what is your favourite book: (g) can you give an example of your brightest impression; (h) what is beauty for you? (i) when do you feel yourself happy; (j) what you like to draw?

The given answers, the way they consider, the language they use reveal the atmosphere in which they brought up, the way they view the world around, the point of their interests, the things they are impressed by (remember the song "My favourite things" from the film "Sounds of Music").

While analyzing the answers to questions, it is important to pay attention to the following things: (a) whether they like dishes cooked by the mother or take away dishes? (b) if they spend summer in one and the same place, whether they are impressed by something? (c) whether children notice the change in the weather, whether they see only dirt (for example, in early spring) or notice dripping roofs, soaked roads, bluish-grey snow, and lots of "mirroirs" scattered everywhere by the spring to make the trees prepare for the spring blooming? (d) what kind of life situations do they appreciate, what makes them think, laugh, cry, feel compassion; (e) what impressed them and what makes them excited and expired; (f) what makes them happy?

4 HOW TO SPLIT CHILDREN INTO GROUPS AND LET THEM SHIFT FROM ONE GROUP TO ANOTHER

Let us start with an example. We have received two descriptions of the late autumn. The first one: "It is the time when the weather is getting colder, the day – shorter, the night – darker and longer, but there is no snow". The second one: "It is the time when the water is getting tired, and it means that the snow is near. "What is up?" – "The snow is up or perhaps down".

The first child enumerates the signs which help him to understand that the winter will come soon. He acts as a observer, as a researcher, discovering the changes and establishing the links between a cause and a consequence.

The second child reveals a poetic way of observing nature, he uses the metaphor "tired water" in case he knows nothing about metaphors. It is just his way of viewing the world and

establishing another kind of links, endowing everything with feelings.
The way children perceive the world influences the type of material presentation: so called poetical or scientific. In both cases the curiosity is aroused, information processing ability and sound creativity are improved. Both cases aim at paying a special attention to improving the language skills.
It is possible for children to shift from one group to another if the changes in the world perception are revealed.

5 TESTING MATERIALS

The swiftness of establishing the conceptual ties between different thematic domains reflects the maturity of a cognitive mechanism. The process of studying and socialization aims, in particular, at constructing a great number of thematic subspaces in the world's conceptual picture of the child.
If the conceptual ties are not activated while discussing various books, stories, while analyzing information, taking a decision, then the child can't use his/her background knowledge. As a result, the processes of information processing, of taking a decision, of socialization become more complicated and very often mislead the child.
An example of constructing conceptual ties between different thematic domains at the lesson during a 20-minutes active creative work is given on Figure 1.
In order to better understand the difference between computer-dependent and computer-independent thinking, we'll consider the essence of creative thinking with the help of a scheme of constructing creative cognitive pinnacles.
Creative thinking suggests the ability of the student to create a new reality or transfigure the existing one. Computer dependent thinking means following the logic of the computer. In case of establishing the conceptual links between various application domains, the qualitative characteristic is defined by the quantity of the application domains linked together, on the one hand, and the

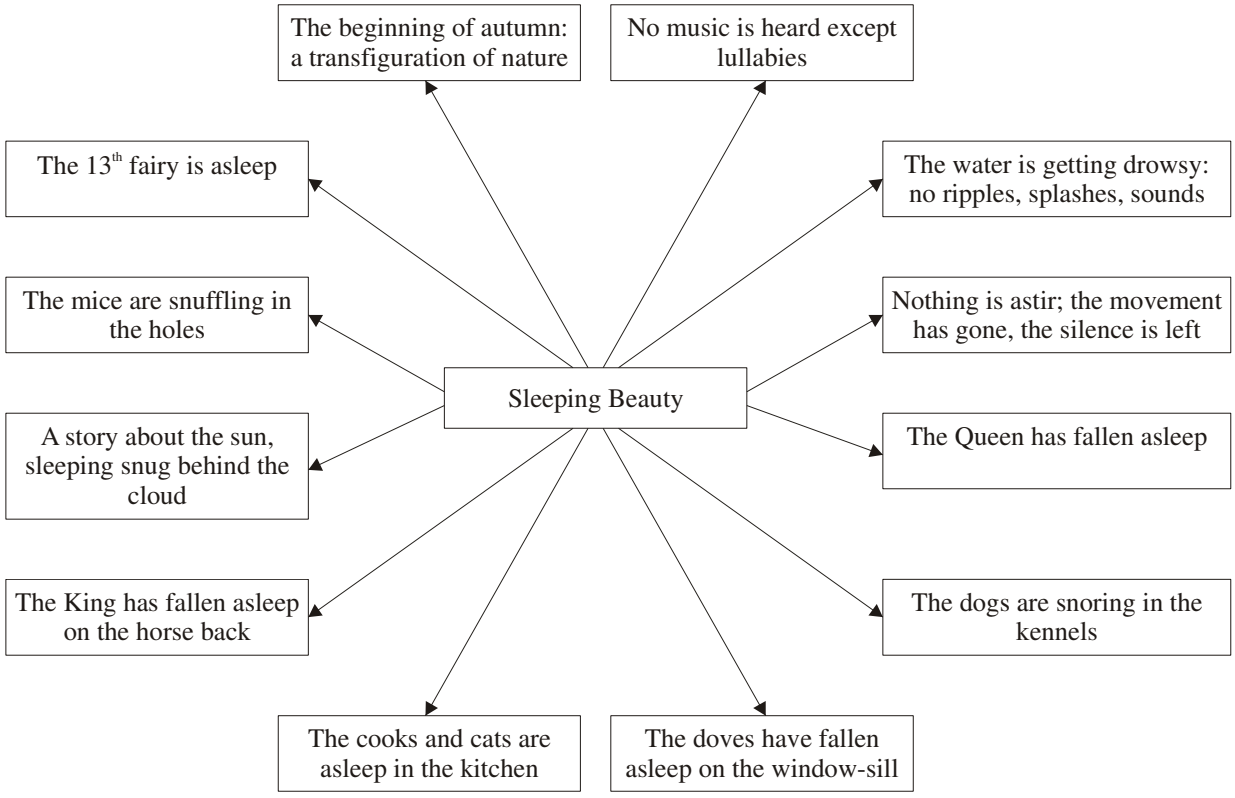


Figure1: *The speed of forming conceptual ties during one lesson of the second year of studies; the age of children is 7 years; V = 12/20 minutes = 0.60.*

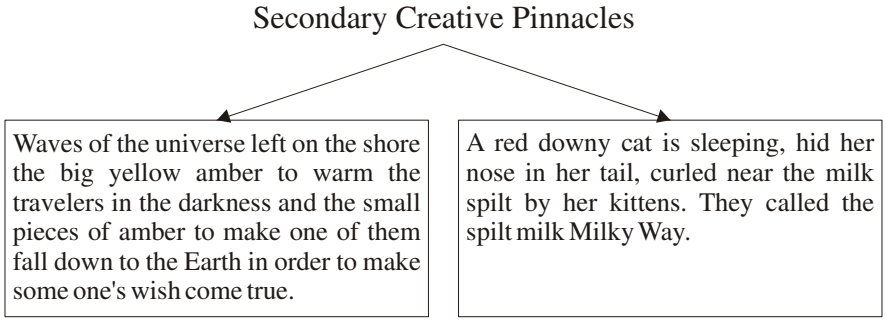


Figure 2: *The examples of secondary creative pinnacles.*

remoteness of these application domains from one another (that is, the lack of the evident ties between the domains), on the other hand. A study of metaphoric thinking was carried out according to the logic described below.

Step 1. Taking into account the initial metaphor and the number of the metaphors created in accordance with the initial model, the students reach *the first creative pinnacle*. It corresponds to a new metaphor being very different from the initial one. It is a result of the unexpected coincidence of the phenomena from two application domains.

Example. Suppose that the initial metaphor is "The moon is a piece of cheese for the mice". Following this model, the young students generate a lot of metaphors, for instance, "The moon is a big round ice cream", "The moon is a pancake with a sour cream", "The moon is a piece of melon". Then one student reaches the following *first creative pinnacle*: "The moon is the silvery ball under the circus cupola. In the circus everyone is awaiting for his/her turn to appear on arena lit up with the millions of the sparkling starts scattered from that silvery ball. In the morning the moon will disappear, the stars will fade, and everyone will go for a work. The miracle happens only night".

Step 2. The *secondary creative pinnacles* designate the appearance of a principally new metaphor based on the independent creative pinnacles (see Figure 2). The initial metaphor usually is a response to the request of a teacher. Then the process of creating metaphors goes on until a principally new conceptual metaphor is created (a creative pinnacle). For the researchers, the creation of secondary creative pinnacles is much more interesting. The existence of the tendency of the emergence of the secondary creative pinnacles and the development of the process of the creation reveal the speed and the quality of the development of the cognitive mechanisms. The maturity of the cognitive mechanisms is revealed in the ability of using metaknowledge.

Unfortunately, computer dependent thinking reveals only the initial metaphor suggested by the computer and the process of creating metaphors according to a model. But it doesn't reveal creative pinnacles of any other levels, because of the lack of a vivid, lively, inspired atmosphere of discussion without computer support. Computer dependency blocks the ability of creating a new reality as a result of considering this activity as an excessive activity.

The digital reality makes the computer and IT overwhelming in numerous spheres of human's activity. It creates the illusion of a new step on the way of civilization. But the development of the civilization without spiritual development is the greatest distortion that diminishes the creative ability of the mind or transfers it into another form, a form of adjusting but not a kind of breakthrough.

There should be two clear, well-balanced main subjects of the educational process of any level: (a) computer literacy, because IT can directly contribute to human capabilities; computers and the Internet have a crucial influence on individual economic achievements and carrier development in the information society; (b) the development of the cognitive mechanisms of information processing and the improvement of the ability of metaphoric thinking, it leads to improving the serendipity.

6 HOW TO ACHIVE COGNITIVE ENGAGEMENT OF THE STUDENTS

Cognitive engagement can be defined as the process of highly motivated intellectual activity when the interest towards the subject under discussion is so strong that the students loose the track of time and, as a result, they are not tired. The students' interest determines the level of involvement. The emotional response is very close to inspiration, because they are making their own discoveries, and their mental efforts are appreciated. It helps to provide a conceptual learning environment instead of a memorization based one and enhances the motivation.

Cognitive engagement is characterized by the following things:

- *focused attention*; it means that within the first five minutes of a lesson the students have come to the conclusion: it is my cup of tea;
- *positive effect* (how do you feel about it); it means that the second conclusion is as follows: "it is good for me";

- *aesthetics*; it means that the way the material is presented meets the expectations of the students, it can be compared with various communicative styles: while communicating, it is better to stick to one style; in this case, it won't disappoint the partner of communication and make the conversation an easy and pleasant business; if the values of the students are clear and they are split into the groups according to their values, then it is easier to arrange the presentation either in a more pragmatic or a more poetical way (metaphorical way);
- *endurability*; it means that a student remembers a good experience and wants to repeat it;
- *novelty*; it is present at every lesson and provides intellectual and spiritual nourishment;
- *reputation, trust, and expectation*; the reputation of a teacher (his/her personal reputation and the professional one) suggests the situation when the students trust the teacher, appreciate his/her time and knowledge and act as the colleagues in the process of co-creation, still being aware of the distance between the teacher and the students, they respect this distance due to reputation of the teacher; in this case, the actions of both sides of the educational process meet the expectations of each other;
- *motivation*; the motivation of the students is closely connected with their values; the human being can be called a biological anticipatory system; everyone answers the questions: "What is good for me and how to achieve the state of complete happiness?"; but everyone defines happiness in his/her own way according to his/her understanding of values; some students are happy if they receive excellent marks; others need not only excellent marks but the awareness of intellectual and spiritual maturity, broad outlook (unconsciously, they are searching for their calling); and only in this case their level of happiness is changed.

To achieve cognitive engagement is very important. On the one hand, it is a marvel, because the teacher and the students become colleagues in the process of co-creation and making decision and keep the distance between the students and the teacher which is underpinned by trust, respect, and appreciation. On the other hand, it is a well managed process of knowledge acquisition. This process is underpinned by the described above mechanism of starting up the creative process in the heads of the students and creating at a lesson a special, thought-provoking atmosphere providing an opportunity for the most effective knowledge acquisition and information processing.

We have discovered the conditions under which this mechanism works well. The main condition is splitting students into different groups according to their values. The values are taken into account in order for creating an inspiring atmosphere, it is the most comfortable for knowledge acquisition. The students step by step receive serendipitous information: it is not expected but desirable and conduces to making their own discoveries.

7 CONCLUSION

This paper grounds the necessity of much earlier socialization of children in modern information society than it is usually done throughout the world. Four discoveries underpinning the proposed way of solving this problem are shortly described. This way is provided by the System of the Methods of Emotional-Imaginative Teaching belonging to the constructive core of Cognitonics. The described methods have been successful tested in the course of a longitude study covering 23 years of introducing young children and adolescents to the humanities.

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THE IMPACT OF THE QUALITY OF TRAINING PROGRAMS ON THE LANGUAGE AND COMMUNICATIVE COMPETENCE OF STUDENTS

Jadranka Herceg, Dean Slavić***
*Ph.D., Agencija za strukovno obrazovanje i obrazovanje odraslih, Radnička cesta 37b, Zagreb, Croatia
e-mail: jadranka.herceg1@gmail.com
**Ph.D., Filozofski fakultet u Zagrebu, Ivana Lučića 3, Zagreb, Croatia
e-mail: dean.slavic@ri.t-com.hr

ABSTRACT

Adult education in the concept of lifelong learning will need significant changes in the organisation of the learning process and adult education. As opposed to the traditional approach with teaching plans and programmes, which stress the content that needs to be taught, teaching basics should prescribe the learning outcomes, define the standards of knowledge, skills and abilities which need to be achieved by all participants.

The main goal of the research described in this paper is to find and create the new models of the teaching basics of the Croatian language in the programmes of training and specialization of the secondary education of adults with the purpose of encouraging the new policy.

The research has shown that there is a need for the implementation of the teaching basics of the Croatian language into each training programme in order to enable the participants to achieve the necessary level of literacy.

1 INTRODUCTION

Adult Education in the Republic of Croatia, in the context of lifelong learning, now takes on a new dimension. It has become an integral part of a continuum of learning and education of person in all stages of his/her professional work, and leisure time with the fundamental aim of education becomes a factor in personal and social development and prosperity.

To respond successfully to the development of challenges in the world market, in 2006 the European Union has set eight main competences for lifelong learning: communication in the mother tongue, communication in foreign languages, mathematical competence and basic science and technology, digital competence, learning to learn, social and civil competences, entrepreneurship and cultural awareness and expression in the culture. The Educational policy of Croatia has accepted the same key competences.

"To achieve the competence as the final goal of learning, the teaching subject and its methodology should be a more powerful step in the life context than the current school, which expands the space of active systems and methods of teaching and learning. The concept of competences certainly requires a new concept of program / curriculum, and thus the new methodical approaches to teaching / learning".

The traditional educational paradigm still prevailed in Croatia is focused on the subject, not the person, on the outcomes, not the process, on the disciplining / adjusting people (students) to existing social patterns rather than creating conditions for the development of effective creative potential.

"The priority goal within the education system should not be the adoption of a large quantum of educational context to extent, but to a larger extent development of logical and creative abilities of individuals and the ability to change and innovate the existing situation".

2 THE FIRST COMMUNICATION IN THE MOTHER TONGUE AS THE FIRST CORE COMPETENCE

The basic purpose and scope of this work is to show nonimplementation of Croatian language as a subject, and thus linguistic communicative competence in the training and development into the programs for secondary adult education and to propose new teaching basis of the Croatian language in the training and development programs for secondary adult education.

In the process of bringing the Croatian Qualifications Framework, we believe that it is necessary to adopt an approach of total quality. The model of total quality management includes planning processes, process management, continuous improvement, total involvement and dedication to the users (students). Achieved level of quality observed in this way has a tendency of constant growth because the educational facilities, as part of the teaching basics of Croatian language, must be replaced in accordance with the changed social demands and needs.
The central part of the teaching basics is directed to the process of the organisation of the learning, and on this ground the decisions are made on teaching activities based on the knowledge, skills and abilities. Our intention is to meet these

criteria in the way that the Croatian Qualification Framework is set as „conditio sine qua non“.

In matters of the language and communication areas language is both the tool and content of teaching and learning. The mastery of the language (especially the mother tongue, but also other languages) is the base for lifelong learning".

The purpose of teaching Croatian language is to enable participants to gain knowledge, abilities, skills, attitudes and values necessary for lifelong learning. Croatian language is the basis to all other subjects and during school education, so in teaching Croatian language, within the usual appropriate approaches and methods of teaching, we should strive to successful application of modern approaches and methods attendant to further language development.

The main objective of teaching the Croatian standard language learners' training programs repeats the previous stages of acquired knowledge, improving knowledge and systematizing the new awareness and a proper official communications, which is wrong.

The outcome of teaching basics of Croatian language training programs for secondary adult education is to teach students the language and the culture of the Croatian language. Language culture is acquired through systematic learning, and the path to it is long and arduous and never stops as part of lifelong learning. However, while learning we become connoisseurs of language who memorise and by the period of time we eventually judge what is proper and what is not, what belongs to standard language, and what doesn't. Culturally speaking or writing means functionally exploit the word, in accordance with the subject, purpose and participant communications.

3 RESEARCH METHODOLOGY

3.1 The Objectives and Tasks of Research

In according to the object and the problems of research, it is possible to set the general and specific objectives of the research:

a) to find out how many training programs for secondary adult education in their curricula нaмy Croatian language represented as a subject, and thus language and communicative competence represented,

b) to analyse the level of linguistic and communicative competences of students training programs for secondary adult education (as concerns the Croatian language system),

c) to analyse the needs for linguistic and communicative competences of students in training programs for secondary adult education and students' teachers in these programs.

3.2 Research Hypotheses

Keeping in mind the theoretical knowledge and the problems and objectives of the study, we are based on the following hypothesis:

In this paper, the main aim of the research (H0) is to identify and design new models for Croatian language training programs developed for secondary adult education, with the intention of promoting new legal regulatory associated with the subject of research. The confirmation of the basic hypothesis as the result of synergistic analysis of **H1, H2, H3 hypotheses:**

H1 Croatian language, as a subject, is not sufficiently represented in the training programs for secondary adult education.

H2 The level of language and communicative competence of students training programs for secondary adult education is low, because of a delayed implementation of the Croatian language as a subject in the programs themselves.

H3 Developed linguistic and communicative competence is a prerequisite for the adoption of quality training programs for secondary adult education as well as for their quality teaching.

3.3 Statistical Research Samples

The first sample of respondents are participants of the training program (NPO = 300) and training (NPU = 200), Np = 500 at the Open University of Zagreb.

Another sample of respondents are teachers (Nt = 50) who teach the students in the training programs of the Open University of Zagreb.

3.4 Methods, Procedures and Instruments of research

Special features of the training programs have resulted in the selection of appropriate methods, procedures and instruments of the research. Method of applying knowledge from the scientific and technical literature and methods of analysis of pedagogical documentation were used. By application of descriptive methods the current situation on the basis of existing documentation is determined.

Two tests we are used in the study. Each test has ten tasks, shaped like tasks closed and open-ended. In some tasks the participants had to circle the correct answer, somewhere they had to formulate a response to the available content, while in some tasks they had to form words, sentences and text independently.

The first test checked the attendant language and communicative competence in training. The test is made up of ten tasks. In the first nine tasks participants supplemented or answered, circled the correct answers, and the linguistic, theoretical knowledge of the rules of this part of linguistic and orthographic system were checked as well as the knowledge of the vote and voice conferences, writing capital and small initial letters, writing, punctuation, writing words, sentences and text. The tenth task was to design a functional writing style (application for employment). The purpose was

to establish knowledge about writing capital and small letters in sentences and words, punctuation use, sentence structure and structuring of the text. For filling the form a period of one academic hour (45 minutes) was provided.

Students tested in language and communicative competence could collect 18 points. Points were collected and the totality of all the tasks (18) expressed the level of linguistic and communicative competence of the participants of the training program. To be able to check individual components of linguistic-communicative competences, the results were grouped into the following groups: a) spelling rules, voices and voice sets (tasks: 1 - 1 point, 2 - 1 points, 3rd - 1 point, 4 - 1 point), b) spelling rules, capital and small letters (5th mission - 5 points) c) correct spelling, punctuation (6th assignment - 1 point), knowledge of verb forms (7th task - 2 points), knowledge of forming sentences (8th assignment - 1 point), knowledge of the Croatian language treasures, Dictionary (9th assignment - 1 point), knowledge of text formatting (10th task - 4 points).
By the second test attendant linguistic and communicative competence in training programs were checked. Due to space in this paper that cannot be further interpreted.

4 THE RESEARCH RESULTS

4.1 Research Training Programs

The first hypothesis wich says that Croatian language as a subject matter, underrepresented in training programs for secundary adult education, is confirmed by the fact that the trining programs we studied Croatian language as a subject matter, is present in 7.81% and training programs only 6.66%.

The second hypothesis, which says that the representation of the Croatian language in each of the training programs prerequisite for developing language and communicative competence has been confirmed by two tests that examined the linguistic and communicative competence of students training programs. The hypothesis was confirmed because no one task subjects / participants has not responded to more than 50% accuracy, indicating low levels of development language and communicative competence because of the ignorance of Croatian language.

The third hypothesis says that developed linguistic and communicative competence is a prerequisite for successful implementation of training programs for secondary adult education, as well as the adoption of a quality program. We confirmed the verifiability of this hypothesis by two questionnaires that showed the need for a developed language and communicative competence of learners training secondary and adult education teachers who teach the students during the program.

5 CONCLUSION

Language is the most important part of the cultural heritage, the foundation of personal human rights, media insights and finally the building of a nation's identity. Proved low level proficiency of participants of the training program and training of the participants here is a sign of the general low level of competence in the area of the Croatian language in similar institutions. Therefore the text indirectly calls for a change in legislation and the obligatory introductions of the program of the Croatian language to create and run by experts in the Croatian language, means Croatists.

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THINK OF CULTURE, CARE FOR ART.

PRESERVATION OF CONTEMPORARY HERITAGE IN MODERN SOCIETY

Monika Jadzińska
Academy of Fine Arts in Warsaw, Poland
Faculty of Conservation and Restoration of Works of Art
Wybrzeze Kosciuszkowskie 37, 00-379 Warsaw, Poland
Tel: +48226251251; fax:+48226229649
e-mail: monika.jadzinska@gmail.com

ABSTRACT

In times of changes, economic and financial crisis, globalization and technological revolution, culture and art seem to be one of the most stable and promising area of development of a civil society, new chance for future, as well as a crucial investment. Modern and contemporary heritage is an important part of it and thinking about its preservation is our duty and privilege. There are some issues described in the paper: the role of culture and art in modern society, complex and sometimes ephemeral character of contemporary art, comprehensive care of visual arts legacy and the role of science in art preservation. The interdisciplinary, innovative project connected with new materials and technologies in art and conservation through building a knowledge for identification, research and methodologies with scientific, artistic, cultural and social importance is mentioned as an example.

1 INTRODUCTION

In the age of economic and financial crisis, crisis of faith in the sense of sharing values, the age of globalization, demography, climate, migration, economic and technological changes, as Androulla Vassiliou, the member of the European Commission described: "the most promising areas of development are education, culture, intercultural dialogue, and citizenship" [1].

1.1 The role of culture in modern society

The role of culture is noticed as a strategic area to force future creativity, innovation and integration in modern society. Culture was and still is the anchor contributing directly to the peace, prosperity, solidarity, and "union in diversity" in Europe but also in many other regions all over the world. Supplementary culture and the arts have a lot to bring to society and the economy as well, creating jobs, new possibilities and needs (see the Guggenheim Museum in Bilbao or Tate Modern in London phenomenon). Culture plays the crucial role in fostering economic growth and stimulating innovations. And it is not only the economical case. Conservation of material heritage which have been damaged through war, natural disaster, or displacement, supported the sense of national identity and collective memory. For example, Warsaw's Old Town, Poland, which was completely destroyed after World War II (more than 80%) was meticulously rebuild and has been placed on the UNESCO's list of World Heritage Sites as "an outstanding example of a near-total reconstruction of a span of history covering the 13th to the 20th century". Today social projects through the cultural, conservation and artistic initiatives create, preserve or rebuild the collective identity and memory in big centers or small, local communities (for example Museu da Maré in favelas – slams of Rio de Janeiro – created and run by natives for natives to preserve memory, find and prove their values).



Figure 1: *Rebuilding collective identity: favelas (slams), Rio de Janeiro, Brazil, 2013. Stimulation of local communities' creativity by cultural events (Museum of favelas- Museu da* Maré*), photo: M. Jadzińska.*

Recent years have brought many events that have affected the projects, congresses and meetings in this field.

Tremendous roles of culture and arts were broadly discussed as a subject of some important initiatives organized by European Commission. *European Culture Congress* in Wrocław, a part of the 2011 National Cultural Programme of the Polish Presidency, was one of it, and a *New Narrative for Europe* – congress organized by European Union President Barroso in June 2013 was the other. They arranged artists, intellectuals, academics, scientists and other citizens to launch a debate on creating a new vision for Europe. As they claimed "the long-standing postwar leitmotiv 'peace through a common market' needs a new 'version 2.0' " to breathe new life into the European spirit by exploring the history, values, symbols and cultural aspects that unite citizens and come up with a "new narrative for Europe". In addition to human dignity, freedom, democracy, equality, the rule of law and respect for human rights, cultural values build the core of the whole European construction. It seems to be not only European point of view. Culture and art seem to be one of the most significant form of human creativity, barometer of material and social civilization, new challenge and the chance for the future. "Culture plays a key role in bringing various divides between people/citizens. It provides us with the tools necessary for reflection and for gaining a deeper understanding of the world, our society, and our own place in it. At the same time, culture is a crucial investment. No other sphere of life is more important in the development of a civil society that will care for the future, memory and spirituality of the coming generations" [2].
Thinking of "how to use the culture and art" to create new narratives and new visions, we cannot forget to think "how to preserve (maintain) the culture and art" to make it all possible.

2 MATERIALITY OF CULTURE AND ART

Each work of art, artifact or object representing the trace of our history, is exposed on the destruction. Materials and technique have the first and foremost influence on the pace and manner of degradation, but also a whole range of external factors related to storing, displaying and other actions which were undergone. New York-based art historian Gary Schwartz in his article, *Ars Moriendi: the Mortality of Art* set that standard for the preservation of works of art is their destruction, rather than lasting. He revealed the test results, according to which to this day 99,4% of manuscripts developed in the Middle Ages HAS NOT survived, as well as 98% of the carved altars of German arising before the year 1800, or 90% of the Dutch paintings created before the year 1700 [3]. Our idea of the art and culture of those times is based on a fraction of what it was then, and this is what survived, often preserved in altered form. Despite the fact that they were usually objects created for their survival, which is in accordance with the rules of technology, these works have not survived.

2.1 Keep impossible

So what will happen with objects and works of art of our time, made often in contradiction with rules of technological correctness? Globalization, cultural change and impermanence are the hallmarks of our time - time of rapidly changing technology, recycling, massive amount of disposable materials, rubbish and incredible speed in all spheres of life. A reflection of those times is the artists making up the work intentionally or accidentally ephemeral, based on an unproven, experimental approaches and with poor quality materials. Perishable materials and lack of information on the position of the artist in relation to forms of behavior can result in deformation of the idea as well as the destruction of matter. This applies in particular to ephemeral artworks, installations, works of *time-based media* due to the galloping changes in technology, but also to kinetic art, land art, environment, happening, and others.



Figure 2: *Contemporary art affects the viewer by arranging all his/her senses: Kimsooja – Korean pavilion at the Venice Art Biennale, 2013, photo: M. Jadzińska.*

2.2 Impermanence of matter

The change of mind about the material in art began at the end of the 19th century. *Small fourteen dancer* (1881) was created by Degas with the polychrome wax, silk and real human hair (obviously there are many examples of such combination of materials in religion art). Another radical step was collage. Cubists used fragments of wallpaper, newspapers, tickets, or other little significant "scraps of everyday life", already degraded when they were reused. Then the artwork became universal in artists' opinion. During their life, at the Museum of Modern Art in New York, it was decided to put a layer of varnish on the top of the pictures. It appeared to be extremely controversial decision for the artists. Braque and Picasso didn't want to accept it as they treated the surface of the work from that period as a reality, not its representation [4]. They were aware of what and why they used. The same as Kurt Schwitters in his *Merzbau* (1919-37), the most famous example of an object made of secondary, destroyed and waste materials, engaged in a few floors of his house,

formed by cartons, rubbish and small “witness of life” like newspaper scraps, cigarette butts, tie, etc.
On the other hand, usually "the choice of material" meant the lack of reflection on the future of its object. Different connections, sometimes destructively affecting the substance, have already produced staggering results after a few years. Usually artists using contemporary measures do not have the experience and knowledge on the processes of aging and the result of damage.
A decisive influence on the change of thinking about art matter had “ready made”. The use of everyday items had led to the fact that "the decisive became the only concept". Since the 1960s the concept of creating works whose existence was linked with the idea of impermanence has been broadly accepted (among others: Marcel Duchamp, Joseph Beuys, Lawrence Weiner, Sol LeWitt, Robert Morris).



Figure 3: *New materials in art. “Venetians”, Paweł Althamer, 2013, Venice Art Biennale 2013, photo: M. Jadzińska.*

3 PRESERVE VALUES AND AUTHENTICITY OF OUR TIME TO THE FUTURE

One of the most crucial factor conditioning the value of an artwork and the manner of conservation treatment is authenticity. It has influence on all decision-making models, as well as methods of preservation, display and conservation-restoration of a work of art. The criteria of authenticity and treatments applied by conservators have changed, enriched by cultural diversity and taking shape throughout the 20th century. Authenticity of contemporary heritage not only concerns the material substance of a work, but also its conceptual content, context, function, space, place, time and perception of the viewer. All of those factors must be considered during the preservation and conservation-restoration treatment.
There are a lot of particular difficulties, for instance, preservation of the ephemeral material when the artist’s idea connected with its degradation is unknown, the importance of context of place (the preservation of a work connected with a specific place – “site specific” artworks), its spatial relationships and sensual elements. In order to preserve the authenticity of the artist’s concept and allow the viewer to perceive the work as originally intended we have to consider all these factors [5]. Huge amount of forms, ideas, tangible and intangible aspects of contemporary artworks force us to use different forms in taking care of the work of art – detailed research to recognize the material, technique, concept, context; preventive, active conservation, conservation through the documentation (among others – conducting interviews with artists and their associates) and many others.
People have the assumption that heritage conservation is an integral part of civil society. “In the same form, conservation of material heritage is a function observed in every modern society. Conservation shapes the society in which it is situated, and in turn, it is shaped by the needs and dynamics of that society” [6].
Conservators seem to be truly “preservers of values and authenticity” of contemporary heritage in modern society.

4 THE ROLE OF SCIENCE IN ART PRESERVATION

“Generally speaking, science looks for causes, while art looks for effects”. Such “effects” in a form of works of art are exposed to destruction caused by age, human activity and effects of the concept and related material, as well as technology of the work. As it was said, contemporary artists seldom think about the lifespan of their artworks.



Figure 4: *“Dead class”, Tadeusz Kantor, 1975, 1989, Warsaw 2012, photo: R. Stasiuk.*

Conservation is the area where the art and science meet. It is a holistic approach. Conservation as a discipline linking science and art, theory and praxis, active treatment and broad interdisciplinary approach to the subject from the cultural context to the strict material and technical knowledge is the best example of how we can use science to serve (preserve) the art. Using scientific inquiry and analytical equipment, we can understand the material used to make a work of art which is essential to its care, display, exposition and interpretation. Looking for “causes”, physics,

chemistry and biology as well as humanistic disciplines like history of culture and art, philosophy, ethics and others are the tools to analyze the structure and meaning of the work of art to find the best solution for treatment to preserve it for the future.



Figure 5: *Visible color and structure changes of material of the work of art. Fragment of "Mannequin" from "Dead Class", Tadeusz Kantor, 1989, photo: M. Jadzińska.*

4.1 How to use science to preserve contemporary art – example

Let's think about only one but huge range of modern and contemporary art or – more generally – huge part of our culture and life – works of art or objects made of synthetic materials. Now we cannot imagine a world without plastics – credit cards, CD's, computers, mobile-phones, electrical and medical equipment, packaging, cars, boats and many others. In art it seems to be modern material but as a matter of fact different objects – from Victorian brooches, through jewelry, clothing, furniture, parts of architecture to the artworks made of different plastics materials – they have been produced over the last 150 years and as a huge part of our cultural heritage should be preserved.

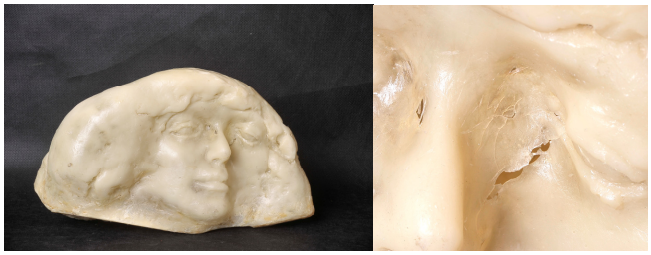


Figure 6: *Visible destruction of synthetic material, "Tumors personified", Alina Szapocznikow. Photo: R. Stasiuk.*

The complex project started in Poland in 2012: *Innovations and new technologies devoted to the conservation of artworks of plastic. Sustainability through building a knowledge for identification, research and methodologies of conservation in the collections and public space.* The project is connected with plastics in art and conservation in Poland created through building a knowledge for identification, research and methodologies made by scientists, conservators, historian of art, artists and registers (founded by National Science Centre, 2012-15). This is the innovative project for interdisciplinary collaborative research, with scientific, artistic, cultural and social importance. It stands for excellence to contribute to developing the scientific conservation together with the possibility of application of the results in museum practice, public and private space. The idea behind the project is to create a kind of signpost, taking from a broad recognition and identification of plastics used particularly in works of art in Poland with the world achievements as background, as well as their maintenance, to identify opportunities for their conservation.

The aim was indicated - the complex care of the plastic legacy in Poland by the research, identification and establishing the methodology of the maintenance, conservation, preservation and exhibition. The essence of the project is to gather the knowledge of the heritage on the basis of extensive interdisciplinary research (chemical, physical and cultural history). This issue has been examined in the countries of Western Europe and USA since the 1980s of the 20th century, but that knowledge cannot be easily transposed to the Polish ground (different cultural, social, economic situation, and other kind of materials). In Poland there is no elaboration on this topic.



Figure 7: *Cross section of "Entitle (Painting)", Leon Tarasewicz, 2001, VIS. Photo: A. Wesołowska.*

The implementation through analytical tests is carried out on case studies of leading Polish artists working with plastics in different period: Tadeusz Kantor, Alina Szapocznikow, Edward Krasiński, Włodzimierz Borowski, Jan Tarasin, Juliusz Antonisz, Stanisław Dróżdż, Krzysztof Zarębski, Mirosław Bałka, Zbigniew Libera, Leon Tarasewicz, Julita Wójcik and Paweł Althamer.

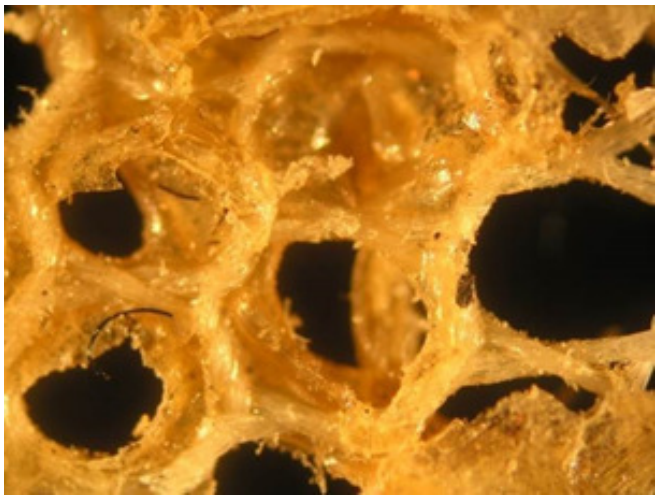


Figure 8: *Sample of "Mannequin" from "Dead Class", Tadeusz Kantor, 1975, VIS. Photo: A. Wesołowska.*

Non-invasive tests were preferred, but also it was necessary to carry out invasive, traditional micro-chemical analysis and the cross-sections, UV, VIS analysis, RTG microanalysis in the scanning microscope SEM-EDS, Raman, IR-RS, GC/MS, FTIR-ATR, HPLC, ASM, TGA, DSC and others. Instrumental examination was carried out in cooperation with the Faculty of Conservation in Warsaw Academy of Fine Arts, Chemical Faculties of Warsaw University and Warsaw University of Technology.

At the same time, the humanity and technical knowledge was built by broad approach, assessment and adapting to the needs: plastics in their historical and cultural context in Poland (art and design), the intentions of artists (interviews with artists), technology, production processes in the region etc.

Such holistic approach to the subject can guarantee proper identification which leads to the proper decision-making model of preservation treatment.

One of the aim of the project, among others (monograph and others) is to prepare the short guidelines – what to do with objects and works of art made of synthetic materials, what is allowed and what is forbidden to preserve them in a good condition (climate principles, rules of storage, transport, exposition) for museums and galleries but also for the public (small private collections, family gifts of the personal importance). It will have the influence for the consciousness and attitudes to the subject in a huge (museums, galleries) and small, local scale in modern society.

5 CONCLUSION

"Preserving the world's cultural heritage to advance civil society" – this is the motto of one of the biggest and crucial conservation research centers, Getty Conservation Institute. Thinking about culture and how it could be used to advance the standard of life, improve economy and create new narration for the future we must take care of our contemporary heritage which force creativity, innovation and integration in modern civil society. And what effect does the conservation of contemporary heritage have on society at large? As Martha Richter from Natural History Museum in London said: change lives, inspire new generations of scientists and artists, offer a democratic space for all citizens, care for and protect the physical and intangible heritage of the humankind [7]. I can only add: let's do it for past, today's and future generation.

Acknowledgements

The project: *Innovations and new technologies devoted to the conservation of artworks of plastic. Sustainability through building a knowledge for identification, research and methodologies of conservation in the collections and public space* was financed from the resources of the National Center for Science allocated on the basis of decision No DEC-2011/01/B/HS2/1/06182.

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SELF-EVALUATION OF HISTORY LESSONS AND SOME RELATED ASPECTS OF CITIZENSHIP EDUCATION

Alan Labus, PhD [1], *Miroslav Miljković, PhD student* [2]
[1] Professor, B A Krčelić College of Business and Management,
Vladimira Novaka 23, 10290 Zaprešić, Croatia
Faculty of Teacher Education of the University of Zagreb
Savska cesta 77, 10000 Zagreb, Croatia
Fax: +385 1 3399983, e-mail: labus.alan@gmail.com
[2] Assistant, Department of Pedagogy, Faculty of Humanities and Social Sciences of the University of Zagreb, Ivana Lučića , 10000 Zagreb, Croatia
Fax: +385 1 3399983, e-mail: miro.miljkovic@gmail.com

ABSTRACT

In this paper, the authors submit the findings of their research focused on self-evaluation of the quality of History lessons in all schools of the Zagreb County, on a sample of 3,617 students and 139 teachers. Results show a statistically significant difference between students' and teachers' attitudes in all aspects of the quality of History lessons which were researched – both in the sense of general teaching methodology (the clarity of learning objectives, the knowledge of expected levels and types of assessment, the quality of feedback on the progress attained, the regularity with which students execute their obligation, the motivation to learn the subject, the development of communicative and cooperative skills, the extent to which work environment is stimulating and interesting, student participation in class activities and lesson planning, and optimism regarding students' abilities to master the content) and that of practical teaching methodology (the didactic justification for the use of chronology and history maps, the didactic significance of textbooks in establishing causal relations, and the significance of History for understanding the importance of citizenship education and political responsibility, for distinguishing between democratic and totalitarian systems of government, and for overcoming prejudice on the basis of nationality, religion and race). A viable explanation for the differences observed would be in the particularly differentiated roles of students and teachers in the organization and implementation of the teaching process. In addition, for a significant number of aspects that were researched, there have been observed certain differences in students' attitudes relative to their gender. Considering the results, the authors offer the proposals for the long-term improvement of the quality of History lessons.

1 INTRODUCTION

School self-evaluation is a relatively complex system of procedures and instruments by which the quantitative and qualitative assessment of the quality and efficiency of numerous educational segments is achieved. Considered necessary for the development of a modern school which adjusts to the needs of students and teachers, such evaluation also tries to respond to the dynamic changes in the post-modern society. In the European context, the basic document in this domain is the Recommendations of the European Parliament and Council. Through promoting quality forms of evaluation and self-evaluation in education, school self-evaluation is encouraged as a method of creating a "learning and improving school" within a balanced framework of the different forms of external and self-evaluation [7]. In Croatia, the Primary and Secondary Education Act (2008) has introduced external and self-evaluation as a legal obligation of schools, based on the explicit argument that such practices aid institutions to further their educational work.

There are different definitions of the term "school self-evaluation". Scheerens (2002) says it is "the assessment of the validity of schools on the basis of systematically gathered information, with the aim of supporting the processes of decision-making and learning" (according to [5]). Mac Beath (2005) regards school self-evaluation as a "systematical and transparent process of reflecting upon their own practices, with the aim of improving the educational process, in addition to promoting professional and organizational learning" (according to [2], p. 7). Blok, Segers and Karsten (2005) consider school self-evaluation to be "a procedure which is initiated and conducted by a school to describe and evaluate its work" (according to [9], p 21).

As a school subject, History facilitates students to learn about and assess familiar, previously established historical facts or phenomena in the course of the teaching process. To a certain extent and relative to the stage of the students' development, materials presented should be a source of

scientific and academic approach to historical issues and their resolution. History lessons should educate students who think, feel and act on the basis of fundamental human values. Therefore, an important part of the teaching aims of History is citizenship education, or the cultivation of responsible and moral citizens.

The function of citizenship education is to prepare students for being active citizens by ensuring that they have "the necessary knowledge, skills and attitudes to contribute to the development and well-being of the society in which they live" [3]. Croatia began addressing the topics of citizenship education in a systematic way with the launching of the National Curriculum Framework (2010) and the Citizenship Education Curriculum (2012). The latter stresses the need to "develop the democratic consciousness in students, but also to encourage their active and efficient participation in the development of democratic relations in school, local community, and general society, relying on the principles of human dignity, democracy, justice and pacifism."

2 METHODS

Research objective. To examine the attitudes (the perception) of students and teachers regarding the aspects of general teaching methodology and the quality of History lessons: the clarity of learning objectives, the knowledge of expected levels and types of assessment, the quality of feedback on the progress attained, the regularity with which students execute their obligation, the motivation to learn the subject, the development of communicative and cooperative skills, the extent to which work environment is stimulating and interesting, student participation in class activities and lesson planning, and optimism regarding the students' abilities to master the content. An additional goal includes the examination of the attitudes (the perception) of students and teachers regarding the aspects of practical teaching methodology and the quality of History lessons: the didactic justification for the use of chronology and history maps, the didactic significance of textbooks in establishing causal relations, and the importance of History for understanding the importance of citizenship education and political responsibility, for distinguishing between democratic and totalitarian systems of government, and for overcoming prejudice on the basis of nationality, religion and race. Student–teacher attitudes, as well as students' attitudes relative to their gender, have been compared.

Hypotheses. 1) There is no statistically significant difference in the attitudes of students and teachers regarding the aspects of the quality of History lessons being researched; 2) There is no statistically significant difference in the attitudes of students, regarding the aspects of the quality of History lessons being researched which could be explained by the difference in their gender.

Participants. Participant structure is available from Table 1. All students and teachers attend or work at the Zagreb County high schools.

Table 1: *Participant structure.*

Participants	M	F	Total
Students	1696	1921	3617
Teachers	47	92	139

Instruments. In collecting data the same questionnaire was used for students and teachers alike. The questionnaire consisted of 15 theses and used the Likert-type 4-point scale, without the neutral choice option (the forced choice method).

Procedure. The research was conducted during March and April 2013, and a new computer program was developed for its purposes. The survey was, therefore, computer based, while the χ^2 analysis was done in Excel. The significance of differences in attitudes was determined by calculating chi-square (χ^2), with the application of Yates's correction of observed frequencies (where the number of observed frequencies in at least one cell of the table has the count smaller than five). Results were interpreted by using percentage calculation and grouping results into two distinct categories, in which the affirmative stance was marked by partial or complete agreement with the theses, while the negative stance was marked by partial or complete disagreement with the theses.

3 RESULTS

As it is evident from Tables 2 and 3, the differences in students' and teachers' attitudes are statistically significant, due to which the first null hypothesis is rejected, in regard to all theses surveyed, both in the sense of general teaching methodology (theses 1-10) and in the practical one (theses 11 to 15). While teachers' attitudes towards the topic of the research are affirmative, students' attitudes vary, but rarely come close to those of teachers.

Table 2: *Values for chi-square* (d.f. = 3; border χ^2 = 11,345; $p < 0.01$).

THESES	Student – teacher comparison	Student comparison on the basis of gender
Thesis 1 – I understand clearly what the study of this subject achieves (its purpose).	58.30025255	24.51329543
Thesis 2 – I understand clearly what I am expected to do, what I have to know or do to receive grade C, B, or A (the level of knowledge).	120.1428226	0.311855356
Thesis 3 – Teacher's assessment of what I have learned helps me to observe the extent and the mode of my understanding class materials.	140.4127453	9.633753466
Thesis 4 – I can track my advancement in this subject and understand clearly where I need to improve.	130.3198499	15.43943439
Thesis 5 – I regularly execute my obligations connected to this subject (attendance in class, writing homework, preparing for lessons...).	32.87121837	18.86542063
Thesis 6 – I am highly motivated to continue to study this subject and work further in its field of interest.	21.97004739	75.32963982
Thesis 7 – Lessons in this subject help me	124.11633466	43.66352896

develop communicative and cooperative skills.		
Thesis 8 – Students find the approach to this subject engaging and interesting.	57.51757664	72.06012114
Thesis 9 – Students actively participate during lessons in this subject (group work, discussions, preparing lesson materials).	16.01889687	23.50607363
Thesis 10 – If I try hard enough, I will be able to apprehend class materials for this subject.	52.33633728	8.156941738
Thesis 11 – Using "chronology" ("timeline") and history maps helps me understand how space and time interrelate.	93.38866336	16.17845638
Thesis 12 – My history textbook helps me establish causal relationships between events in national and global history.	26.2927105	32.79630553
Thesis 13 – History as a subject helps me to understand the importance of citizenship education and political responsibility.	70.29124565	19.16206414
Thesis 14 – History as a subject aids me in understanding the differences between democratic and totalitarian systems.	110.8050987	17.57297648
Thesis 15 – History as a subject helps me to overcome prejudice based on nationality, religion or race.	51.0997027	9.675087274

Table 3: *Extent of accepting theses (Negative stance = I completely disagree; I partially disagree; Affirmative stance = I completely agree; I partially agree).*

THESES ***(as seen in Table 2)***	**Negative stance (%)**		**Affirmative stance (%)**	
	Ss.	**Ts.**	**Ss.**	**Ts.**
Thesis 1	21.81	5.76	78.19	94.24
Thesis 2	15.59	-	84.41	100
Thesis 3	27.23	4.32	72.77	95.68
Thesis 4	24.74	2.88	75.26	97.12
Thesis 5	26.90	24.46	73.10	75.54
Thesis 6	51.65	36.69	48.35	63.31
Thesis 7	50.03	9.35	49.97	90.65
Thesis 8	42.08	11.51	57.92	88.49
Thesis 9	32.98	17.99	67.02	82.01
Thesis 10	9.84	-	90.16	100
Thesis 11	36.09	5.04	63.91	94.96
Thesis 12	34.25	14.39	65.75	85.61
Thesis 13	33.62	7.91	66.38	92.09
Thesis 14	30.25	5.04	69.75	94.96
Thesis 15	31.60	4.32	68.40	95.68

Comparing students' attitudes based on gender, there appears a statistically important difference in nearly all theses, or 11 out of 15. Theses in which no difference was noticed are those that pertain to being familiar with the level of knowledge, accepting methods of assessment, optimism regarding success and the role of History in overcoming different forms of prejudice. Nevertheless, female students are somewhat more critical of the aspects researched (with the exception of theses 10 and 15).

4 DISCUSSION

The self-evaluation of lessons as basic school activities is of a particular importance, which holds true for History as one of the fundamental general subjects in our education system. A significant discrepancy in the attitudes of students and teachers regarding the final five theses, which pertain to very important educational aims of History lessons, clearly indicates failures in teaching methodology, textbook defects, and a lack of motivation. It is a fact that 36% of students do not understand what chronology as an auxiliary historical discipline is, or its purpose. Over 30% of students are incapable of understanding causal relations crucial for social processes from their textbooks, nor can they observe how History as a subject is important for their citizenship education. All of this indicates that nearly a third of all students consider History completely useless and irrelevant as a subject. It is also rather disconcerting that over 30% of students are not able to create a clear image of or notice the important differences between totalitarian and democratic states and social structures.

Unlike students, teachers have huge expectations from History lessons and their influence on both personality formation and the cultivation of responsible and moral citizens. A very high percentage of positive statements in every of the final five theses (there was a positive response from 85-95% of teachers) clearly indicates history teachers believe that the teaching process helps students build a positive stance towards space and time, form a value system based on modern civil morality, and acquire a categorical apparatus in order to understand basic social relations. Only when assessing textbooks as a teaching aid, 15% of teachers responded negatively, ie. they voiced a doubt regarding the realization of an important educational aim, the understanding of causal relations in historical events.

We should not disregard the fact that there exists, though significantly smaller, a certain discrepancy in students' attitudes based on gender. Female students have a more pronounced negative stance regarding the expectation that History lessons could develop a positive stance towards the categories of space and time, towards causal connectivity and towards enlightenment in the sense of citizenship education. When responding to the final five questions, in four out of five cases female students had a negative stance of over 30% and towards 40% regarding the survey theses. This definitely proves the fact that adolescent girls have an even lower degree of interest for History as a school subject than their male colleagues, or that the methodological organization of the teaching process has significantly failed.

The results obtained may generally be applied to Croatian high schools of similar features, such as geographical and demographical characteristics (students of urban and rural areas), the vicinity of a large town, the diversification of educational programs, etc. The research, however, has several limitations: it was conducted in only one county; there are several other valid approaches to the choice of indicators for the quality of lessons and for aspects of

citizenship education; the same issues could be researched combining the quantitative and qualitative methods, etc.

5 CONCLUSION

The subjects of the teaching process – students and teachers – are best placed to reflect on the teaching process itself through the analysis of its aspects. The differences in students' and teachers' attitudes can probably be explained through their specific (differentiated) roles in the reflection on, organization and implementation of the teaching process. This conclusion is supported by the fact that teachers are more affirmative than students regarding all theses. The differences in attitudes based on students' gender are somewhat more difficult to explain and would require additional (qualitative) methods or research before a definite conclusion is reached.

Analyzing the results of the researsch, the authors believe it is necessary to modernize the teaching methods of History lessons and thus suggest the following steps:

- Improving the didactic-methodological training of teachers, concentrating on specific aspects of History lessons;
- Raising the quality standards of History books and accompanying teaching aids;
- Establishing high-quality correlations and an interdisciplinary approach integrating the contents of History lessons with other subjects from the field of social sciences;
- Strengthening the values of citizenship education through History lessons as well as a cross-curricular approach;
- Achieving a higher level of active participation from the students within the educational process (public appearances, offering hypotheses, debates) which will then lead to increased motivation;
- More significant use of modern information and communication technology in lesson planning and teaching;
- Developing a form of self-evaluation, concentrating on the results of learning.

These suggestions would lead to a significant improvement in the quality of lessons and the students' motivation for History lessons. Considering the fact that this leads to students who are more civilly competent, we believe that the responsibility lies not only upon the teachers and schools but upon the creators of the Croatian educational politics as well.

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THE SOCIAL LEARNING IN CONTEMPORARY CRISES, BETWEEN WEB *SITES* AND NATURAL *LOCI*

Rita Micarelli, Giorgio Pizziolo*, Margherita Pascucci**, Lucia Maiorfi****
*International Institute for Advanced Studies in Systems Research and Cybernetics (IIAS), Italian Division, Florence, Italy
e-mail: rita.micarelli@libero.it; pizziologiorgio@gmail.com
**PhD, Free Philosopher
e-mail: mp463@nyu.edu
***Architect, Florence, Italy

ABSTRACT

The financial, economic, political and social crisis -in which all of us are globally compelled - exasperates the contradictions between our natural and technological instruments of information and learning. In this condition the concept of *Virtuality* shows the roots of these contradictions, especially towards the Learning. This paper, throughout the contribution of philosophical and informational researches, explores new learning processes based on an interaction between the two ideas of Virtuality, toward new *life–long learning* evolutionary processes.

1 INTRODUCTION

In this paper we propose an approach to the contemporary globalized condition by exploring the theoretical and material aspects which have been bringing to light its present achievements and contradictions. In this sense the *Virtuality*, intended in its - natural and informational - meaning constitutes a crucial issue to deal with the contradictions of our contemporary world, and their repercussions towards the individual and social processes of Learning. Our exploration begins from the original meaning of the natural *virtual-actual dynamics* -discovered by the philosophical thinking along the centuries- and continues through the current technological exploitation of the virtuality- attempted by the dominant powers.

Along our path we are accompanied by the philosophical thinking explored by M. Pascucci and the recent researches on contemporary informational revolution studied by L. Maiorfi in search of innovative means (approaches and procedures) to reach a suitable *life–long Learning* for the contemporary age.[1] The two approaches allow us to critically re-consider the whole matter of the Learning as crucial issue towards the manifold aspects of our contemporary crises at different levels. In this way we can also imagine a suitable new modality of *Virtual Learning* practiced as a *life–long learning* by the contemporary societies.

2 TEN STEPS, FOR A WHOLE IDEA OF LEARNING

1. The social learning in contemporary globalized world is equally influenced by the websites mechanisms –linked to global authorities- and the daily Life conditions, still-even if weakly- linked to the natural world. The contemporary crisis tends to separate and exasperate these situations, breaking the relationships between human life and nature, strengthening and hardening the hyper mechanical trend of the web net structures.
2. This crisis is produced, and produces at the same time, multiple involutionary simplifications and trivializations, together with various exasperated phenomena (hyper expansions, separations, fragmentations, annihilations) which involve the living world in a self-destructing whirling dynamics
3. Despite these troubles, the spontaneous tensions - recognized throughout the ages by a certain philosophical thought as manifestations of a natural virtuality, that is as intrinsic potentiality of the in becoming phenomena - are still pervading the living systems. At the same time the web world tends to misappropriate these tensions – progressively neglected, annihilated and replaced by a new web virtuality.
4. In this way the web world attempts to dominate the quintessence of the learning processes, hitting in particular the phenomenon of spontaneous acquisitions, which characterize the learning processes and the production of complexity in the living systems
5. In this case the social/individual learning -traditionally practiced throughout progressive experiential acquisitions- could become a web globalized property, removed from the original living contexts, stocked and merchandized elsewhere.
6. The acquisition remains a fundamental step of all in becoming experiences (social and individual) which distinguishes – unequivocally - the natural learning processes from the parallel steps of mechanical stockpiling of data, usual in the web procedures.
7. Nevertheless the living contexts can react and produce new modalities of learning processes, based on a re-acquisition of their vital quintessence, according to the philosophical idea of virtuality expressed - but often neglected throughout the ages- by Olivi, Spinoza, Deleuze and Bateson.

[1] Margherita Pascucci and Lucia Maiorfi are respectively the authors of the **points 3** and of the **point 5**.

8. A new Learning can flourish from these revealing origins, to reconstruct a coherent structure on which a contemporary virtuality becomes again an active and intrinsic part of social processes throughout different experiential modalities where the web dynamics could take part, under the whole control of an adequate and responsible social knowledge. In this way the stockpiled data could be adequately managed and used again to enrich the natural learning processes.
9. In the contemporary condition - with its fragmented phenomena- it becomes necessary to use all the possible modalities of learning, from the natural experiential participative procedures to the natural/virtual philosophical thinking, to the web mechanism of contemporary virtuality. All of these modalities, even if different and contrasting, are necessary to cope with the complexity of our crisis.
10. We could call this phenomenon a very new virtual learning, practicable throughout a multiplicity of integrated experiences where the participants could found again their belonging to the living world and create new Loci of Knowledge

3 THE VIRTUALITY

As we go in depth into the theoretic thinking and into the hyper techno-informational contemporary dynamics, two new questions arise:
*1)… **how** the virtuality has been revealed as the quintessence of the living phenomena and of their autonomous / spontaneous creativity?*
and,
*2) **how** the concept of virtuality has been stolen from the nature to pass into the informational world as an* acquired *prerogative?*

The *first question* leads us toward the philosophical approaches to the inextricable complexity of the world pursued along the centuries, while the science approached and understood the natural phenomena becoming progressively able to control their dynamics and behaviors. This latter approach has been progressively developed through material, theoretical and technological achievements, which allowed the humanity to reach complex levels of knowledge.
But, as the philosophical thinking illuminates, the wholeness of the reality remains *around* and *beyond* our control, while the very living world maintains its autonomous creative prerogatives, keeping the inextricable secrets of its becoming as its very quintessence. Along the ages the philosophical approach to such quintessence considered it as a *virtual and actual unity* able of a continuous *invention of the new*, through an endless, vital, inseparable exchange between *tensions and facts*, *mind and nature.*
The epistemological valuations throughout the western philosophies along the centuries lead us to the original meaning of the virtuality intended as intrinsic prerogative and *sacred unity* [2] of the living world. All of these valuations are suitably expressed by Margherita Pascucci who discussed the original meaning of the *virtual-actual dynamics* as an endless source of creativity which affects and pervade all the living world from the molecular to the social scale [1].

3.1 Virtual-actual *can* and *have to* be translated into tension-fact

What does it mean for us today practically, i.e. politically, to translate the relation virtual-actual in the one tension-fact?
It means to disclose the productive nature of the relation virtual-actual, or, as Deleuze [2] affirmed, to potentiate the nature of the virtual, which is the invention of the new. I would say that the "dynamics of becoming as differentiation and creation" comes to be in the relation between actual and virtual. Actual and virtual are not separated, since the *former* designates the status of material and present things, while the *latter* expresses the event, incorporeal, past, ideal. It is from their exchange, or mutual passing one into the other, that the nature of becoming occurs.
The relation virtual-actual and its dynamics is important to us for understanding the productive nature of that very dynamics, which crashes any equilibrium and irrupts with new seeds, with new rhizomes.

Deleuze showed us the path to conjugate these ontological categories (fundamental also for the creation of new subjectivities) into political ones. The step here proposed is the one which sees the ontological relation virtual-actual be translated into the political one tension-fact; it is the production of the new event according to the exchange between actual – the present, the state of things – and virtual – the 'pure past', the potency of the Whole, the coexistence in an unique Time. In this exchange, in this dynamics, is overcome "the opposition between essence and existence (the existence as contingent realization of the essence) as well as the opposition between possible and real (the possible preexisting logically to the real)".

*The concept of the **virtual** is ontologically, therefore politically, substantially different from the concept of the **possible.*** For Deleuze it is a question of thinking the becoming without reducing it to a *linear realization of the possible.* The virtual is not less existent than the actual, the actual is not the (logical) development of the virtual, and the time is not a line of successive development from the virtual to the actual. In this way the virtual distinguishes itself from the possible, because:

the *possible* belongs to a system of representation (possible/real), that no longer expresses us.

the *virtual*, instead, belongs to the *adequate knowledge* of being, to that material knowledge which produces the

[2] According to these G. Bateson's words.

plus of the matter (difference). It belongs to the *time fold* (past-present-future), to time as the breathing of being.

the virtual belongs to imagination, it is the *indiscernible threshold of reality*.

the *possible* is nothing but a mirage, an illusion of a renewal of the real, when it is only its mirror.

Virtual knowledge does not mean immaterial nor does it mean possible: it is knowledge that coexists with actuality toward the *insurgence of the new*. It has a *whirlpool structure* because, as with the knowledge of the whole of Time, it is on the brim of being, and struggles to be, against death. It is the knowledge outside boundaries, the outlaw knowledge, the knowledge of the common, of the singular composing to the whole. It is the knowledge of what traverses confines, meanings, status quos, in order to open with knowledge's own body another angle, another perspective on the world which is teeming out there, through a "molecular revolution", through a revolution which "comes from the south" as F.Guattari and G.Deleuze said [3].

3.2 The virtual is our south: so, how to potentiate our south? how to construct a *molecular revolution*? And... how to resist the *web occupation* of the planet?

First by seeing that this aspect of our knowledge of the virtual as the pulsating body of one's own productivity in life is the place that has mainly been violated by the production based on capital. Capital, as system of production, provokes an exchange in our system of knowledge: it *substitutes this virtual of knowledge, of our capacity for producing new life, with the possible*, a possible that is cast into and thus managed by its own system of production. The system of representation based on the substitution of the virtual with the possible is today in contradiction again. And it is from this space of the crisis, from the space of the rupture of representation that we can understand the extent to which this substitution has managed our lives and taken away from us our *south,* our *capacity of becoming* the *adequate cause* of ourselves, of being our own *revolution*... With in mind that...the possible is clothed in the virtual because the knowledge of the virtual would empower us with the real connective structure of the social, of the common texture of the social, and would make *the production of the new*. It is this knowledge of the real connective structure of the social, of the collective singularities that we have to pursue, that we want to desire. This is the *longed-for* knowledge that constitutes the *womb of learning.* Theoretically the political conjugation of the relation actual-virtual, which corresponds to the translation of the dynamics of the two into the productive relation tension-fact, can be explained with the disempowering of the dynamics of equilibrium, continuously set by the Power.

3.3 We can briefly refer, as example, to the Israeli-Palestinian conflict.

The friction (tension) given by the body-to-body relation of two opposite forces (Israel-Palestine) if read according to 'mechanics physics' {today's politics} produces the dynamics of equilibrium (occupation), which is nothing but a theft of the time of people's free life. In this equilibrium the movement (the Palestinian resistance expressing the right to life) risks to be annihilated together with the transformation that would adequately express *the differences of reason*, the difference which provoke the dynamics virtual–actual in terms of the status of differences between the two people. But if we think of the dynamic of the real, the dynamics of all the bodies and the minds who still desire their becoming (free, independent, new, common singularities), then we can recognize that the relation *tension-fact* can yet be produced by the adequate relation *virtual-actual*. That material knowledge which exceeds itself in being, is self-productive and marks the new.

3.3.1 For this we need a new *physics of politics*, i.e. a new modality of materialization of it. To grasp the moment in which the new originates and is brought on the brim of being, we have to grasp that the creation of new information happens through a continuous production of new differences. i.e. according to G. Bateson, "information is a difference which produces new differences" [5], with in mind Deleuze's words "the virtual cannot proceed by elimination or limitation, but must create its own lines of actualization in positive acts" and that virtuality's characteristic is "to exist in such a way that it is actualized by being differentiated and is forced to differentiate itself, to create its lines of differentiation in order to be actualized".

3.3.2 The above mentioned thinking gives us the horizon into which this translation *actual-virtual*: *tension-fact* comes to be. The tension must create its own lines of action in order to become fact, and this occurs by differentiating itself from itself, like Bergson's *élan vital*, which "at every instant separates into two movements, one of relaxation (*détente*) that descends into matter, the other of tension that ascends into duration". The tension should 'ascend' into duration – foster and becoming womb to multiple buds - and then 'descends' into matter, that is to expand its contraction and produce the new fact [6, p. 4].

4 THE SECOND QUESTION

Now, about the second question, we wonder to know *how* and *why* the exasperated new conditions of contemporary age have been determined.

We all are conscious that the present crisis has a capitalistic nature and that, in this sense, its behavior towards the living world is homologous to the ones practiced in the past: the misappropriation of the spontaneous resources produced throughout the natural and human evolutive processes and phenomena. Such a misappropriation, which has been practiced along the ages towards the exploitation of matter, energy and human capabilities, is now attacking the secret (and sacred)

phenomena which *produce the new* by *producing information.*
This latter misappropriating attack has been frenzy expanded thanks to the informational technologies, able to reach in depth the very quintessence of the living world: the capacity of producing the *New* throughout natural and social processes. This frenzy dynamics is now influencing the vital dynamics of the Learning processes which are progressively substituted by the sharp, insidious informational mechanisms where the very original *virtual-actual unity* could be annihilated in favor of a mere mechanical relation between *possible* and *real*.
We all have to be conscious of this devious, pervading new condition without giving in to the illusions of such substitution. What we can instead hypothesize is a new balanceable coexistence of the two worlds.

The recent challenging researches developed by Lucia Maiorfi [7] supply a wide and critical seeing on the Web World, enlightening –through a balanced exploration - its dominant tendency and its social potentiality.

5 SOCIAL LEARNING AND TERRITORIAL COMMUNITY IN THE WEB 2.0 AGE

The progress of WWW in the Web 2.0 through online applications allows various high level interactions among the users through the web sites (Blog, Forum, Chat, Wiki, platforms like Flickr, Youtube, Vimeo, Social Networks). By these interactions a complex series of phenomena defined as social learning, participated innovations and co-creation of values, has been developed. In such a new *horizontal interactive context* the individual is involved in a network of specialized *online communities*, focused on wide ranges of specific interests and aims, from the report to the "value proposals".
These *Communities* operate in an *online environment* suitable to develop various forms of *mass- collaboration* – the social media- by using specific interactive technologies, as the ones recently offered by the Web 2.0.
Individual, Communities and Environments, reciprocally linked by sophisticated forms of mass-collaboration, become new *online subjects*. Thus these interactive technologies, originally aimed to amplify the natural capabilities of their users, have been propagated within the whole social living systems, to constitute a whole artificial world, which has been called 'virtual'. This world attempts to substitute the natural one by imitating its behaviors, so that the intrinsic prerogatives of the social living world are actually at risk. The *wholeness* of the *virtual-actual,* the natural fuzzy source of the creative dynamics is progressively annihilated by a crisp mechanical *cause/effect* interaction, while the *social and natural environment*, the very *womb* of the social *learning processes* is substituted by a simplified *online environment* where new *on line Communities* operate as *knowledge citizens* [8, 9].

5.1 The contradiction Attraction /Involvement

Coherently with these insidious but pervading transformations the opportunities offered by the web 2.0, on one hand, *attract* the persons who really believe of becoming responsible and competent managers by interacting with their on line environment;
on the other hand, can *influenc*e the public powers to use these opportunities to go with the times their political leadership and governance patterns.
But, as it happened in the past when the *net- enterprise* pattern spread within the business management where Enterprise 2.0 established Humanistic Management concepts, the homologous Web 2.0 articulated approach has been set in the recent times.
This new Web 2.0 theoretical setting combines the use of social software platforms with a new approach to collaboration and auditing, aimed to "catch new ideas" (…) "learn how to learn" (…) "understand how we are determined by the world and how this world is the result of our efforts", and so on.
In this way the recent information devises once again *imitated* the complexity of the living world, and propagated their influence.
In spite of this successful imitation of the natural processes, the core of the intangible natural womb of creativity is still inaccessible and, even if the 'humanistic methodologies' have been successfully propagated within the business management, they aren't yet adequately utilized by the public governance authorities.
In fact the application of so called "inclusive politics" is quite rare and often neither concrete nor participatory even if merchants, no-profit sector, families, associations are attracted in participatory processes. In these processes they take part just as a pre-conditioned audience without any direct decisional powers. Actually for the territorial political hierarchies it is yet extremely difficult to translate the traditional approaches to local communities into participatory management models. These difficulties have been magnified towards the environmental or urban management as it has been testified by the rare experiential activities recently developed by communities focused on their local problems.
These experiences clearly show how these citizens, separated from their natural communities and life environments refer themselves to a poor imitation of it and operate within a thematically selected *on line environment*, just in terms of services, city planning, and so on, without being concretely involved in the wholeness of their problems

5.2 New horizons

Recently, in spite of these structural difficulties, some experiences of more complex methodologies of territorial participatory governance have been attempted.
They range from dedicated social networks like Decoro Urbano (DU) and ePart which allow the citizens to contact their local government and report disruptions and problems, or allow them to free a new geospatial dataset

participating in the production of interactive maps of their *social life*. Two kinds of these dedicated social networks, as *Open Street Map* or the *Voice of Kibera* testify that the active collaboration by the citizens can help them to experience at the same time the *on line environment* and their *real life environment* through a more articulated self-manageable representation of *environment*.
In this sense the social participatory activities have been developed by using the acquisitions of GPS data or by special maps (walking papers) ri-edited by a free program (JOSM). Practically this website uses the software Wiki [11] which makes the users free to add, modify and delete the contents of *their* maps. In such a way the citizens become builders and users both of their *on line* environments (maps and websites) and of their *real* life environments. The *Open Street Map* (OSM) and *Voice of Kibera* represent the most advanced interactive experiences ranged from the Web world (Communities/on line environments) to the natural one (Societies/Life environments).
In particular, by using a free software Wiki for information collection, visualization and interactive mapping produced by the no-profit firm Ushahidi as a Platform, the Voice of Kibera slum [12], close to Nairobi, mapped and monitored the daily life environment of its population, invisible and not represented in official cartography. Through the website created by this no profit association, the users (inhabitants of Kibera, humanitarian associations and NGO, journalists, etc.) became contextually able to *perceive* and *represent* their life environment, *report* on the map events, emergencies and facilities, even *localizing* the different ethnic groups that live in the slum and their own activities.

The most innovative territorial communities - as Kibera - are based on three different levels of "knowledge": territorial knowledge, ability in representing the ground, technical competences and acquisitions. The share of information and levels of knowledge, the dialogue among the subjects established in such a re-awakened condition allow every user to reach new level of consciousness, in terms of acquisitions of information and competences in each level. Among the subjects, equally referred to the life environment and the on line environment, a dynamic exchange improves and increases the quality of contributions, while the whole process rewards the best practices and the contents, appreciated by the users as the quality of their contributions, continuously improving.

6 CONCLUSIONS

The Kibera experience shows how within the context *community/life environment* has been established that *virtual-actual* creative dynamic is in a continuous translation of the virtual-actual into a new *tensions –fact* dynamics.
Furthermore, we would say that within this context a new dynamic womb has been created, teemed with new differences, shares and exchanges, able to create new differences of conditions (the ones that the philosophical thinking called *differences of reason.*).
The Palestinian experience shows that the natural virtual-actual dynamics can still be translated into tensions-fact social learning processes

The exploration throughout our ten steps and Pascucci's and Maiorfi's researches led us toward a new *virtual-actual* and *tensions/fact* fertile field, where advanced integrated researches can be developed by keeping in mind that:
- The virtual- actual wholeness is still alive and can manifest its potency throughout social learning processes if the natural contexts are maintained;
- From the online environments can raise unexpected connections to the natural ones by attracting but also involving their inhabitants;
- These connections open some surprising relational contexts which are social, cultural, experiential and informational at the same time;
- Unexpected numberless *south* can raise from our contemporary world and disclose the potentiality of a new kind of web/natural acquisitions, available for contemporary learning processes;
- Such potentiality is revealed in its becoming through the continuous interexchange –'nature/web' and vice versa- which produces new *acquisitions* and *differences of reason*.

In this way through the learning processes a new contemporary *ecotone* between the natural and the web world can be established as a new womb where these learning processes are constantly fostered and enriched in an *on line* and *natural* complexity.

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SOCIO-LINGUISTIC ANALYSIS OF SCIENCE TEXTBOOKS IN MAHARASHTRA

Shrikant Kalokhe

Department of Education, Tata Institute of Social Sciences, II Floor, S.R Sankaran Block,

AMR-APARD Campus, Rajendranagar, Hyderabad – 500030;

Shri Tilok Jain Jr. College of Science, Pathardi.Dist., Ahmednagar, Maharashtra

e-mail: shrikantkalokhe77@gmail.com

ABSTRACT

This paper is focusing on the issue of cultural and linguistic dimensions of science textbooks. How science education has to be introduced at the very first primary stage has been discussed. This paper aims to analyse the ways in which the culture and language of child education can be employed in textbooks. It is discussed how an analysis can be made using the content and social-pedagogic relationships promoted by the language of the textbook.

1 INTRODUCTION

After the 13 years of continuous research application work for translating culture from ethnographic information to educational programme in an action research to create successful language arts programme for Hawaiian students Cathie Jordan [1] has proved that in order to be successful educational practice must be compatible with the culture(s) of the children. The natal culture should be used as the guide in the selection of educational programme. Educational anthropology is a helpful discipline for this transformation of knowledge from cultural set to formal education setup. It has rarely seen that such type of mechanism has established over the schools which are educating minority students. The concept of cultural compatibility is central throughout this action research [1].

As the behavior of the child is context sensitive, the way in which a textbook addresses the context and the language of the child becomes the influential issue in the educational achievement of the child. It is known that the behaviour being smart in one culture may be stupid in other culture [3]. This idea can easily provoke us to search in what extent the role of culture and context is important to assign and to shape the intelligence of child. As language and culture are so interlinked, this implies that culture reflected in a textbook must be an influential aspect in the educational achievement of child. Conceptualization, development and assessment of intelligence even cannot be meaningfully understood out of cultural context [3].

In Maharashtra in addition to majority regional languages the linguistic situation is complicated. The presence of several minority languages and hierarchical relationship of caste and class dialects make the discource critical. Therefore the focus on transformation of culture and language in learning, teaching, assessment, and evaluation of science education will surely be helpful to improve the effectiveness of teaching/learning discourse.

About the transformation of knowledge in the academic domain it has been proved that it is possible by multidisciplinary action research to create successful language and arts programme for Hawaiian students. In this programme special attention has been given to the process of translating anthropological knowledge into effective education practice. The role of anthropology has emphasised in such work. The process and the stages involved are organized for moving from cultural theory and ethnographic information to an academically effective educational programme described for the ethnic minority students.

It explains that the knowledge of educational anthropology is helpful for the transformation of knowledge from cultural setup to formal education setup but the rare cases are observed in this regard. It has been very rarely seen that this type of mechanism has been established over the schools which are educating minority students. It also has to be emphasised that to know the problem is not necessarily helpful to discover the solution. They found very well that those students were facing the cultural problems regarding the achievement in the education but they didn't conclude how to develop a new form for them as it was not guided by their findings. That is why five to six years after starting their action research they not succeed to get a direction for the proper action. The concept of cultural compatibility has been central through the application of research.

Textbooks are primary and teaching aids, sources from which students obtain knowledge. Therefore it is important to be aware that the inadequate and inconsistent scientific knowledge presented in the science textbook can negatively affect students ideas. If a textbook is to describe the links between real world phenomena and scientific theories, it is important to take into account the fact that it

is common for students to have misconceptions or other learning difficulties with different science concepts at all levels of education. There must be somewhere relationship between success of the child and textbooks to develop inter linkage between real world phenomenon and scientific theories.

It is the prime need to build the framework of socio-cultural analysis of science education textbook in Marathi language with the help of some basic questions such as:
1. What image of science education has portrayed by the internal content of this text book?
2. Does a textbook helps to understand and acknowledge the value of cultural and linguistic diversity and possess the knowledge, skills and understanding to contribute to and benefit from such diversity?'
3. To what extent a science textbook allows student to have access to the scientific content?

2 THE CRITERIA FOR EVALUATING THE QUALITY OF THE SCIENCE TEXTBOOKS

When we think about the universal approach to the textbook, the question strikes to mind that what would be the ideal form of the content for all? Is it worth to develop such universal form of the textbook to apply on such diverse platforms? What would be the base line of that content which would make consensus among members of all strata of the society? This problem was formulated by Aristotle, who wrote more than 2300 years ago:

"In modern times there are opposing views about the practice of education. There is no general agreement about what the young should learn either in relation to virtue or in relation to the best life; nor is it clear whether their education ought to be directed more towards the intellect than towards the character of the soul ...And it is not certain whether training should be directed at things useful in life, or at those conducive to virtue, or at non-essentials ...And there is no agreement as to what in fact does tend towards virtue. Men do not all prize most highly the same virtue, so naturally they differ also about the proper training for it. Everything we do is guided by our basic philosophy of what we consider to be true and valuable in life. Since this basic philosophy also determines our approach to education it deserves our attention".

This is about the universal focus on education but it becomes more critical during triangulations of content with the socio-cultural diversities. Is it possible to find a critical way of the analysis to balance the all necessities? The critical analysis of textbooks is vital in improving teaching and learning at all levels in the subject. It is a very important issue to discuss the range of academic perspectives on how that analysis should be done.

3 TEXTUAL AND LANGUAGE ANALYSIS OF SCIENCE TEXTBOOK

In the specific sixth standard science textbook of Maharashtra it has been clearly seen that the textbook language plays an important role to classify and organise the content formality and to frame it in an academic setup. This function of language can be realised by specific lexico-grammatical conventions that act as resources for constructing specific pedagogical messages. A teacher must not only acquaint the students with the strange sounds and structures of the new scientific textbook language; he/she must also familiarize his/her students with the culture underlying and pervading the language he/she teaches.

For most people, the main opportunity to learn something about a foreign culture is when they learn a foreign language. Therefore science teaching should incorporate some teaching of culture in its content. The teachers of a science thus have the responsibility to ensure that their students have some awareness of the language culture of the science textbook language.

After the observation of the sixth standard science textbook of Maharashtra it can be seen that reading scientific words in Marathi language science textbook which are often Sanskrit saturated has became a complex skill. Sometimes it could be happen that child may answer brilliantly if the question is simply asked in their regional dialect, how many non flowering plants do you know ? In fact, it would be very difficult if the question would be asked in Marathi that APUSHPA VANASPATINCHI NAVE SANGA (in sanskritised upper caste/class Marathi language).

In the discussion about the different parts of leaf and flower the use of sanskritised words makes reference to the familiar parts. For example, in a simple Marathi a leave is called 'PAN' but to make academic in Sanskritised form Marathi it is written as PARN. With reference to this the Edge of the leaf becomes PARNDHARA, the tip of the leaf becomes PARNAGRA, the veins in the leaf become PARNSHIRA. The use of such words contributes to making a the textbook more academic. The conversion of the contextual empiricist knowledge into academic knowledge goes necessarily through the Sanskritisation. The use of Sanskrit is not an arbitrary or without prejudices in Indian context. The reason is that Sanskrit has been the language of upper castes since thousands of years and especially it has used as a weapon to limit the access of knowledge only for upper castes and to ban it for lower castes in a a hierarchical division of peoples in caste system. It becomes the essential component of textbook to provide alternatives or to control overuse of such Sanskritised words. In order to get meaning and to read with ease and enjoyment, students must know the sounds of the language, its structures, and its vocabulary.

The stereotyping of the gender is the obviously observed fact in the culture of science textbooks of Maharashtra. To illustrate the concept like 'force', the hands making dough to cook bread are always shown with bangles, the fetching of water from well has also shown as a duty of woman. Household work and motherhood are also emphasized as

the duty of woman The textbook gives a very clear message that cooking is the job of females. The binding of textbook with urban and upper class , the caste culture which leads to the certain frame, certain language by considering It as a standard language are serious issues which affect the children from the marginalized sections in Maharashtra.

It can be seen the that whole discourse of science textbook has been driven by the pattern of assessment and structure of question paper.

4 CONCLUSION

There are constructional deviations in the Science textbook of Maharashtra from the reflection of natural setting of socio-linguistic and cultural context of child. Textbooks can play a key role in the introduction of science at primary stage if they assist teachers by providing the scope of freedom to notify the contextual examples from various socio-cultural settings to illustrate the skeletal of the content in textbook.

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DAVID AND LEVIATHAN: FORMING COGNITIVE TUNNELS BETWEEN CLASSROOMS AND ARTIFICIAL PEOPLE IN THE REAL-WORLD

Thomas B Kane
Management Education Centre
University of Stirling
Stirling, UK FK9 4LA
e-mail: t.b.kane@stir.ac.uk

ABSTRACT

Thomas Hobbes gave us a description of Leviathan, as an artificial man, composed of many natural people, who join together and are governed by means of a social contract. We make a case for a new branch of artificial intelligence and education - that Leviathan, working with its natural and artificial persons in real-world settings opens up doors into school classrooms for the benefit of pupils who would ordinarily be socially excluded from such real-world settings.

1 INTRODUCTION

We live in a time when Universities are being criticised for not taking enough young people from disadvantaged backgrounds, at a time when school teachers are being asked to offer evidence of pupils' developing capacities using subjective metrics, at a time when jobs in the real-world change so quickly that it is difficult for school curricula to stay relevant, and at a time when social mobility is on the decline across the western countries. The Organisation for Economic Co-operation and Development (OECD) describes the United Kingdom's [2] troubling social mobility problems: more than 50% of youngsters will grow up to have the same salary as their father. The Sutton Trust[16] shows that 53% of the UK's most influential people were independently educated, including 24% of university vice-chancellors, 32% of Members of Parliament, 51% of medical consultants, 54% of top journalists, 70% of High Court judges… when only 7% of the UK population are. And yet, we know that academic ability is randomly dispersed across all socio-economic groups [3, 4] and that advanced societies endeavour to seek out the best talents within the population to fill top professions.

There is clearly a systemic issue. Within Artificial Intelligence is the notion of Singularity [5], the point at which Artificial Intelligences finally dispense with human intelligence, and set about pursuing their own advancement at the cost of human advancement. The OECD figures suggest that we may have arrived at a Singularity-like situation in modern-life: that tools of our modern cultures, the institutions of our advanced professions may be working alongside educational systems to exclude talented youngsters from socially deprived backgrounds from reaching the height of their potential within the advanced professions. This hypothesis, whether it is true or false, certainly merits investigation. And if it is true, society itself can undertake steps to rectify any unacceptable behaviours.

Independently of such hypothetical work, we are living at a time when communications technologies can connect parts of our world together in a way that was unimaginable even 5 years ago. The proposal in this paper is that we seek to cognitively link operating parts of our society with the educational parts of our society so that pupils have a chance to feel their way into professions, network, and understand the world around them as it is. Such work will open real-world opportunities to pupils at school in an immediate way and with intelligence.

2 LEVIATHAN

Thomas Hobbes[6] introduced us to Leviathan, which he described as a commonwealth, or state, *"which is just an artificial man—though bigger and stronger than the natural man, for whose protection and defence it was intended";* supplying analyses of the social contract natural people accede to in joining up with Leviathan, the civic responsibilities attendant upon the social contract, and how natural people within Leviathan should be governed – by sovereignty, democracy or aristocracy. The frontispeace of Hobbes book showed a crowned monarch whose body and arms were composed of many human heads, all looking up to him.

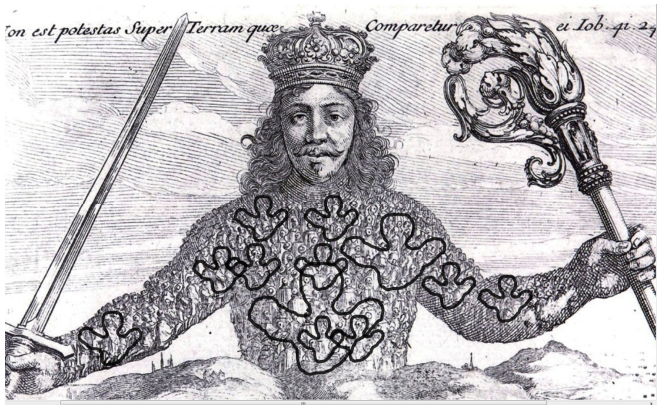


Figure 1: *People, Natural and Artificial, in Leviathan.*

What Hobbes did not foresee was a time when organisations of people within Leviathan's body, would become lesser artificial persons, and would grow to Hobbesian commonwealths themselves, each with its own goals and social contracts. Figure 1 shows what the frontispiece might look like today.

The artificial persons of our modern world (national authorities, local authorities, school systems, businesses) are tools of society. They can be composed of thousands, or even millions, of people at the same time. They have their own reasons for existing, they offer services and have codes of conduct with which their members must conform. Each of these artificial people, like us, is governed by and subject to the overall social contract imposed by Leviathan. Today, a natural person might be a member of any number of different artificial persons at the same time, and may be torn in behavioural terms between differing social contracts; and some of the artificial persons might partner one other, or occasionally be at odds with one another. Schools need methods of engaging with persons, natural and artificial, while they are at work – so that we can see what they are doing in real-time, in the real-world of today, so that they can learn from it

3 TELEPRESENCE and COGNITIVE TUNNELING

Minsky [7] introduced the word "telepresence" into the language. He imagined people at work physically controlling apparatus that is far away from them, with a sense of connectedness. Today, telepresence is a term that is sometimes used for immersive videoconferencing.

Types of videoconferencing that could be described as telepresence in Minsky's terms include situations where young people need to be protected from the overwhelming nature of an event, such as giving evidence at a criminal prosecution, and are allowed to give evidence from abroad. In such cases, the important part of the link is that the young person is both present and absent at the same time.

Cognitive Tunneling

We are looking to a type of telepresence as a Vygotskian [8] scaffolding tool that can aid the bridging of the cognitive gaps between what pupils are currently capable of and what they could achieve. Such telepresence allows us to link pupils to a place of work where cognitive capacities are called upon, and for a while to join the classroom environment with that external environment. (For some young people the cognitive distance between their living environment and these external working spaces might as well be the distance to the moon.) With suitable educational scaffolding, we can ask young people to engage with the real-world as it is (and, even, as it changes), and for the real-world to engage with pupils as they are developing. A key issue in working with socially excluded pupils is in joining the environmental languages of the pupils – their local accents, idioms, dialects - and the professional languages – technical terms, idioms, jargon - of working spaces using Bakhtinian [9] techniques of hybridization and dialogue.

Telepresence allows us to transform a pupils learning areas into a stage upon which pupils can perform, and from which they can draw on school objects and achievements. Similarly, the working environment and working materials of an expert can be brought into a link.



Figure 2: *Artist, Art Gallery : Art-Classroom.*

The challenge is to develop appropriate scaffolding devices that allow a real-world link to be an authentic engagement between pupils and the real-world, to remain in the pupils's mind, and to familiarise the young people with professional activities that they themselves might perform later in life as a result of their education and professional development. We describe work in this area as **cognitive tunnelling**.

4 ANATOMY OF A REAL-WORLD, EDUCATIONAL VIDEOCONFERENCE

The city of Glasgow has linked all of its 29 state high schools into a shared videocoference service network that allows business quality links to any classroom in any high school in the city. The link we are dissecting was part of a programme called "Listening to Young People". The programme engaged young people in schools throughout Glasgow with the Scottish Parliament and with the Civil Service. This school involved in this link was Holyrood High School – one of the largest high schools in Europe.

Real-world educational videoconferencing falls into two types of activities: production activities, and educational activities. A successful real-world link involves a partnership between an educational authority, a content provider, active curricular classroom work, technical services provider and a programme co-ordinator.

Educational Authority – Glasgow City Council had the vision, relationships, power and financial ability to promote the endeavour and make a link viable (within all social obligations) and interesting: this is the highest level of Leviathan at which we operate.

Real-World Content Provider – The Scottish Parliament, provides a real-world scenario for the schools as an educational experience. We linked with a Member of the

Scottish Parliament, Frank MacAveetie, who had been a teacher at Holyrood High School; and one of the parliaments education officers – who brought the parliamentary mace. We saught to explore real-world knowledge which is experiential, drawn from the content provider's daily activities and of their operational procedures, which is Open[10], which is harmonised with classroom learning, which can afford interaction and allow pupils a real-world experience.



Figure 3: *Modern Studies Class to Scottish Parliament.*

Active Curricular Schoolwork – We worked with a first year secondary school Modern Studies class, who were studying the Scottish Parliament. The published Curriculum[14] requires the following capacities:

I can investigate the features of an election and the work of representatives at a local, national or European level to begin to develop my understanding of how democracy works. **SOC 2:18a**

I can evaluate the impact which decision making bodies have on the lives of people in Scotland or elsewhere **SOC 4:18a**

I can debate the reasons why some people participate less than others in the electoral process and can express informed views about the importance of participating in a democracy. **SOC 4:18b**

Technical Services Providers – provider of link from where exactly in the school to where exactly in the real-world. Technical services also have to support users in how to set up camera positions and how to present themselves effectively for transmission. This area of coordination ranges across the educational Internet/communications service provider, the technical support officers at education services, schools and the external places of interest. Smooth coordination here is the technical achievement of the link. This link was between the pupils classroom and a Parliamentary committee room.

Educational Event Producer, or Programme Coordinator – These four areas mentioned above have occasional need to be coordinated during the period of the educational activity. Because the link is scheduled to happen at a particular time and there is a matching of the working day with the school day, there are often small problems that need to be addressed in each of the four areas, and there is always a need for communication between one area of expertise and another (e.g. local authority and real world provider). A fifth category of expertise that co-ordinates the real-world educational intervention, sympathetic to the real-world time and content constraints between classroom, service-provider, content producer and educational authority, is introduced here as the Educational Event Producer, or Programme Co-ordinator. Any tool or person involved in this kind of work needs to be concerned with the quality of the communications and needs to ensure that co-operation between parties takes place appropriately.

The Link

The link was scripted to last30 minutes and followed the format:

1. General Welcomes – welcome to Parliament, Frank MacAveetie; welcome to Holyrood, by deputy head, Bernie Pollock
2. Classroom teacher, Mrs Brady engages with contributors, introduces class
3. Presentation from MSP on Parliament
4. Questions from Class to MSP and Education Officer
5. Questions to class from MSP
6. Goodbyes and round up

One interchange with Mr MacAveetie, regarding homelessness solicited a professional response that crossed all the languages involved in the link – the local, the educational, the personal, and the professional. The question regarded finding a political solution to homelessness, and Mr MacAveetie spoke of a member of his own family, a 71 year old, who was a street vagrant. And then he said:

"But it's not just 71 year olds that are on the streets. I've even seen former pupils of mine who have got heroin problems, actually begging on the streets of Glasgow and it actually breaks your heart, because those young boys in

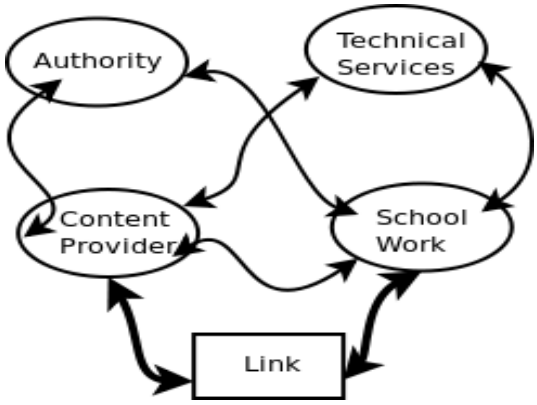


Figure 4: *Lines of Dialogue for Real-World Links.*

particular used to play on your school football team. They were as fit as a fiddle, and then at 16 and 17 they suddenly get into drugs, and there they are at 23, begging on the streets of Glasgow from their former teacher."

The live experience of such a link is very powerful. But videoconferences can also be recorded, as can dialogues between contributors at all levels of the cognitive tunnel. These recorded objects can be constructively, subjectively examined, and the humanity of the contributions can be debated, with a view to making improvements. Such materials can be shared across all state schools, making it possible for all schools to benefit from every link.

Such links require good working relationships between partners within Leviathan. Once a complete real-world programme has been co-ordinated for the first time, it can then be improved upon from within any of the contributing areas of expertise.

5 COGNITONICS, TESTING HUMANITY, EXPLORING REALITY

Viva Voce style Turing-test [1,12] games that could be applied to the production of a link include:
A) Test of Educational Authority: Did the idea serve a valuable purpose? Was it worth the effort?
B) Test of Real-World Provider: Did the external party produce material suited to the pupils and the curriculum? Was this an authentic link with the real-world scenario, or could their real-world contact be shown to be self-congratulatory, cursory, inauthentic or unenlightening?
C) Test of Schoolwork Activity: Is the activity involved in this link related to curricular requirements and suitable to the age and development of the pupils involved? Can recording be used in class? Can learners reflect appropriately, or annotate the experience relevantly?
D) Test of Technical Services: Does the link respect the real-world context of all parties involved?
E) Test of Educational Impact: What impact had the school on the real-world? What token of reality passed from the real-world to the school?

Larger societal questions can be articulated and questions of Cultural Psychology [11] can be addressed. For example:

1. Operational procedures in artificial persons, how they work and whether there are societal issues that need to be addressed;
2. Collective intentionality: whether the artificial persons are welcoming to all, or partial to a few. Do artificial persons use natural persons as shields;
3. Social practices and agreements between artificial and natural persons: whether we are tolerating inappropriate behaviours between persons that is to the detriment of society;
4. Interpersonal dialogues of a Socratic kind. Such dialogues as Socrates might have with the beings of our world where he here today, tailored so that we can understand the world as it is, and the world can know and understand itself;
5. Good relationships between natural and artificial persons within Leviathan.

Cognitonics [15] enables us to recognise exclusion and societal under-achievement, and using ICT itself, to tackle it.

6 CONCLUSION

Modern communications technologies alongside cognitive tools embedded within Artificial Intelligence, allow schools to ask probing questions of the real world. The paper suggests a type of cognitive telepresence that can be achieved through cognitive tunneling, a term that is introduced as a means of bringing pupils right to the working methods of natural and artificial people at work. It suggests a way of extending Vygotsky's scaffolding work to places of live activity that are remote from the school. It suggests that Bakhtin's extraordinary analysis tools for working on language, narrative and dialogue can help us to articulate and then to overcome the cognitive hurdles presented to talented youngsters from disadvantaged communities.

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INFORMATION TECHNOLOGIES AND GLOBAL EDUCATION

Joonho KIM
School of International Relations
Tokyo International University
049-232-1111, fax: 049-232-7477
toko9a@gmail.com

ABSTRACT

The concept of global education has been used in various contexts, but it should be redefined according to human ideal, the worldwide public education system. Digital network system, as technological revolution in the late 20th century, made this education revolution possible.
The globalized network functions as a worldwide social overhead capital to every participant to the network, and education business had become capital-intensive as well as labor-intensive industry, which made the education cost much lower than ever.
This public education system on the cyber space is anticipated to eventually produce the global community in the physical world through the global citizenship consciousness.

1 TUITION AND THE RIGHT TO LEARN

Recently the student rebels occured often in many parts of the world, due to the tuition, for example, in South America, North America, Europe, and Asia. And in some countries, the college curricula are damaged, owing to the students' work for income after class or even during class (called "Arbeit" in Japan or in Korea).

The governments are responding to these educational problems, but the effect is not good enough. All these problems arise because the supply system of education is commercial-based. And unless the intellectual demands of learners are supported by income and respond to the commercial base, the disequilibrium in the educational demand and supply would perpetuate itself.

The solution lies in the epoch-making technological revolution which can join these two contradictory concepts: education and business. The bright side of this age is that we have the possibility to acquire and use this methodology for educational purpose.

2 EDUCATIONAL CHANGES AMIDST TECHNOLOGICAL REVOLUTION

2.1 New technology

Knowledge as the intellect contents is the meaningful information, in the perspective of human being. And education is a system which balance the intellectual demand and supply.
For the equilibrium of these countervailing forces, in other words, for the educational strategies of doing, dissemination, exchanges, discussion, intellectualization [8, pp. 29-32], every age had used the most advanced techniques it could make use of. Nowadays, information technology (IT) methodology creates the media complex, which mixed the educative media and non-educative media. Network technology makes various educational functions possible like the following:
1. the notice board, 2. the public tutorial, 3. the individual project, 4. free flow discussion, 5. the structured seminar, 6. peer counseling, 7. a collective database, 8. group products or projects, 9. community decision-making, 10. inter-community network [4, p.6].
And IT technique revolutionized the education system totally.
Cyber space developed from web 1.0 to web 2.0 with the change of Britannica online to Wikipedia, personal websites to blogging, … domain name speculation to search engine optimization, … publishing to participation, … stickiness to syndication [11, p.13].
These changes show the generalization process from individuality of net participants, through the technology as "natural" outgrowth of society, as agent of social amelioration, as means of social control, as re-shaper of perceptions of space and time, as agent of unexpected outcomes (satire), as agent of doom [9, p.21].
Technology grows out of society and changes society itself. And globalization based on the technological innovation would and could change human society in the direction of globalism. The structural change in education is a typical theme of from globalization to globalism.

2.2 Changes in educational system

Digital network makes it possible to create and share the common space, which is the classroom in education. This classroom exists real as well as virtual in the network space. And the educational difficulty in the past becomes methodologically overcome at present.
Generally this is thought as the development of distance learning. The concepts of learner and teacher disappear over timeless space for intellectual coexistence, in which education is performed in the process of globalization as action at a distance [7, p.199]. But actually distance itself disappears, and the common space of knowledge exists.
Emile Durkheim defined that education is the influence exercised by adult generations on those that are not yet ready for social life. Its object is to arouse and to develop in the child a certain number of physical, intellectual and moral states which are demanded of him by both the political society as a whole and the special milieu for which he is specifically destined [3, p.80].

Here the traditional structure of education is clearly expressed, as the relation of the upper and the lower. But in the cyber classroom everybody can be a teacher as well as a student, who is engaged in joint work, sharing knowledge, not only transferring information. Traditional education format based on the same time, same space, fixed position of teacher and student changed into the education style of the different time, different space, flexible teacher-student relation through the global share of knowledge. And naturally the problem of tuition disappears.
Education is a production system of intellectual value, in which labor and capital are the two elements of production. Traditionally the educational system has been a labor-intensive enterprise, with quality labor in short supply, relatively expensive, and comparatively unspecialized. It is difficult, therefore, to reconcile education for many with education at least cost [6, p. 178].

The characteristic of labor-intensive has been inherent essentially in its direct personal, human relations of educational activity. Historically, education has been dependent upon personal contact between teacher and pupil – referred to previously as "labor intensity in education" – and we find no reasons for anticipating a radical shift in this pattern [6, p. 184].
But by digital technology, education became capital-intensive industry as well as the labor-intensive industry, because general participation can be educational essence in this era of network technology. Participant is a student = teacher = player = laborer, working with computer and smart phone as the phone = game player = machine = capital. The huge amount of personal IT equipments linked to global network offers the unlimited scale of capital as the element of educational production. And this capital produces the educational synergy effect with the unlimited number of human kind using it around the world as laborer. This unlimitedness of the two elements breaks the traditional concept of production function in economics and leads to unlimited production of educational effects.
And so the technology on the global network increases the social overhead capital over the world, with the augmented capital intensity, leading to economies of scale.
By harnessing the power of technology, … "schools can be operated at lower cost, relying more on technology (which is relatively cheap) and less on labor (which is relatively expensive) [5, p.5]."

Overall reduction of educational costs makes possible the general education in its true meaning, which is the economic effect of IT revolution. Technical development can reduce educational costs by
1) increasing the rate of student learning by increasing motivation and student time on task and helping students grasp concepts and demonstrate competency more efficiently;
2) reducing salary costs by redesigning processes to allow for more effective use of teacher time, increasing teacher-student ratios or transferring some educational activities to computers;
3) reducing facilities costs by leveraging home and community spaces in addition to traditional school buildings;
4) realizing economies of scale by leveraging initial development costs as broadly as possible [1, p.27].
On the demand side, a learner can make plan for study, according to his or her own purpose and ability. Therefore learning can be personalized or individualized, and economized. And evaluation and accreditation system will be more effectively managed globally, based on the unified criteria on the network space.

3 UNIVERSAL EDUCATION FOR GLOBAL CITIZEN

3.1 Global intellect structure as common goods

Education system should be common goods, as long as it forms the base of society. Education should be based on the commons concept of knowledge.
In sheer accessibility knowledge keeps moving from the status of monopoly toward that of commonwealth [6, p. 364].
Global common goods should be naturally shared between worldwide participants. Share of knowledge and its limitless usage are performed in the global knowledge pool, and synthetic intellect as the knowledge commons is formed and improves through technical development.
Web 2.0 harnesses collective intelligence [11, p.13].
Furthermore, smart phones, recently, function as terminal to the Big Data and realize the Global Brain (Peter Russell, 1982).
Communication in the network develops the community. If the extent of the network is global, then the global

community already exists. And media becomes more and more the synonym of education. Participation in the network means, in other words, teaching and learning unconsciously.
Human being has two aspects: individual ego and universal Self. Man usually exists as an ego, but when place, time and the point of concentration is given, human can express himself as the universal Being. People throw away the narrow individual ego concept and identify with and be satisfied with this universal Self. The proof of being the Self is done through anonymity in the network space. People are satisfied in being the representative Self, to live as a human being, human kind, not a little individual self. This is the global humanity, in holistic sense.
Here the concept of "having" disappears, and every participant feels happy in "being". This is the typical character of play. So the universalization of subject occurs, on the playground of network space. Ego tries to expand self by "having", but the Self is "being" happy with Itself in playing (=Lila). Nataraja enjoys Cosmic Dance. Global Brain enjoys the world wide flow and structure of virtual reality. When one becomes holistic, "having" loses its own meaning. Usually a person tries to augment himself/herself, because he/she thinks himself/herself as a part. That is the origin of "having". The feeling of link to the wholeness dissolves the urgency of enlarging self as ego.

Thus symbiosis of work and play occurs. Somebody's interest and joy is somebody's work. Therefore when individual plays are offered into the internet, they are transformed into the work, from other's perspective. Therefore on the internet, play and work are synonyms. What is important in this assimilation phenomenon, is the perspective of the many participating in and connected to the network. So one can contribute to the digital world by enjoying one's own play. Playground becomes the classroom. When an individual chooses the field of knowledge according to one's own interest, many others can acquire and develop the contents of the knowledge as the results of the effortless joy. Consequently, micro-level individual interests are conglomerated into macro-level holistic commons on the global network plane. As the result, intellectual pool as the object remains. Wikipedia shows this possibility of common knowledge. The contents in Wikipedia are not merely an accumulation of information but a result of knowledge production. This voluntary participation as an "impossible public goods" is still a "mystery" [8, p.99] and a challenge to human instinct. Similarly, as an alternative to the copyright, the concept of "creative commons" may prevail on the global network, which forms "harmonization from below" [10, p.249].
"University" comes from "universal", which is the character of "universe", all in one. The global network space, which may be called the "globalcity", is the authentic university in its real meaning. IT network includes and synthesizes all the elements of traditional facilities to make the universal educational environment effective;

Library + classroom + teacher + student = university
Here the global education becomes efficient through this synthesis of intellect, if the managerial organization is activated. Consequences of this global knowledge system are not limited in the education field. Timeless and spaceless share of global common knowledge forms broader base of globalism.

3.2 Change for the global society

Global education is natural rights and duty to the global citizen. Global knowledge commons presupposes the share of global ideal and values, which is strengthened by global citizen education. It is a process to identify self to the global over the national ideal and values. This should be offered unconditionally, without private cost.
World peace is attained not through objective relations between nations, which educate their people as patriot to the country, but through the integration of individual subjects through the global common intellect pool, that is, through global citizenship over nationality.
The only justifiably standardized educational curriculum in this sense contains only those kinds of knowledge which are necessary to the process of learning itself, plus perhaps those concerned with the duties of citizenship – which are in a sense tools also, for living together in an interdependent world possessing a vast commonwealth of knowledge [6, p. 364].

Global citizenship fortified by global education makes civilizational change occur. The holistic Global Brain takes care of its own physical entity, which cannot be performed in the level less than the globe. Thus global education anticipates the birth of new planet civilization.
As human knowledge becomes integrated in the holistic Global Brain, organization of knowledge or its system is necessary. That means the formalization of informal education, the systemization and certification of valuable educational contents on the internet. This should include the process of restricting commercialized education system and building the public education system. This would be voluntary organization, as the participation in the net is arbitrary. And the characteristic is successional, developmental, as the participants themselves as learners and teachers improve this system of education.
Structure for the change is summarized as
Global education (contents) + technical development (method) + institutional organization (system)
The most insufficient element of these three is the third, which is to systemize the method of sharing contents and certificating the knowledge.

All this process of education development includes the evolution of human being, from ego to the Self, which seems to be impossible in everyday life.

What is difficult on the physical plane becomes easier on the virtual space. That is the great contribution of network technology to the human being and society. Even the global commons are an object external to human being, but the Global Brain formed in the informational flow evolves into a subject, which constructs those information contents into a knowledge structure, and individual exists as the holistic Self.

4 CONCLUSION

God created the physical world by yin and yang. And human created the digital world by 0 and 1. Now the digital network society has become the synonym of the world itself. That means that we live more and more in digital space, and less and less in physical world.

Through the development of internet society, global education acquires a new and essential meaning to human society, despite of some concerns about "the perils of utopianism and a narrow instrumentalism" [2, p.178].

Actually, technical development is not value-neutral. It is inclined to be linked with the weak point of human nature. That is why so many non-ethical cyber products have prevailed with the introduction of digital globalization.

The significance of global education in worldwide network is that this is the most typical way of globalization to globalism. Technological change is directly linked to the human ideal. Technology can be used in the right way, to the right purpose.

Furthermore, this is the most efficient approach to the global citizenship. Since 1990s, the world has rapidly changing into the "inter-netional" from the "inter-national". People have become more and more to behave based not on the "nationality" but on the "netionality". And netizen means global citizen, on the unlimited cyber space. Just like national identity is strengthened by national education, the global identity can be developed by global education. This can be possible by the capital-intensive education system on the worldwide network.

This technical innovation is not panacea to all the education problems, but at least, it offered the general possibility of eradicating the fundamental problems embedded in this commercial-based education system.

People who are benefited from the global common goods, will contribute to the global society, over the limited national consciousness. And of course, this global identity is the most natural and effective personal identity to the new and righteous world order.

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THE ARCHITECTURE OF PERSONALITY AND PERSONAL DEVELOPMENT

Tarkko Oksala, Aino Oksala***
*Aalto University, Department of Architecture, Otakaari 1, FIN-02150 Espoo and IIAS
e-mail: Tarkko.Oksala@gmail.com
**University of Stockholm, Vanadislunden 1A 1101, 11347 Stockholm, Sweden

ABSTRACT

The aim of this paper is to describe the architecture of personality. Firstly the order, disposition and harmony of mind and personality are discussed. Secondly mutuality, fit and distribution of mentality are considered. This all is made in order to form a firm conceptual basis in cognitonics to discuss the development of ego, the self and a person. The results of analysis may be applied when resolving conflicts at group, national and the global market levels.

1 INTRODUCTION

Architecture as an idea is mainly interpreted with the extensive reality of cosmos (Vitruv) [1] or with the actions of man (Benedict the Nursian/ Gregor the Great). Here we make an experiment to interpret the same idea with the intensive mind and forward to ones personality. The architecture of personality consists of ordination, disposition, harmony (of personality), symmetry, décor/ decoration, distribution (of personality). The content of these notions is described below.

The problems of personality in parallel with architecture were discussed by Cicero [2]. In modern times this spirit was manifested during Enlightenment [3]. Modernism concentrated on dominating amount on the extensive in its architectural theory [4]. Today mnemonics and cognitonics offer a scientific forum to discuss mental processes and personal development in exact terms [5, 6, 7].

2 THE ARCHITECTURE OF PERSONALITY. A

2.1 Ordination in and of Personality and Personal Development

Order is invented in "cosmos" by man and so we learn to see "chaos" around as ordered cosmos. This is possible due to the general concepts (Porfyrios, Boethius) [8]. The self is also ordered in certain extent by itself. [9 - 12] Ordination may be understood in the cosmic sense via categories (Aristotle) [13, 14] or in rhetoric sense. The latter means ordination in dimensions (partly Aristotle), like logos, pathos, ethos, mythos, nomos, cosmos.

Logos and the scale of generality define our understanding of cosmos but also the understanding of human mind as microcosm. Pathos is a type of mental state and is ordered according to intensity. Ethos is ordered in relation to good action [15] (for applications see [6]).

Mythos is an archetype to organize world as history (memory). Nomos and law-likeness is the basic ordering principle of mind (laws of nature and thought). Finally brains as processors follow the laws of nature and cosmos.

Personal development happens parallel with learning some (above) factor after another as regards to our classification of order. These ideas can be applied when studying mind [16], personality [17] and ego [18, 19]. Order as dimension is connected to dis-order like sickness or confusion. Today we have in the information society a novel problem to be confused due to the vast bombardment of both information and dys-information since our childhood [6].

2.2 Disposition in and of Personality and Personal Development

Disposition means the relation of object to each other and to the universe [20]. Disposition may be also cosmos oriented in architecture. In mental architecture the idea of disposition is related to our attitudes [21, 22]. They consist of belief, knowledge, will, desire, feeling, skill.

Our personality is first of all determined by basic beliefs. Knowledge may correct false beliefs in general and concerning the self. [17] Our will is relatively free in relation to what is generally believed or known. Volition is in close mutual relation what we are. "I am what I will" [23].

Desires are typically directed also outside the well-known, but some of them are still realizable in future world. Emotions are guiding humans in great extent and help in cases where we do not know [24, 20]. Finally skill is needed in the manipulation of attitudes in the right and rational way as potential or in flow state as emotionally guided ability to act [25].

A person has continuously to develop his/ her attitudes. In our recent Information Society the value of knowledge is over-emphasized sometimes in the cost of other attitudes (above). Personal development means that we have to learn

the role of all attitudes [7] also in this situation of Global ICT-development.

2.3 Harmony of Personality and Personal Development

The harmony of a person is considered in relation to world (environment), personalities, culture and values [26, 6, 7]. Here we consider harmony as regards to the values of architecture itself, like prudence, honesty, utility, firmness, beauty, goodness.
Cicero called [2] architecture as an art "prudens, honesta & utile". Prudence means to be knowledge-based [27]. "Honestas" means to be firm (noble), beautiful, and good as expressed by these hidden sub-meanings. This has a connotation to the Vitruvian values [1] (firmity, beauty (love), utility). It is also evident that goodness in general is a typical value of architecture of cosmos (Thimaeus/ Plato) and mind. According to the maxim of Cicero, utility and goodness coincide in the long run.

Our personality can develop in the process of knowledge acquisition. This should be done however in honest way and in order to create utility and happiness to ourselves and others [28]. A person should be firm as regards to counter forces (tragedy, torture). Aesthetics and ethics coincide as understood in antiquity but also in modern times [28, 29].
The lack of harmony in relation to environment, other beings and culture cause stress and consequently bodily or mental dis-order [30, 31]. A typical example of violated harmony of personality can be found when domesticating dis-behaved emigrants to their new affiliation. Then the start situation depends on the dis-order of the personality of refugee and the success on therapeutic development [32]. The idea of domestication, clearly, is to forget suffering and to create happiness [28] in the life.

3 THE ARCHITECTURE OF PERSONALITY. B

3.1 Symmetry and Mutuality

We expect that persons are similar enough for understanding one another (ecumeny). In this respect we expect "greatest unity in greatest variety" [33]. This means that people should understand each other in mutual dialogue. Symmetry and mutuality are manifested in the aspects of psyche [30, 5], like thought, mind, spirit, experience, soul, body.
In community we have to share certain thoughts with others, but we should have our own thought to contribute to the common welfare. Human mind and thinking ways have certain common roots (Aristotle/ Poetics), but they are developing all the time in various directions. Spirit keeps the development of mind in the right way. Mind is all the time in interaction with experiences and expectations, which create intensions [22, 34]. Soul controls as based on them our motivation, in few words "what to do next". Body is responding via feeling to all that we are doing [28].

3.2 Décor/ Decoration and Fit

Our mind should fit with the situation around. This is manifested in positive or conflicting ways, like fitting, simple, suitable, unsuitable, abundant, unfitting.
Fit of personality means that we are in good condition. Simple mind may mean good characteristics like to be clear. Suitability refers in certain extent to the fact that we are accepted by others too (compare utility) [17].
Some are unsuitable to certain posts because of lack of talent or education [20]. Some are good in many skills of mind but this is in potential conflict to be really good in certain skill. Finally unfitting mind may be connected to mental sicknesses. They refer to the situation where our mind and personality cause conflicts, crises and catastrophes.
Fit as décor (suitability) is a concept referring to the social reality. The development of a person in relation to various groups can be studied in socio-diagnostic methodology [7]. Décor is related via abundance to the decorative aspects of targets. In the case of personality this dimension is mainly an allegory.

3.3 Distribution and Oconomy (Oikonomy)

The properties of our mind are distributed in certain way, and all this may be studied using statistical profiles. They may describe facts like personal identity, roles, adaptation, profiled mind, polter geist, divided mind. A well-developed human has his/ her recognizable personal identity. A person may act in many roles in society [7]. Both identity and even the roles are to be adapted in the changing world.
Strong egos like to form a strong profile in being something important and resist adaptation [17]. After certain extreme level of resistance we consider a person as Polter Geist [5]. He/ she may be difficult in being before "his/ her time" or also simply stupid. Finally our mind can be dispersed in the sense that it is disordered in psychiatric sense.
For the society it is good if persons are thinking economically in the sense of functional clarity [35]. This is a central goal in education. The development of mind is, however, complex and we have to adapt via humor and empathy to the comedy and tragedy of life [24, 20] in absurd and irrational world (co-existentialism/ [26, 36]).

4 DISCUSSION

The architecture of personality is quite an abstract idea. Its usefulness is tested in the variety of applications. Here we discuss a collective application of mental healing and therapy. Our personality is naturally rooted in certain region of habitation. If this is violated we face problems like stress and trauma. "A person who is everywhere is nowhere" is an antique wisdom [20]. The ostrachism as lost of home was hard punishment at that time. We live in the world of war and un-succeeded regimes. Many persons have as a consequence to leave their homes. Our personal development is violated in the processes of refugee. The only

way to get identity of refugees back is to boost [7] it in the right way and to create new order in life to be internalized. In one word, we have to rebuild identities and notice in addition to avoid unsustainable dis-order and all other dysforms of mental architecture (mal-disposition, disharmony etc.), which lead to consequences like depersonalization [17].

The task of applying architectural theory of personality especially concerns the possibilities of personal development, build up and progress since childhood. Socio-diagnostics [7] offers tools to construct development paths from a certain state of personality to another in individual and group context in order to navigate the personality [6] towards better future.

5 CONCLUSIONS

We have shown how human mind has its own architecture like cosmos do in alternative interpretation. This idea has remarkable consequences when applied to complex concepts like ego, self and personality. These analogies form a theoretical basis to study personal development and therapy in greater detail. The results of this analysis concerning individuals may be applied to larger contexts when resolving problems at group, national and global level.

Acknowledgements. This paper is based on discussions with Joel Majurinen.

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NATURAL PERSONALITY IN VIRTUAL ENVIRONMENT

Ivan Pogarcic[1], Marko Pogarcic[2], Matej Pogarcic[3]
[1]Business Department
Polytechnic of Rijeka
Vukovarska 58, 51000 Rijeka, Croatia
Tel: +385 51 353753; fax: +385 51 257203
e-mail: pogarcic@veleri.hr
[2]MSc in Law, Law Novice, 51000 Rijeka, Croatia
[3]BSc Candidate, Faculty of Civil and Geodetic Engeenering, University of Ljubljana
Jamova cesta 2, 1000 Ljubljana, Slovenia

ABSTRACT

Depending on the perspective and features of science used as base for defining a certain standpoint, personality can be defined as a group of characteristics which consistently define a cultural profile of an individual. Individual himself has a personality which its realisation or manifestation expresses through communication with other objects or persons. Personality, on the other hand, represents a frame which embeds features of the culture and cultural behaviour, acquired moral, ethical and aesthetic values. Basic features of society's culture derive a generic frame for definition of personality. Clearly, a set of cultural features can vary both in content and volume, so they cause differences between societies and their segments. These conclusions were defined according to the personal communication with the respondents. In such relations, the appreciation is confronted to the conflicts which could occur due to differences. Placing such relations within virtual environment could lead to very interesting situations. This paper analyses sensibility of individuals in regards to others and different cultural characteristics of an individual or a society, within a virtual environment. Questionnaire tried to analyse individuals' attitudes on apparently hidden identity, blurred by possible virtual cloud. Paper also tried to examine in which measure the possible virtual anonymity influences existing cultural, moral and other norms.

Key words: Cultural identity, Moral norms, Virtualisation, Virtual identity, Heritage

1 INTRODUCTION

Globalisation, Internet, Web, ICT. These are just some examples of the concepts which turn the world into a "village". Today, the possibilities of communication have become endless. Someone's happiness or misfortune becomes news which can cause the same feelings in physically different and distant places due to speed and possibilities of communication. Still, the communication doesn't solely depend on technical means. These technical means specify and enable mode and volume of communications. More profound side of communication refers to people – participants in communication. By their personal and cultural qualities, people define purpose and goal of communication, as well the other characteristics of interest. In the process, communication itself can assume different forms and modes. Computers, network and the Internet have placed communication into different frames – virtual. Though the concept, according to authors, isn't the most appropriate within existing circumstances, it will be of special interest in this paper and will be analysed accordingly. The goal of this paper is to examine a dependence of ICT and virtual communication upon the individuality, personality and cultural identity. Can virtual frames become the integrator of human society or, in contrary, cause even greater differentiation, or even worse, discrimination and/or segregation of any kind?

2 BACKGROUND

Personality is the characteristics of an individual which differentiates him from the others. Chambers [1] claims that personality is "a unique and unlimited part of people's life, which differs one person from another". The real question is what actually defines a personality? What is the basis for a definition or a classification? Who and in what way defines taxonomy and rules which regulate individual characteristics of personality. The basic idea of this research lies in a claim that personality is determined by cultural identity. If the personality is a measure of uniqueness then it also defines someone's identity. On the other hand, identity is a feature that unquestionably and gradually shapes an individual in comparison to his environment. This individual is surrounded by people and things which place him in time and space. The positioning itself is also unique, if not by other features, than at least by the strict law of physics. A person, as a reasonable human being, is necessarily a social creature, who has a need to communicate with the similar creatures.

Communication implies a need to respect certain rules and laws, regardless to the purpose and complexity of

communication. The way someone communicates reflects his/her personality and so it should be. The other dimension of personality and identity is a culture with all its characteristics. Cultural personality or cultural identity is also a feature which differentiates an individual from the other participants of a group or a culture, and vice versa, according to which someone can be identified as a member of a certain group.

What should be considered as determinants of individual's or group's identity? Pratt [2] considers culture as a "historical treasury" which helps to create identity. Gans [3] comments the claims of critics of cultural identity who believe that preservation of (cultural) identity is a basic which differentiates individuals and societies, but also a force which can anticipate the cosmopolitism. All this should be considered from the aspect of society's quality. The culture shouldn't be something that divides, since difference doesn't necessarily imply the segregation itself in its global sense. In case these circumstances actually do develop, the international societies would become a mission impossible. These kinds of societies enable the exception and exchange of the personal inherent parts which make them recognizable. In this sense they provide the common basis for activity and definition of the possible alternative procedures.

A research started with the assumption that there is a certain group of culture's characteristics which can generally be implied to all people and human societies. These characteristics help to recognize the above mentioned inherent part unique for each cultural institution starting from human – an individual to the society in a global sense. When one adds ICT features to the above mentioned relationships and places communication into the virtual frames, things could change. But first, let us define a frame that will encompass basic features and required guidelines applied in this research.

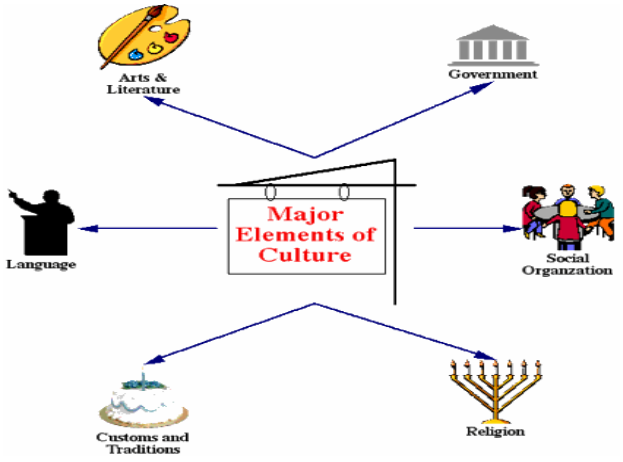


Figure 1: *Major Elements of Culture* [7].

What specifies culture and cultural identity of an individual, a group or a complete society? The literature offers several different classifications of the parameters and attributes of culture which help to define culture in more or less details. The most authors use a set of seven features, which would be:

- Social organization – creation of cultural norms through communities and organisations with the purpose of fulfilling the needs. A family, as a nucleus of a society.
- Customs/Traditions – adopted rules of behaviour in determination of values – customs, tradition, rules, written and unwritten laws.
- Religion – basic ideas of the purpose of life. Monotheism, Polytheism, Atheism, Christianity, Islam, Judaism, Buddhism. Hinduism.
- Government – rules applied in managing and implementation of the cultural norms.
- Language/Education – language is a core of the culture. Even the communities which don't have an alphabet own it.
- Arts/Literature – any form of expression with an artistic character: literature, painting, dance, music etc.
- Economy – the modes of providing goods or making the profits. Are there the traditional forms. Commerce, exchange, public economy

Seven defined characteristics can be considered common to the most of organised communities, with appreciation of specificities which arise from them.

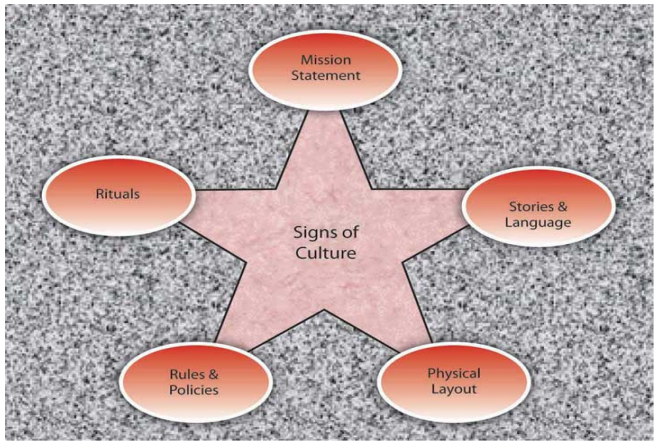


Figure 2: *Visual Elements of Culture* [8].

Figures 1 and 2 display some variations of described concepts, while Figure 3 considers the influence of a certain culture to some characteristics of the organisation's unit according to the principles of evaluation, creation and preservation. By appreciating the standpoints and needs which lead to the consideration of cultural characteristics, and for the purpose of this paper, a group of characteristics can be resumed to four main indicators. These are:

- Symbols – any form (information) which has the same or similar meaning for the members of the same group.

- Language – culture's rudiment, a crucial form of culture's transfer. A system of symbols which allows a communication.
- Values – culturally defined standards applied by members when defining things which are good, nice or useful for social behaviour and life. Values embed the beliefs as well.
- Norms – rules and expectations which are applied in the group members' behaviour. Traditions and customs are included. Sanctions are ways to regulate non-usage or violation of norms.

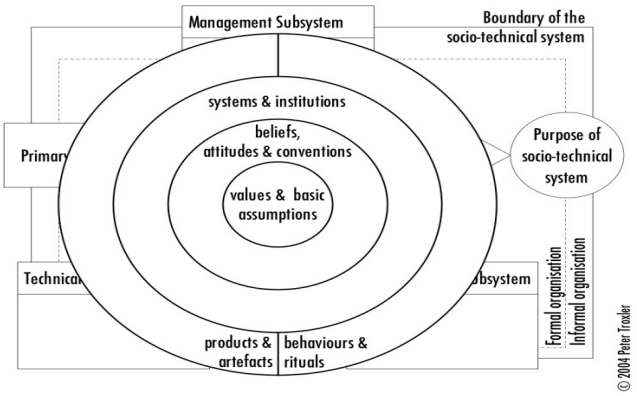


Figure 3. *Aspects of Knowledge Culture* [8].

3 RESEARCH

The basic hypothesis of this paper is that ICT significantly influence the culture's characteristics. A research has been conducted for the purpose of analysis of the perception of intensity and quality of such influence.

Development, availability and brutal consumerism of different ICTs surely have a major influence over the existing cultural frames of any community. Naturally, this applies to those communities which can in a significant proportion use such possibilities. The influence and change are apparent in the phase of insisting on eThis or eThat, such as eLearning, eGovernment, etc.

New circumstances also create a new language. For instance, [5] mentions concepts-coins of the Virtual Nation or CorpoNation, which meaning surely isn't recognizable to someone who wasn't included into the eProcesses.

The research tried to determine in what measure are the respondents informed upon the forms of communication and the according rules. The authors tried to define in what measure are respondents aware of their own cultural values when communicating in the virtual environment. Especially important is how much are they aware of the cultural values of their interlocutors, and whether they can, in a cultural way manage their eventual differences. "All people are the same, they just act differently", said the Kung Fu Ce. Since differences can lead to the misunderstandings, and consequently the conflicts, the authors tried to define the behaviour and actions which the correspondents apply in such situations.

3.1 A questionnaire

A questionnaire has been prepared in two versions: Croatian and English, they were conducted on the Web which provided a possibility of communicating with respondents from different cultural environments, educational levels and different ages.

The population wasn't targeted, except within connoted frames of the possible application and usage of the ICT.

The questionnaire consisted of 20 questions divided into three groups. The first set of six questions was used to determine the structure of the respondents, their age and educational profile, ownership of the specific ICT equipment and the frequency of using the same. The next group of five questions tried to define how much the respondents were socialized during the usage of ICT equipment, how do they behave in communication and in what way do they perceive the elements of culture used as basis of this paper. The final group was comprised of 9 questions to which respondents suppose to answer either by ranking the offered answers or by their evaluation according to Likert scale.

The questionnaire was active on the Web for one month, during which period totally 140 respondents completed it within the first ten days. After that, the number of respondents decreased at approximately three per day, so the polling was determined after 150th respondent.

3.2 The analysis of data and provided answers

Totally 150 respondents approached the questionnaire, of whom 120 respondents completed the questionnaire and answered all questions; 24 respondents didn't complete all the answers, especially the ones belonging to the third set which was the most important; while 6 respondents gave up after reading the instructions. The cultural profile of respondents is created within strict frames of the completed answers, that is, according to the answers provided by 120 respondents.

Totally 43% of respondents were women, 57% men, while one respondent didn't provide an answer to the sexual orientation. Respondents are mostly younger than 25 years (42%), with total population of 90% which was younger than 50. Less than a half, app 40% of respondents, has a higher educational level. The majority owns various devices: 94% computers, 55% smartphones and 17% tablets. The possibility of the constant Internet connection has 95% of respondents, 37% of them use the Internet frequently, while 56% use the Internet quite often. Totally 59% of respondents use Youtube activities, 21% uses Linkedin, 17% uses Twitter, with the majority of respondents using Facebook, totally 74%. 11% of the respondents mentioned the other possibilities and less known networks. The majority of 83% outlined they abide the rules of communication on the network – 46% always, 37% regularly, and 4 respondents answered they never abide the regulated rules of communication. 75% of respondents agree that the Internet communication should insist on the strict rules of behaviour, while 18% disagree. 14% of the respondents prefer to stay anonymous in communication, 75% identifies themselves

after the personal evaluation of the circumstances and only 9% completely identifies.

When analysing the common characteristics of the individuals, the respondents give advantage to the age, education, financial status, religion and gender. High 46% concluded that they appreciate something different, but without a clear definition. Regarding the offered cultural features: 62% agrees that artistic abilities define the cultural identity, 49% priorities the political background of the individual, 48% emphasizes the economic structure of the society, 46% considers the language important, 77% considers the social circumstances, 73% appreciate tradition, while the religion was uniformly divided with 40% respondents who believe this feature to be irrelevant. An interesting fact is that ¼ of respondents cannot determine whether the gender influence cultural identity. 90% respondents believes that offered features can define cultural identity in complete, while 10% supplements it with some attributes (hygiene, parents' breeding), which can be connected to defined categories. When questioned whether the virtual environment can influence the artistic expression of an individual, the respondents were confronted and divided: 32% confirmed and 30% declined. The similar attitude is created for the political structure of the society: 31% said no, while 25% said yes. The influence on the economic structure is according to 37% impossible, 16% believes it is possible, while 30% cannot decide. Totally 26% respondents believe that virtual environment modifies native language, 23% cannot decide, while 34% declines. The similar distribution is with the question of social elements and social organisation. The opinions were confronted for the influence of tradition and customs, since 31% claims these are important, 29% claims that they don't posses such importance. The majority of 46% is decisive in attitude that the virtual environment cannot influence the religious beliefs. If the respondents were treated as minorities and threatened in the virtual environment, 36% would defend their artistic abilities, 40% wouldn't defend their political and economic structure, while 51% would defend their native language, 40% their social security and constitutions, while 50% would defend their tradition and customs. The question of religion is uniformly distributed with 30% per answer.

In case of the cyber attacks, 54% would ignore the communication, 33% would try to animate the larger group in defence, while 16% would confront directly. The answers to the sequence of defending the cultural characteristics were as follows: the first, the second or the third place belongs to the social constitution (13-20%), the forth place belongs to the sexual orientation (17%), the fifth place belongs to tradition and customs (16%), followed by the economic structure (17%) and the sexual orientation (16%). The seventh place belongs to the economic structure and sexual orientation with 17%. 39% of the respondents believe that the Internet and virtualisation contribute to the unification of cultural norms within global frames, but 40% considers this to be threatened by individual cultures.

As a special issue, the respondents emphasize: the language of hate, the usual impersonality and the issue of age identification. As the most interesting attitudes one could extract two opinions which claim: "the Internet: unification of thoughts, consumption of time but with huge amount of news, possibilities and contacts in the field of culture", and „use the Internet with moderation because virtual is not real".

4 PROFILE INSTEAD OF A CONCLUSION

Though the question of the sexual identification was appointed, it is not relevant for the creation of profile but could be used for more specific researches because it offers the possibility of extracting the sexual population from data. The profile of virtual culture refers to competencies and possibilities in the application of ICT. For that reason, an individual in virtual environment has at least medium level of education in the social network of general or more specific type. Approximately 75% of the respondents identify themselves in communication, depending upon the circumstances. The offered set of common characteristics underlines the elderly and education, with other features as equally important. Approximately 40-75% respondents support defined cultural characteristics. 90% respondents believe that offered characteristics can define the cultural identity completely, while 10% supplement them with certain attributes (hygiene, parents' breeding), which can be connected to the certain categories (but there were some opinions that this would mean mixing the apples with pears). In case of the cyber attack, respondents would mostly ignore the communication while in the virtual environment they would defend the following features: social constitution, tradition and customs, economic structure and the sexual orientation. Respondents are aware that the Internet and virtualisation contribute to the unification of cultural norms in global frames, but they do threaten specificities of the individual culture.

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BUILDING PROFESSOR'S MENTAL MODEL OF STUDENT'S ACTIVITY IN ON-LINE EDUCATIONAL SYSTEMS

Țacu Mihaela Gabriela, Mihăescu Marian Cristian, Burdescu Dumitru Dan
Department of Computer Science and Information Technology
Faculty of Automatics, Computers and Electronics
University of Craiova, Romania
Tel/fax: +4025 1 438198
e-mail: mihaescu@software.ucv.ro

ABSTRACT

This paper presents the development of a new feature for an e-learning platform which has the goal to improve the teaching process by helping the professor form a correct mental model of each student's performance (capability). The main functionalities offered by this module are: evaluation of the level of understanding of the course material by the student and analysis of the difficulty level of the questions proposed by the professor for an exam. The prerequisites for accomplishing the task are a good structure of the on-line educational environment and information about students' activities on the platform. An important part of the process of obtaining the desired result is performing a text-analysis and concept extraction on the professor's uploaded courses. The languages supported by this module are both English and Romanian. Using this module, a professor will have the ability to control the difficulty of test and exam questions and make changes accordingly: add, delete or modify test/exam questions.

1 INTRODUCTION

During the last years, the interaction between professors and students in on-line educational environments has considerably improved, especially by developing new tools and implementing different features that integrate intelligent data analysis techniques. An area that still needs further work is the cognitive area, particularly as concerns helping the professors build more accurate mental models of each student's capabilities. In regular educational environment, a professor can achive that mental model by continuously interracting with students and observing their learning skills and capabilities. Online, it is harder to accomplish that because of the lack of permanent and valuable analysis of feedback that is offered by students. That is why the approach to building a professor's mental model of student's activity becomes a tool that can improve an on-line educational environment. The main purpose of the tool is to help the professor understand and analyse student's activity without having any face-to-face activity.

2 RELATED WORK

Analysis of the students' activities in the online educational systems with the goal of improving their skills and experience through the learning process has been an important area of research in educational data mining [1].
Many research hours have been allocated to the purpose of extracting key concepts from course materials, messages, questions and finding ways of using them for enhancing the teaching and learning processes [2, 3]. Also, a considerably amount of work has been put into discovering the similarity between concepts. Relevant in this area is the paper that Tara Madhyastha wrote in 2009 called „Mining Diagnostic Assessment Data for Concept Similarity"[4] where a method is presented for mining multiple-choice assessment data for similarity of the concepts represented by the multiple choice responses. The result obtained was a similarity matrix that can be used to visualize the distance between concepts in a lower-dimensional space.
The NLP (Natural Language Processing) is a major research area with a strong focus on documents (text and diagrams). Particularly interesting from our perspective is the research conducted in the domain of linguistics [11, 12]. The work put into constructing treebanks, both monolingual [13] and parallel, is also important. In [9] M. Colhon presents the construction of an English-Romanian treebank, a bilingual parallel corpora with syntactic tree-based annotation on both sides, also called a parallel treebank. Treebanks can be used to train or test parsers, syntax-based machine translation systems, and other statistically based natural language applications.
Agathe Merceron and Kalina Yacef published a case study about how educational data mining algorithms can be used for extracting relevant information from web-based educational systems and how this information can be used for helping teachers and learners[5]. A comprehensive report on the state of the educational data mining (EDM) was published in 2009[6] and presented a general view of

the EDM field, including the methods used, the papers with the most influence in the field, and the key areas of application.
One of the main goals of the educational research is identifying students' current level of understanding. For this purpose, a series of estimates have been used, including DINA model, sum-scores and capability matrix. A comparison between these estimates was presented in „A Comparison of Student Skill Knowledge Estimates"[7].
This paper presents an approach to using concept extraction along with activity monitoring and concept weighting as concerns constructing accurate models of students' present knowledge and level of understanding of the courses, as well as detecting the difficulty level of each course, course chapter, test question or exam question.

3 TOOLS AND TECHNOLOGIES

The first step in accomplishing this module's purpose is retrieving the text from documents. For reading *.pdf* files we used Apache PDFBox, which is is an open source Java tool for working with PDF documents [10]. For manipulating *.doc* and *.docx* files our choice was Apache POI [14], a powerful Java API designed for handling different Microsoft Office file formats.
Stemming [16] is the process for reducing inflected (or sometimes derived) words to their stem, base or root. The documents written in English were stemmed using the snowball stemmer [15]; as for the Romanian stemmer, we used as a base the PTStemmer implementation [17] and adapted it for the Romanian language by building the corresponding set of gramatical reduction rules: plural reduction, genre reduction, article reduction. The PTStemmer is a toolkit that provides Java, Python, and .NET C# implementations of several Portuguese language stemming algorithms (Orengo, Porter, and Savoy).
The XML processing was done using the Java DOM parser.

4 SYSTEM ARCHITECTURE

The most important prerequisite for the development of such a tool is an online educational platform that has a proper structure for the educational assets and the ability to integrate proper intelligent data analysis techniques. The online educational system we have chosen is Tesys Web [8], an e-learning platform used in several faculties in Romania, that has been designed and implemented to offer users a collaborative environment in which they can perform educational activities.

4.1 Concept detection tool

A key feature of this module is the extraction of the most important concepts from every chapter that belongs to a course. This part of the module is divided into two steps: stemming and computing TF-IDF values. Several tools and algorithms have been developed for English word stemming, but for the Romanian language this research area is still at the beginning, therefore we developed our own tool and set of rules to accomplish this task. After the stemming process we use the TF-IDF formulas for every word in the document and then we store the obtained data into a xml file which has the following structure:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<words>
    <regul originalForm="reguli" tf="1.00" idf="0.47"/>
    <fapt originalForm="fapt" tf="0.74" idf="0.47"/>
    <atribut originalForm="atribut" tf="0.45" idf="0.47"/>
    <sistem originalForm="sistem" tf="0.33" idf="0.47"/>
    <inferent originalForm="inferenta" tf="0.32" idf="0.55"/>
    <algoritm originalForm="algoritm" tf="0.32" idf="0.55"/>

    ……….
    <absolut originalForm="absolut" tf="0.01" idf="1.25"/>
</words>
```

Each concept extracted from the course chapter's document is represented as an element in the xml file. The stemmed form of the word is stored as the element name, and its original form, TF value and IDF value are stored in the element attributes.
The first five concepts that have the highest TF-IDF value will be inserted in the database, for further use on the platform.

4.2 Discipline structure

Within the online platform a discipline has the following structure: Chapters, Test Questions, Exam Questions, Concepts. The chapters are documents uploaded by the professors which can have one of the following extensions: *.pdf*, *.doc*, *.docx*. Test questions are the questions used by the students through the semester for evaluating their current knowledge. A feature that allows the professor to choose from a list the concepts that are related to the test question and assign them weights was added to the e-learning platform. The exam questions are the ones from which the students will take the final exam and obtain their final grades. The concepts are the ones extracted from the chapters' documents which were previously reviewed by the professor.

4.3 Activity monitoring

This step is very important because it is decisive for the determination of the student's ability to understand the course material and to hightlight his/her progress. The most relevant information can be obtained by evaluating the correctness of the answers from the test questions, taking into consideration the concept associated with those questions and their given weights. This will help the professor figure out which are the concepts that the student has difficulties with them and how he/she can be helped.

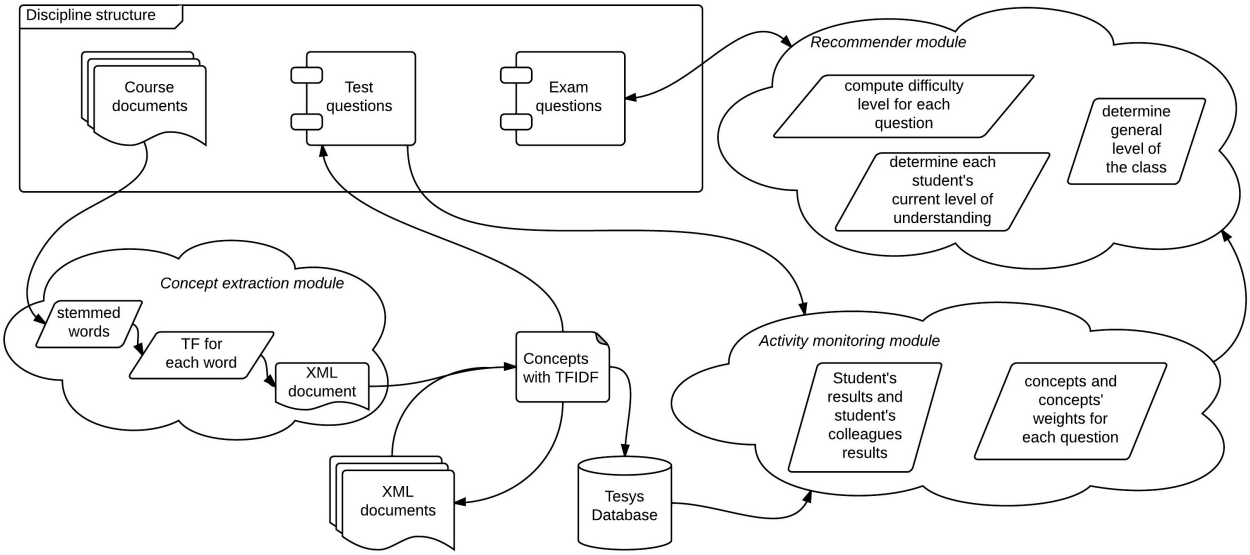


Figure 1: *System architecture.*

4.4 General architecture

Figure 1 presents the general architecture of the system. In the left part of the figure we can see only persistent data, basically found on the server, and on the right side is the core business logic that includes the concept extraction, activity monitoring and recommender modules. Starting from the course documents, that were previously uploaded by the professor on the platform, the system extracts the concepts, using a custom concept extraction module and then transfers the data into the XML files. The five most relevant concepts are also inserted into the Tesys database, for further use. As soon as the professor uploads the test questions and specifies each concept's weight for every question, the student's activity monitoring process can begin. Afterwords, using the concept-weight association, student's responses to the test questions, and taking into consideration the performances of student's colleagues, the system will be able to show relevant statistics to the professor, so he can understand each student's learning difficulties as well as the general level of the class. The recommender module is designed to review the difficulty of the proposed exam questions and advise the professor on lowering or increasing the exam difficulty. All this process is supervised by the professor, who takes the final decision.

5 EXPERIMENTAL RESULTS

In order to better explain how the system works, we will consider a usage scenario, assuming professor P is a professor on the e-learning platform and has a course with two chapters. Immediately after he uploaded the chapter documents, the system extracted five key concepts from each file: C11-C15, C21-C25. In this moment the professor can view the concepts, he/she can delete the ones that he considers irrelevant or maybe add new ones.

The nest step is performed when professor P loads test questions for the students to answer, and for each question assigns weights of the extracted concepts, denoting the relevance level of every concept for each particular question. The weights have values in the range of [0.0,1.0]. Table 1 presents a possible weight distribution for concepts among questions. The cells corresponding to the concepts that have absolutely no relevance to a question and therefore have a weight of 0.0 are left blank.

	C11	**C12**	**…**	**C21**	**C22**	**C23**	**C24**	**C25**
Q1		0.1		0.7			0.2	
Q2			0.4		0.6			
Q3		0.7			0.1	0.1		0.1
…								

Table 1: *Sample weights distribution.*

Let's consider the student S1. The first test the student takes contains questions 1,2,3,5,7. Table 2 presents possible values for the correctness of the answers given by the students that answered these questions. S1 is the analyzed student, S2 to Sn are the other students that answered the questions. It is assumed that the tests contain only single choice questions, so the answer can be only evaluated as CORRECT or INCORRECT.

	Q1	Q2	Q3	Q5	Q7
S1	CORRECT	CORRECT	INCORRECT	CORRECT	INCORRECT
S2	INCORRECT	CORRECT	INCORRECT	INCORRECT	CORRECT
S3	CORRECT	CORRECT	INCORRECT	CORRECT	CORRECT
			...		
Sn	CORRECT	CORRECT	CORRECT	CORRECT	INCORRECT

Table 2: *Sample answer data.*

After computing the weights and results the system will provide the professor with the following statistics: student's level of understanding of each concept, the student's performance relative to his/her collegues, the difficulty level of every test question and concept.

After analysing the presented data the professor will be able to start creating a mental model regarding the student's current level of understanding of the material and his/her place among the other students. Also, if necessary, the professor might decide to modify the course material, for example add some extra information on a particular concept that the students have trouble understanding. Another action the professor might choose to take, given the reported level of the class, is to increase or decrease the general difficulty level for the test questions, as well as deciding which will be the best exam questions.

6 CONCLUSIONS AND FUTURE WORK

The above presented module is working on Tesys e-learning platform as a feature meant to improve the online learning experience for both the students and the professors. This paper is a quick overview of the developed application, which combined information retrieval techniques and text analysis tools in order to obtain the above mentioned results. A big challenge in the designing and developing process was bulding the Romanian stemmer as well as finding the right formulas to use for the recommendation module.

As Tesys is a growing platform which has to manage many students from different faculties, improving the module performance and scalability could be considered as a future task.

The information about the students' performances and progress collected throught the years could be also used to improve the capabilities of the module and provide better and more diverse recommendations for professors.

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DIFFERENTIATION IN THE TEACHING OF SOCIAL SCIENCES WITH THE DEVELOPMENT OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Anastasia D. Vakaloudi[1], Vassilios Dagdilelis[2]
[1]Dr., Teacher Advisor in Secondary Education, Department of Teacher Advisors, Ministry of Education
website: http://users.sch.gr/avakalou, e-mail: anvakaloudi@yahoo.gr
[2]Professor, Department of Educational and Social Policy, University of Macedonia
e-mail: dagdil@uom.gr

ABSTRACT

This paper is based on the findings that arose from lessons that took place within the context of a research study carried out on a diverse student population at various Secondary Schools (Junior and Senior High Schools). The objective of this research was to examine the effectiveness of teaching methods employing Information and Communication Technology (ICT), in comparison with other traditional methods that were applied during the learning process.

1 INTRODUCTION

This article is based on the findings that arose from lessons that took place within the context of a research study carried out on a diverse student population at various Secondary Schools (Junior and Senior High Schools), within the county of Thessaloniki (Greece), during the school years 2009 – 2011. The objective of this research was to examine the effectiveness of teaching methods employing Information and Communication Technology (ICT), in comparison with other traditional methods that were applied during the learning process [1, p. 28, 29]. The findings and conclusions that will be presented arise from lessons that took place in classes of students in a variety of schools, in the Computer Science Laboratories, where the children worked in teams using computer terminals. In general, the lessons were designed so that they could furthermore be conducive to the following objectives: the cultivation of new literacy, technological and digital literacy or *techno-literacy*, the social extent of which is very wide – a fact that cannot be overlooked by schools. The content of this *new literacy* could be focused on: the cultivation of information search strategies, the ability to pinpoint a specific piece of information – an important part of which includes the ability to assess its validity, the technique of scanning a text using distinct Internet grammar (hypertext), the techniques relating to organizing information that has been found and using it when carrying out specific projects – for instance, incorporating this information into written and oral discourse. The lessons, findings and general research that are presented in this paper are a part of a wider research project that will be implemented and which aims to investigate the educational use of ICT when teaching History as well as provide relevant phrasing of educational recommendations.

2 DIGITAL MATERIAL AND THE THEORETICAL FRAMEWORK OF ITS USE

It is perceived that computers are not a means of teaching, but an environment which enables search and experimentation during the writing process, a cooperative means of learning, the most effective cooperation between students and the educator, realistic circumstances for communication at and away from school – all within the context of promoting the social dimension of knowledge and language [2, p. 57; 3, p. 103; 4].

The Internet is a source of dynamic, digital content. Focusing on the internet as a source of information that can be used by students during the class, one cannot help but notice that a problem which arises is that students' searches often give rise to information that does not serve educational purposes. Therefore, an important issue that needs to be examined is related to the ways in which one can organize and guide student activities while they search for material on the Internet, in terms of the specific educational goal of accessing essential, useful, and worthwhile material.

In situations where factors such as the young age of students, their unfamiliarity with internet search techniques, and the absence of tools enabling safe searches for internet content play a defining role, educators are required to employ guided, exploratory learning when using the information provided by the Internet. In this way, an approach to organizing lessons – called web searching – has been developed in recent years [5, 6].

The teaching scenarios that were put into practice during the lessons follow the structure of a web search, i.e. they include: (a) suggested sources in order to search for material on the Internet and potentially, other than that, in addition to; (b) the actions of students in relation to unique activities, where they have the ability to apply the information they have collected and experiment with it. The structure of a web search includes fields which are aimed at introducing the student, step-by-step, into the theme of the activity, informing him/her of the role that (s)he is to take on during the activity, applying parameters and indirectly guiding his

work. During the design of a web search, the educator sets the objectives and the prospective results of the lesson, the primary sources within which the students search for material, and the questions that will define as well as guide students' exploration towards the anticipated results [6, 7].
At the same time, various Computer Science tools were applied in teaching, such as Word Processor (Word Processing is the most common way to utilize ICT for educational purposes and can contribute to the development of critical thinking skills [8, 9]) and Presentation Software. Writing a presentation with Presentation Software requires a certain type of knowledge and skill that did not exist in the past. The modern, literate person should be able to produce, understand and process multimodal texts in a critical way (texts that are not only linguistic, but are also formed via the development of other semiotic systems, such as: pictures, sound, graphs, etc.), because social practices often require the use of a variety of communication technologies, from the more traditional ones (pencil, paper, print) to the more contemporary ones (digital media).

3 DIDACTIC APPROACH AND METHODOLOGY

The tools that we used for the observation of the progress of the procedure were recorded teachings, the worksheets that teachers gave to the students, the written works of the teams which were presented to the whole class and discussions with the teachers and teachers-listeners who observed the teachings; thus we concluded to the findings which are presented. During the research a combination of quantitative research (small-scale) and qualitative research was applied. The researcher who uses a qualitative method observes, takes notes, describes and interprets the facts exactly as they are. By studying the facts we examined whether the students were thinking critically in order to arrive at a conclusion, whether they apprehended the teaching subjects, whether they paid attention and participated actively during the whole teaching hour, whether they cooperated productively and whether the teachers performed their tasks more effectively in the classroom with the help of ICTs.
The students in the Computer Science laboratory worked in groups. They convened at computer terminals by team and engaged in the process of web search, i.e. they were assigned a topic by team, with personal investigation of a topic as an "open-ended problem." Through cooperative group learning, they explored specific websites (e.g. websites with historical and cultural subjects (e.g.: http://www.culturenow.wordpress.com/), digital dictionaries (e.g. http://www.greek-language.gr/) etc.) in conjunction with the educational software or printed material from the school library, in order to reach conclusions that they put together in an assignment based on worksheet activities. Each team's assignment was performed on the Word Processor or Presentation Software and, subsequent to completion, the assignments were presented in the class plenary session by the teams, accompanied by analysis, explanations and clarifications.
A role-playing game, which engaged the imagination and empathy of the students, was put into practice. The students were divided into groups, with the teachers' guidance, and sat in groups at a computer terminal. They had to carry out their research independently, determine the areas that their research would be focused on and, in order to accomplish this, they had to work in groups (each group chose its coordinator who coordinated the processes, the secretary who kept notes on the findings, the manager of the computer and the members). They also had to manage, in a variety of ways, the computer and the ICT in general, as well as interactively participate in the learning process in an "open-ended software program" (Internet) based on contemporary learning theories of *constructivism* and the *socio-cultural dimensions of knowledge*, in effect *socio-cultural constructivism,* that allow the students to interface with the digital teaching environment and determine the issues of investigation according to their needs and potential [10].
The above was considered to be particularly helpful and had very satisfying results at schools where the characteristics of the students were distinct, such as, for example, at schools where the students were, for the most part, Romany children, with a great deal of learning difficulties and family problems who lived in particularly difficult circumstances, or at schools with a large percentage of foreign students, or in classes with disorderly and boisterous students who were at a low level of learning. However, the reason for this disorderliness could be the learning difficulties experienced by the students, which lead to misbehaviour, owing to their inability to cope with the demands of the lessons. The activities of the particular scenarios strayed from the linear organization of information and supported exploratory learning.

4 FINDINGS

i. The lessons gave rise to the cross-thematic and interdisciplinary approach to knowledge (History, Geography, Modern Greek, English, Literature, Computer Science, Aesthetic Culture, etc.). The correlation of various, distinct subjects of the Curriculum with undifferentiated goals and integrated, inseparable teaching content was applied, in connection to the experiences and knowledge of the students. The resolution of a problem with the verification of information through research, the collection of findings and their study was accomplished. The research had a personal and distinct procedure for each team (depending on the subjects that were being investigated), through the different pathways of choice taken by the students as the procedure was carried out. In effect, the meaning of *navigation in software* (which is the main idea of hypertext and hypermedia use) was applied in the case of utilizing the internet.
ii. A substantial environment for interaction was created, with the handling of objects and tools, both material (e.g. the internet, computer science tools, worksheets) and symbolic (language, communication,

interaction, cooperation of educators-students and students amongst themselves). Analogous educational environments allow exploration and learning by way of experience and are interactive [11]. The educators used ICT to design the lessons, with the objective of transferring the central focus from the educator to the students, from the individual to a collective way of working. In this way, the lesson was converted into an open-ended process of learning where the boundaries and the processes were not strictly defined. Also established was the development of a variety of linguistic and multimodal forms of expression, which arose in a natural and cooperative way, in cross-thematic combination with the processing of questions.

iii. The students chose to participate based on their interest, they evaluated the process and the results based on the originality of the approach, the enjoyment that it sparked in them, the interest, the enjoyment arising from making decisions using intrinsic criteria and with these criteria they substantiated and presented their work. The members of the team negotiated, discussed, reflected, assessed. The learning was not a behavioural but a cognitive process; it was not a static situation, but a dynamic progression. The student was not a "blank page," but brought his/her preceding knowledge and experience to the learning process and was given the possibility of exploring the module. During the lessons, the groups engaged in intense movement and action. The Computer Science skills were combined with search, research, cooperative group learning and the processing and composition of material. The teachings that took place were based mainly on the possibilities that ICT provides [1]: access to sources (written and/or visual), involvement in authentic research procedures, search and exploration of the internet, multiple re-enactments of information. A variety of Internet media, such as Websites, Search Engines and Computer Science tools (hard disk drive files, Concept Maps, Word Processing, Presentation Software, Toolbars) in combination with books from the school library, maps and related texts were utilized by the students in a variety of activities so that they could generate the requested material, in written or multimodal texts. Using the electronic tools that were employed during the teaching process, skills were developed both in terms of the digital environment and in terms of the constructivist method of teaching, e.g. the utilization of Word Processing for semantic categorization, the utilization of maps and Toolbars in order to support the Geography lesson in conjunction with History, the use of the Electronic Dictionary to reinforce the Modern Greek Language as well as Literature, the use of foreign language websites in order to achieve a cross-thematic approach (e.g. History and English) through processing the material. The study of the data, the creative thought and action arising from the immediacy of participation, the spirit of cooperation and teamwork, the collective work, the investigation of subjects were aimed at guiding students toward the cultivation of skills and knowledge. The students were converted from passive recipients into active participants, who actively took part in the process of teaching the lesson, research, elaboration of material, thereby breaking away from the teaching manual and getting into the ICT environment. That gave them satisfaction and elicited their curiosity.

The educators were impressed by the fact that, in the course of teaching the lesson using ICT, the groups participated attentively, quietly and cooperated impeccably. The teachers were particularly impressed by the fact that the groups studied their material, chose the appropriate data and composed their assignment based on the conclusions that they reached from studying this data. In effect, the students did not simply copy the material in front of them; they practised organizing and categorizing the data which they had found and collected, through making relevant, indexed tables. They analysed works of art, i.e. the students interpreted them based on the artistic features of the period that they represented (e.g. Renaissance or Romanticism). In order to interpret the works, they used corresponding concepts (such as in the case of Renaissance art: "mythology, Christian religion, beauty, man"). They selected the appropriate visual material to back up the written and oral discourse for their presentation, having created an authentic written or multimodal text. The group work was, on the whole, their original creation. In all of the teachings, the enjoyment and satisfaction that the students expressed for the learning process was clear.

iv. After the collection, observation, categorization and study of the material, the groups were requested to engage in discussion and come up with conclusions from their findings, referring to their notes and making arguments using oral and written discourse.

v. The use of semantic maps, which the groups of children completed on the computer with related meanings, highlighted the complexity of knowledge, especially through the process of making semantic connections and correlations according to an interdisciplinary approach to learning.

5 SUMMARY AND CONCLUSIONS

The methods were adopted in the teachings which had the objective of experiential learning (learning by doing), by making use of the various possibilities of the Internet and Computer Science Tools, as well as research, role-playing games and narrative reconstructions. Through observation and the study of a variety of tools, the students reached conclusions which they used in order to make arguments, responding – either orally or in writing – to different questions put to them by the educators or contained in the worksheets. The data that was collected clearly indicates that the students had a much greater personal involvement in the elaboration of the topic that was suggested, compared to what they would have had in traditional teaching.

The goals that were realized were: (1) Achieving the management of sources: (i) Production (digitalization, formatting, registration, saving, classification) and presentation of educational material, with multiple

representations from the educator. (ii) Processing by the students of a variety of sources, by searching through the material either on the hard disk or on the Internet (e.g. through a search engine). (2) Materializing the potential of teaching development: (i) Interconnectedness with the Internet and its use by the groups. (ii) Diffusion of digital material through the computers (composition of assignments using Digital Environments which enable the writing process). (iii) Creation of activities, setting questions. (iv) The possibility of presenting the results in a written, multimodal or oral format.

The educators used ICT in the design of their lessons with specific parameters: (a) Determination of the goals that were to be achieved. (b) Position of the subject to be examined. (c) Observation by the students and the problematization of a subject with discussion. (d) Analysis or development, with the students' research, for the concentration of information, by way of individual work or joint discussion or group work. Critical thinking does not arise without the proposition of a problem, since the following phases are considered to be the necessary requirements: (a) the position of the problem within the questions, the dilemmas, the problematic situations (critical challenges), (b) the supply of relative information and the encouragement of the children's interest in research (intellectual resources), (c) the quest to find solutions for a problem (critically thoughtful responses) [12, p. 147; 13].

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COMMUNICATION STRATEGIES IN THE MANAGEMENT OF ARTS - MUSEUMS

Marija Valčić
College of Business and Management B. A. Krčelić
V. Novaka 23, 10290 Zaprešić
e-mail: marija.valcic@vspu.hr

ABSTRACT

This study utilizes a content analysis of 100 Croatian's Museums websites to explore how they are managing their web relationships with publics. While most cultural organizations in this sample are engaging in all six of the relational strategies (access, positivity, openness, shared tasks, networking, and assurances), the level at which these strategies are engaged is low. Positivity was the most often used strategy. Assurances was the least engaged strategy, thus making it the one most in need of improvement.

1 INTRODUCTION

Social media platforms provide users with unlimited storage space and numerous tools to organize, promote and publish their thoughts, attitudes, behaviors and media to other users. Social networks are flexible, mobile and flexible.

2 TASK STATEMENT

Discussing museums and marketing, McLean [1] agrees that "the lowest common denominator is about building a relationship between the museum and the public". This relationship is built on the open exchange of information and ideas. Recent literature on museums discusses a "new museology" where society, often broken into specific publics, is central to the interpretation of museums [1].

As museum professionals reconsider disciplinary principles and exhibition methods, key publics are "becoming more involved in the choice and interpretation of exhibit topics" [2].

It is well known that the museums have long been interested in building relationships with publics. Today, the public relations aspect is a necessity. According to McLean [1], "the most significant threats to museums come from central and local government". Croatian museums are becoming more dependent on wealthy benefactors and public subsidy to generate income since the current political climate lacks long-term vision and policy cohesion. In this time of "financial stringency," the governments also play a leading role in encouraging museums to market themselves, large European market. In order to receive government money, a museum must prove its quality of service by developing performance indicators [1]. A survey would be an example of an appropriate indicator.

With limited government grants, the museums are at the mercy of their publics. Communications strategies continue to be an area of communication study that needs to be researched through theoretical and practical approaches. Furthermore, the Internet is a medium that is not fully understood. Thus, an area of interest for research in public relations is how practitioners in the Museums use the Internet. Specifically, this research will address how practitioners in the cultural sector use the Internet for the purposes of relationship building and maintenance. This study is based on the previous research by using relationship management model, developed by Hon and Grunig, and Internet research to examine 100 Croatian s Museums website.

Based on this literature, the following research questions were posed:

RQ1: Are the museums utilizing the web to engage their various publics in dialogic relationships?

RQ2: What relational strategies are the museums organizations' websites using?

3 CATEGORIES

3.1 Access

Access is the first relational strategy investigated. The three areas of access coded for this concept are: (1) telephone contact information – which refers to telephone numbers by department, manager, art manager, experts, as well as names of contacts and positions; (2) physical address – provides physical address by department, branch or division, as well as names of contacts and positions and; (3) email address – provides email address by department, branch or division, as well as names of contacts and position, (4) place for possible purchase tickets, catalogs, souvenirs (in Croatian and English)

3.2 Positivity

Permanently interesting website, a website that is deemed 'user friendly' invites the user to stay on the website rather than leave with confusion or unanswered questions. Thus, the items coded for this concept are: (1) ease of navigation – every item is clearly labelled, content accessed is what is to be expected and all links work well; (2) search functions – the website provides advanced search capabilities as well as tips for searching; and (3) site mapping – the website provides clearly hierarchical structure, content is easily

found. Additionally, this study follows at least addition of a fourth element, which is audiovisual. This strategy component means inclusion of photographs, illustrations, video, design, or music.

3.3 Openness

For this strategy the items are coded as: (1) organization overview (also known on the Internet as an 'About Us' section) – this will include information on an organization's history or creation as well as goals and objective; (2) organizational news; and (3) annual reports and records, future plans, performances, exhibitions, new acquisitions etc.

3.4 Shared tasks

Since the museums are non-profit organizations, it is important to think of this construct as more engaging in community or educational activity, since it is the institution of the culture, and it should emphasize the need to act in a way that raise awareness, educated character and scientific research and to raise awareness of knowledge and awareness of the existence of national identity and national and world heritage [4]. Thus, the items coded in this area are: (1) community activity – programmes that engage the community; (2) educational activity – programmes that educate the community; and (3) donation of time or money or giving monetary contribution.

3.5 Networking

The items in this section were coded as: (1) networking with similar museums; (2) networking with experts and connections with the scientific and educational communities, and individuals.

3.6 Assurances

Assurances is the final relational strategy in this research. On the web this strategy would mean for websites that there are places for computer-mediated communication. Thus, three items were coded for in this area: (1) presence of a chat room; (2) presence of a message and social Network board; and (3) presence of a social Network, and a blog.

4 METODS

4.1 Research hypotheses

The purpose of this study was to investigate the relations among relationship maintenance strategies and support for cultural organizations/museums in Croatia. Based on the literature review, the following research hypotheses were proposed:

Hypothesis 1: Symmetrical maintenance communicative strategies (access, positivity, openness, assurance, networking) will have a positive effect on the quality of cultural organization – Museums.

Hypothesis 2: The quality of the cultural organization-communication strategy (commitment, trust, satisfaction, control mutuality, reputation, community involvement, attachment) will increase the likelihood of members' intention to support the organization (donation and critics).

Hypothesis 3: Symmetrical communication maintenance strategies (access, positivity, openness, assurance, networking, sharing of tasks) will have a positive direct effect on members' intention to support the cultural organization.

5 CONCLUSIONS

The Internet has greatly impacted the day-to- day activities of most people. One can check the weather, follow a sports team, purchase a sweater, find exhibitions or event, buy the tickets, the pieces of art. It is only logical that if what people do in their daily lives transpires to the Internet. Although cultural organizations (non-profit organizations) have begun to use the Internet for building and maintaining relationships with their publics, the levels at which they are engaging in these activities could be higher. This assertion supports the research conclusions drawn by Spencer [3] that non- profit organizations are behind for-profit organizations when it comes to technology. This research question seeks to understand how museums like non-profit organizations engage their publics via the web. Descriptive statistics were used, also to express if the communication strategies are high, medium, low, or not at all. Access was coded in three areas – telephone contact, physical address contact, and email contact. Of the 100 Museums websites, the majority were coded as having low access in all three areas. Art management in the world of different cultures in the global market becomes a subject study in different interdisciplinary approaches. Managers wanting to deepen and understand a complex relationship between artist, the art and their profession must acquire diversified knowledge, including knowledge of the communication sciences.

Communication strategies in the management of artistic resources can be viewed through several levels such as communication and contract at the level of talent discovery and understanding, communication and interaction at the level of science or profession. So far, such strategies have not been empirically investigated, and this paper will be on this track. The data obtained will be useful to establish a management direction in the art market in our country as a part of the larger European market and to develop methodologies for interdisciplinary scientific study of these areas.

The basic hypothesis is that, in the contemporary social conditions, it is necessary to closely link art and artists, to connect the art and management at the level of scientific and professional cooperation. Thus, it is necessary to develop communication strategies that will contribute to better synergy between two professional and scientific areas. Media also play an important role in shaping communication strategies, because they are the primary means of mediating an artist and art to the public. A special accent is given to the study of hypotheses on the relationship of the art and the internet, because artists attach

even greater importance to the new media than to the traditional. The methodology, qualitative as well as quantitative techniques are used, such as content analysis, questionnaire, in-depth interviews, and 100 website of Croatian Museums.

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Zbornik 16. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2013

Proceedings of the 16th International Multiconference

INFORMATION SOCIETY – IS 2013

Vzgoja in izobraževanje v informacijski družbi

Education in Information Society

Uredili / Edited by

Vladislav Rajkovič, Tanja Urbančič, Mojca Bernik

http://is.ijs.si
http://lopes1.fov.uni-mb.si

11. oktober 2013 / October 11th, 2013
Ljubljana, Slovenia

PREDGOVOR

Že pred časom smo si zastavili vprašanje, kdaj bodo otroci hodili v šolo le z USB ključem in copati. Glede na razvoj tabličnih računalnikov in pametnih telefonov bi danes vprašanje lahko nekoliko preoblikovali. Vemo pa, da ni problem le v tehnologiji, ampak tudi v tem kaj uporabiti v šolskem kontekstu in kako. Tudi brez sodobne računalniške in komunikacijske tehnologije (IKT) so bili procesi vzgoje in izobraževanja v zgodovini uspešni, če so učenci, učitelji in okolje našli primeren skupen jezik. Nove tehnologije, kot je bila npr. tiskana knjiga, so bistveno vplivale na vzgojo in izobraževanje. Potrebne so bile spremembe v miselnosti in delu. Tudi za uporabo teh knjig so bile potrebne nove kompetence. Bili pa so tudi pomisleki, da bo knjiga uničila pedagoški proces. A ga ni. Preživel je pedagoški proces in preživela je tudi knjiga, čeprav danes vse bolj živi v digitalni obliki. Nastale so pomembne spremembe v družbi, širilo se je in se še vedno širi znanje ter njegova dosegljivost.

S sodobno IKT se porajajo številna vprašanja v smislu: **KAKO NAPREJ ?** Kaj početi s pametnimi telefoni v šoli? Naj njihovo uporabo prepovemo? Kako je z družabnimi omrežji? Res zmanjšujejo samozavest in poslabšujejo samopodobo mladine? In če, kaj lahko storimo? Kako v zdrav življenjski slog umestiti IKT?

Tehnologija je tu. Dostopna je. Mladina z njo živi in dela. Odgovori na ta in podobna vprašanja povezana s tehnološkim razvojem so vse prej kot enostavni. Kdo lahko poišče odgovore? Strokovnjaki? Da, vendar ne le oni. Sleherni človek ima pravico in dolžnost iskati odgovore in rešitve. Pa je usposobljen? Je za njegovo usposobljenost dovolj digitalna pismenost? Ta je potreben, ne pa tudi zadosten pogoj usposobljenosti. Poleg širokih znanj in razumevanj različnih strok je potrebna **sposobnost kritičnega mišljenja**. V takem razširjenem smislu gre razumeti tudi e-kompetence, ki jih potrebujemo danes. Biti moramo dovolj izobraženi in dovolj modri za presojo, **kaj je res in kaj je prav.**

Kot je znano, tudi v našem šolskem prostoru potekajo številni projekti v okviru e-učenja in poučevanja od e-šolske torbe, preko e-učbenikov, do pedagogike v luči kompetenc 21. stoletja. Gre za projekte, ki raziskujejo in razvijajo tehnološke, organizacijske, pedagoške in druge rešitve v šolah in proučujejo njihov vpliv na spremembe v šoli sami, kakor tudi v miselnosti mladih, učiteljev, staršev in širše družbe.

Svet tehnologije nas rad očara. Obstoja bojazen, da ta svet mistificiramo. To se je pogosto dogajalo v človekovi zgodovini. Šele ko je dobila tehnologija pravo mesto, je bil njen doprinos resnično velik. Tudi v ekonomskem smislu. Tako je npr. izum parnega stroja prispeval v največji meri k družbenemu bruto proizvodu Velike Britanije šele po sto letih od zagona prvega stroja. Čeprav so ekonomski vidiki pomembni, naj na tem mestu še posebej poudarimo pomen pravega mesta in vloge IKT, ki je v tem, da služi človeku in pripomore k **boljšim odnosom med ljudmi, da je lahko človek človeku spet človek.**

Na letošnji konferenci VIVID 2013, ki poteka že 16. leto v okviru multikonference Informacijska družba, se bomo seznanili s potekom nekaterih projektov v okviru e-učenja in poučevanja ter se pogovorili, kako poiskati pot naprej, še posebej z vidika **kaj in kako učiti.**

Vladislav Rajkovič, Mojca Bernik, Tanja Urbančič

PREFACE

It has been a while since we posed the question: when will children start going to school with nothing more than their USB flash drives and their slippers? Considering the development of tablet computers and smartphones, this question could now be rephrased in a slightly different manner. That being said, we are aware of the fact that the problem lies not only in technology but in deciding what and how to use it in the context of school. Even without modern computer and communications technology (ICT) the educational processes throughout the history have been successful when the students, the teachers and the environment managed to find common ground. New technologies such as printed books have profoundly affected education and schooling. Changes in mentality and work were necessary, and to be able to use these books new competences were required. Some people had second thoughts about books in that they regarded them as something that will ruin the pedagogical process. But that did not happen. Both the pedagogical process and the book survived, although today the latter exists more and more in its digital form. We witnessed important social changes and knowledge and its availability spread and are still spreading.

Modern ICT poses many questions such as: **HOW TO PROCEED?** What do we do with smartphones in schools? Should we ban them? What about social networks? Do they really have adverse effects on self-confidence and self-image of the youth? And if this is true, what can we do about it? How to integrate ICT into a healthy lifestyle?

The technology is here. It is accessible. The youth work and live with it. Questions regarding the technological development are not easy to answer. Who can find the answers? The experts? Yes they can but they are not the only ones. Every individual has the right and the obligation to look for answers and solutions. But are they qualified for that? And is digital literacy enough for this purpose? It is a necessary but not a sufficient condition. Apart from having a broad skill set and the understanding of different expert skills it is necessary to have **the ability of critical thinking**. And it is in this broader sense that we should understand the e-competences that are required today. We have to be educated and wise enough to be able to judge **what is true and what is right.**

We know that there are many e-learning projects in our education environment, from the so called “e-school bags” and “e-textbooks” to pedagogics in the light of the abilities of the 21st century. Projects research and develop technological, organizational, pedagogical and other solutions in schools and their impact on the changes in the school itself as well as in the mentality of the youth, the teachers, the parents and the broader society.

We tend to be amazed by the world of technology. But there is also the fear that we might mystify it. This has been a common occurrence throughout human history. It was only when technology was assigned its proper place that its contribution became really significant – in economic sense as well. For example, it took the steam engine a hundred years to become a contributor to the gross domestic product. And even though the economic aspects are important, we should at this point stress the importance of ICT's proper place and role – that of helping the human kind to achieve **better interpersonal relations so that we can once again become more humane to each other.**

At this year's VIVID 2013 conference, which is organized within the Information society multiconference for the 16th time, we will learn about some of the e-learning and teaching projects and discuss how to proceed, especially when it comes to **how and what to teach**.

Vladislav Rajkovič, Mojca Bernik, Tanja Urbančič

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Naravoslovno tehniška fakulteta

INFORMACIJSKA DRUŽBA – IS'2013
11. oktober 2013
VZGOJA IN IZOBRAŽEVANJE V INFORMACIJSKI DRUŽBI

Pouk angleščine z glasovalnim sistemom ActiVote

Teaching English with ActiVote

Barbara Abram
Osnovna šola Sečovlje, Slovenija
barbaraabram4@gmail.com

Povzetek

V prispevku so predstavljene prednosti uporabe glasovalnega sistema ActiVote pri poučevanju angleščine. Uporaba glasovalnih naprav omogoča učitelju, da na hiter način preveri napredek učencev in, upoštevajoč rezultate, načrtuje pouk v skladu s trenutnimi potrebami učencev. Aktivno sodelovanje učencev je zagotovljeno, to pa pripomore k boljšim rezultatom. Pouk je s pomočjo glasovalnih naprav zabavnejši za učence in preprostejši za učitelja. V prispevku je opisano, kako deluje glasovalni sistem ActiVote ter primer uporabe glasovanja za preverjanje napredka učencev.

Ključne besede: angleščina, glasovalne naprave, preverjanje napredka

Abstract

The intention of this article is to show some advantages of teaching English by using ActiVote. ActiVote enables teachers to assess student progress and, based on responses, tailor lessons to specific student needs. It encourages whole-class participation which leads to better results and it makes lessons exciting for students and easier for teachers. The article describes how ActiVote works and it gives an example of student progress assessment.

Keywords: English, ActiVote, Progress assessment

Reflektivna praksa kot temeljna sinergija med pedagoškim in poslovnim okoljem

Reflective Practice as a Fundamental Synergy between the Educational and Business Environment

Branka Balantič
ŠC Kranj, Višja strokovna šola, Kidričeva 55, Kranj
branka.balantic@guest.arnes.si

Branka Jarc Kovačič
ŠC Kranj, Višja strokovna šola, Kidričeva 55, Kranj
branka.jarc-kovacic@guest.arnes.si

Zvone Balantič
Univerza v Mariboru, Fakulteta za organizacijske vede, Kidričeva 55a, Kranj
zvone.balantic@fov.uni-mb.si

Povzetek

Cilj prave reflektivne prakse je v pedagoško okolje posredovati najboljše in najbolj učinkovite izkušnje delovnih okolij. Povratna informacija mora biti ustrezno kodirana in mora poudariti ključne značilnosti izkustvenega učenja. Namen je spodbujanje in multipliciranje pravih sinergijskih učinkov, ki izhajajo iz praktičnih izkušenj. Praktično izobraževanje (PRI) je temelj pridobivanja strokovnih kompetenc, ki jih je potrebno nadgraditi v procesu izobraževanja. Z metodo deskripcije smo poenotili poglede na posamezne programe izobraževanja v višjem šolstvu. Kasneje smo z analizo in sintezo proučili posamezne člene celotnega sistema PRI in oblikovali celovita mnenja o reflektivni praksi. Oblikovali smo nabor pozitivnih in negativnih izkušenj študentov na PRI. Združili smo posamezna sugeriranja in ugotovitve ter sestavili sinergijsko lupino izboljšav PRI.

Ključne besede: Reflektivna praksa, sinergija, izobraževanje, poslovno okolje.

Abstract

The goal of real reflective practice is to spread best and most effective experiences from working environments. Return information must be appropriately coded and

must highlight key properties of practice learning. Purpose is encouragement and multiplication of real synergy effect of practice learning. Practice education (PE) is crucial for professional competences improvements which need to be upgraded during educational process. Different views on individual educational programs were unified by description method. Individual articles of whole PE system were analysed and comprehensive opinions were itemized. Positive and negative experiences from PE students were collected. Individual proposals and findings were combined and synergistic shell of improvements was obtained.

Keywords: Reflective practice, Synergy, Education, Business environment

Psychology of Adolescent Online Behaviour and Learning in Slovenia and the Southern States of Mediterranean Europe

D.L. Bearden
Academié St. John

Abstract

Adolescent behaviour using mobile technology is a concern to parents and educators worldwide. Slovenia, like the all the European states in the southern Mediterranean region, is concerned about cognotics in education. How will the emerging cyber youth culture affect traditional teaching and learning? What can be gained by adopting mobile technology and at what cost? Does the use of cyber technology remove human contact and does it create a schism between generations? This paper answers these questions and provides a snapshot of the cyber readiness of Slovenia. It offers suggestions for best practices for combining the best attributes of traditional schools and cyber schools.

Keywords: Mobile technology, Cyberschooling, Cognotics in education, Adolescent online behaviour

Optimizacija evidentiranja delovnega časa in varovanja infrastrukture v šolstvu

Optimizing the Recording of Work Hours and the Protection of Infrastructure in the Education Sector

Nastja Beznik
Šolski center Kranj, Višja strokovna šola, Slovenija
nastja.beznik@guest.arnes.si

Povzetek

Optimalna informatizacija poslovnih procesov prinaša v poslovanje številne prednosti v smislu učinkovitega dela zaposlenih, ki temelji na zniževanju stroškov in povečanju učinkov dela, menedžmentu pa nudi vso potrebno osnovo za kvalitetno poslovno odločanje. Na podlagi analize stanja ročnega evidentiranja poslovnih dogodkov je podan predlog izboljšave fizične kontrole dostopa in ročnega evidentiranja prisotnosti na delu v izobraževalnih organizacijah. V prispevku so v nadaljevanju opredeljeni pozitivni učinki informacijsko podprte kontrole dostopa ter elektronskega evidentiranja delovnega časa. Predstavljenih je nekaj že uveljavljenih rešitev. Preprečevanje redundance z enkratnim vnašanjem podatkov na mestu nastanka, avtomatizacija ročnega dela ter integralnost nam omogočajo vso potrebno osnovo za nadgradnjo informacijskega sistema v sisteme za podporo odločanju, kot so direktorski informacijski sistemi ali informacijski sistemi za najvišji menedžment kompleksnih organizacij.

Ključne besede: Avtomatizacija ročnega dela, kontrola dostopa, registrirnik delovnega časa, racionalno upravljanje z zaposlenimi, identifikacijski medij

Abstract

Ensuring optimal IT support to business processes results in several operative advantages, especially with regards to more effective work based on cutting costs and enhancing the results of work, as well as with regards to offering management all the necessary bases for high-quality business decision-making. Based on our analysis of the state of manual recording of business events, we provide our proposal for improving the physical control and manual recording of presence at work in educational organisations. The article defines the positive effects of providing IT support to workplace presence monitoring and electronically recording working hours

and presents some established solutions. Preventing redundancy through the one-time input of data at the location where the data is generated, automating manual work and integrity provide the necessary bases for upgrading the IT system to support decision-making, such as in the case of directors' IT systems of management IT systems of complex organisations.

Keywords: Automation of manual tasks, Access monitoring, Record of work attendance, Rational employee management, Identification medium;

Računalniška tehnologija – most od človeka do sočloveka

Computer Technology – A Bridge Between People

Dragica Brinovec
OŠ Primoža Trubarja Laško, Slovenija
dragica.brinovec@oslasko.si

Povzetek

Prispevek prikazuje nekaj praktičnih primerov uporabe učnega okolja Moodle na predmetni stopnji pri pouku slovenščine v osnovni šoli, in sicer s poudarkom na sodelovalnem delu in medsebojnem učenju. Gre za uporabo računalniške tehnologije, ki ima v našem primeru izrazito dodano vrednost: povezovanje in sodelovanje ter razvijanje pozitivnih medsebojnih odnosov ob sočasnem premagovanju časovnih, geografskih in kulturnih mej.

Ključne besede: računalniška tehnologija, sodelovanje, Moodle, slovenščina

Abstract

The following article illustrates some practical examples of the use of the learning environment Moodle for the middle school level of Slovenian Language course, emphasizing cooperative work and interactive learning. It is an example of the use of computer technology which, in our case, has an important added value: interaction, collaboration, and development of positive relationships while surmounting time, geographical and cultural boundaries.

Keywords: Computer technology, collaboration, Moodle, Slovenian language.

Dišave, eterična olja in parfumi - S sodelovanjem do znanja (projektno delo)

Fragrances, Essential Oils and Perfumes - Through Cooperation to the Knowledge (Project Work)

Nika Cebin
Gimnazija Ledina
Slovenija
nika.cebin@gmail.com

Povzetek

Dišave, eterična olja in parfumi predstavljajo projektno delo, ki temelji na sodelovanju, timskem delu (strokovna ekskurzija) in medpredmetnem povezovanju. S pridom sta bila uporabljena digitalna tehnologija in virtualno okolje. Slednje je omogočilo učinkovito usvajanje in poglabljanje novih znanj s pomočjo komuniciranja in sodelovanja na daljavo. Dijaki so bili pri projektu zelo aktivni. Naredili so zgodovinski pregled dišav, sintetizirali različna mila, jih odišavili in obarvali z naravnimi barvili, predstavili so laboratorijske načine pridobivanja eteričnih olj. V šolskem laboratoriju so pridobili eterična olja iz nageljnovih žbic (klinčkov), svežih ekološko pridelanih agrumov in cvetov vrtnic. Predstavili so nekatere začimbe, ki vsebujejo veliko eteričnih olj in imajo izrazit vonj in okus. Na osnovi preizkušanja so samostojno izdelali recepte za različne sladice z uporabo začimb in poskrbeli za degustacijo na predstavitvi projektnega dela na šoli. Izdelali so tudi spletno anketo o najpogosteje uporabljenih parfumih med različnimi generacijami, poskrbeli za organizacijo in izpeljavo virtualne ekskurzije po tovarni dišav v Franciji in predstavili pomen aromaterapije. Udeleženci strokovne ekskurzije po Provansi so se videokonferenčno preko »skypa« povezali z dijaki, ki so iz različnih razlogov ostali doma. Dijaki so bili ocenjeni z odliko, saj so zastavljene naloge opravili odgovorno in kreativno. Njihovo delo je bilo ovito v paleto številnih dišav.

Ključne besede: dišave, eterična olja, parfumi, virtualna ekskurzija, uporaba IKT

Abstract

Fragrances, essential oils and perfumes presented the crucial part of the project, based on cooperative learning, team and interdisciplinary work. While executing all the above stated, we took advantage of digital technologies and virtual environment,

which enabled the students more integral learning. The whole project was placed on students' activities. They made a historical research of fragrances, synthesized soaps, to which they added fragrances and natural colours. They also created essential oils in the school laboratory, mostly from cloves, fresh ecologically produced citrus fruits and rose petals. They presented some spices laden with essential oils, therefore having very strong taste and smell. Based on their knowledge of the latter, they individually made dessert recipes. They carried out an on-line survey about preferred perfumes of different age groups, organized a virtual trip around a perfume factory in France, and explained the importance of aromatherapy. ICT were used during the trip to Provence (a perfumery and a lavender museum) by means of a video conference. Some of the students attended a field trip there, the others not, and they communicated via Skype. The students taking part in the project accomplished their assignments with great creativity and responsibility, which is shown extremely well by the project results.

Keywords: Fragrances, Essential oils, Perfumes, Virtual trip, ICT

Sodelovanje z e-kompetentnimi starši preko spletnih družbenih omrežij

Distance Cooperation with E-Competent Parents via Online Social Networks

Olga Dečman Dobrnjič
Zavod Republike Slovenije za šolstvo, Ljubljana, Slovenija
olga.decman@zrss.si

Bojan Jeram
Dijaški dom Vič, Ljubljana, Slovenija
bojan.jeram@guest.arnes.si

Alenka Temeljotov-Salaj
Evropska pravna fakulteta Nova Gorica, Slovenija
alenka.temeljotov-salaj@evro-pf.si

Povzetek

V članku diskutiramo o pomenu informacijsko komunikacijske tehnologije v šolskem okolju. Poudarimo pomen e-kompetentnosti pedagoških delavcev in izpostavimo nujnost vključevanja staršev v procese informatizacije šolstva. Prikažemo rezultate raziskav, ki so bile v zadnjih treh letih izvedene med starši dijakov dijaških domov z namenom, da bi v dijaških domovih razvili dobre modele in strategije sodelovanja s starši na daljavo. Iz raziskav izhaja, da starši vse bolj sodelujejo z dijaškimi domovi preko interneta, da sodelujejo v spletnih družbenih omrežjih in da dijaški domovi načrtno in sistematično uvajajo v politiko razvoja modele sodelovanja s starši na daljavo. Starši so izrazili pripravljenost, da bi se s področja informacijsko komunikacijske tehnologije izobraževali, če bi jim dijaški domovi ponudili to priložnost.

Ključne besede: informacijsko komunikacijska tehnologija, dijaški domovi, starši, vzgojitelji, sodelovanje preko spletnih družbenih omrežij

Abstract

In this article we discuss the importance of ICT in the school environment.We stress the importance of the e-competences of teachers and highlight the need to involve

parents in the process of informatization of education. We show the results of researches of the last three years, which were conducted among parents of students of boarding schools with the aim to develop good models and strategies of distance cooperation with parents. The research shows that parents are increasingly involved with boarding schools via the Internet, they participate in online social networks; and boarding schools systematically introduce models of distance cooperation with parents in their development policy. Parents have expressed their willingness to betrained in the area of ICT if they boarding schools offered this opportunity.

Keywords: Information and communication technology, Boarding schools, Parents, educators, Engagement through social network sites

INFORMACIJSKA DRUŽBA – IS'2013
11. oktober 2013
VZGOJA IN IZOBRAŽEVANJE V INFORMACIJSKI DRUŽBI

Uporaba interaktivne oglasne table pri izdelovanju zapiskov obravnavane snovi

How to Use Interactive Bulletin Boards to Produce Notes From Textbook

Mateja Drnovšek
OŠ Polje, Slovenija
drnovsek.mateja@gmail.com

Povzetek

V šoli se pogosto srečujemo s problemom motivacije učencev pri sledenju tekoči učni snovi. Zaradi tega moramo biti učitelji tisti, ki se bomo znali približati učencem in jim narediti pouk zanimivejši. To najlažje naredimo z vključevanjem sodobne tehnologije v pouk. Dve izbirni vsebini iz učnega načrta za zgodovino sta bili zato obravnavani s pomočjo interaktivne oglasne table Lino It. Učenci so v parih izdelovali izpiske, ki so jih njihovi sošolci pregledali in se na ta način seznanili s celotno vsebino izbirnih tem. Njihovo sodelovanje je bilo preverjeno z vprašalnikom, izdelanim v Googlovih dokumentih. Kljub predhodnemu nepoznavanju programa Lino It so ga učenci hitro osvojili. Delo z računalnikom je bilo osmišljeno, vključena je bila interakcija med učenci, pokazali so veliko stopnjo kreativnosti, se urili v samostojnem izdelovanju izpiskov ter bili visoko motivirani za delo.

Ključne besede: Lino It, Googlovi obrazci, izdelava izpiskov, pouk zgodovine, visoka motivacija za delo

Abstract

In school we are often faced with the problem of pupils low motivation for tracking the current subject topic. For this reason teachers must be able to make a step towards pupils and to make lessons more interesting. The best way is by using modern technology in classroom. Two elective subjects from the curriculum of history were processed with the help of interactive billboards Lino It. Pupils in pairs made notes, their classmates had to review it and in this way get to know what their classmates had done and got to know the entire contents of the current subject topic. Their co-operation has been verified by a questionnaire produced in a Google document. Despite the previous lack of knowledge about the program Lino It, the use of this program did not made any problems for pupils. Working with a computer has to make

sense for them and in this case they are highly motivated for work, they show a high degree of creativity, they interact with other pupils and they learn how to make notes individually.

Keywords: Lino It, Google Forms, Making notes, History lesson, High motivation for learning

Šolska torba 21. stoletja (e-šolska torba)

School Bag for 21. Century (E-School Bag)

Andrej Flogie
Zavod Antona Martina Slomška, Slovenija
andrej.flogie@z-ams.si

Gregor Mohorčič
Zavod RS za šolstvo, Slovenija
gregor.mohorcic@zrss.si

Marko Bonač
Arnes, Slovenija
marko.bonac@arnes.si

Povzetek

Če bi lahko dosedanje aktivnosti informatizacije slovenskih VIZ razumeli kot slovensko e-šolstvo 1.0, lahko združitev in nadaljevanje dosedanjih aktivnosti: zagotavljanja IKT, usposabljanja, pomoči in svetovanja osebju na slovenskih VIZ, ki omogoča nadaljnje delovanje in razvoj Slovenskega izobraževalnega omrežja (SIO), s katerim bi e-vsebine, e-storitve in IKT še bolj približali osebju na VIZ, posebej pa otrokom oz. učencem in dijakom preko uporabo računalniških, telekomunikacijskih in ostalih elektronskih (prenosnih) naprav, imenujemo e-šolstvo 2.0 oziroma s prispodobo kar »e-šolska torba«. Eden bistvenih pogojev za uspešnost navedenih aktivnosti je tudi krepitev IKT infrastrukture (omrežja, računalniška oprema, ...), nadaljnje ustvarjanje e-vsebin in spremljajočih e-storitev. Projekt »e-šolska torba« je tako nadgradnja in nadaljevanje nekaterih že utečenih aktivnosti s področja informatizacije slovenskega šolstva.

Ključne besede: informatizacija, SIO, šola, izobraževanje

Abstract

If the previous activities of informatization in Slovenian educational institutions, including the provision of ICT training, assistance and advice to the staff in the Slovenian educational institutions that allow the continuation of operation and

development of the Slovenian Education Network (SIO), which could familiarize the staff at educational institutions and especially children and pupils with the e-contents, e-services and ICT through the use of computer, telecommunication and other electronic (mobile) devices; the continuation of the previous activities can freely be named as e-Education 2.0 or as "e-school bag" with the allegory. . One of the essential conditions for the success of these activities is the reinforcement of ICT infrastructure (networks, computer equipment, etc.) and the continuing creation of e-contents and supporting e-services. The "e-school bag" project is in that way an upgrade and continuation of certain established activities in the field of computerization of the Slovenian educational system.

Keywords: Informatization, SIO, School, Education

Pedagoško orodje Svizec

Pedagogic Tool Svizec

Matjaž Gams
Odsek za inteligentne sisteme, Institut »Jožef Stefan«,
Jamova 39, 1000 Ljubljana, Slovenija
Matjaz.gams@ijs.si

Damjan Kužnar
Odsek za inteligentne sisteme, Institut »Jožef Stefan«,
Jamova 39, 1000 Ljubljana, Slovenija

Aleš Tavčar
Odsek za inteligentne sisteme, Institut »Jožef Stefan«,
Jamova 39, 1000 Ljubljana, Slovenija

Povzetek

Na Odseku za inteligentne sisteme na Institutu »Jožef Stefan« smo razvili sistem Svizec z dvema namenoma: kot pedagoško orodje predvsem v osnovni in srednji šoli ter kot sistem za 40.000 članov sindikata SVIZ. Predstavili bomo Svizca kot pedagoško orodje, ki nudi vrsto aplikacij za v pomoč pri poučevanju za učitelje in učencem za učenje. Sistem zna tudi odgovarjati na vprašanja v naravnem jeziku in sledi trendu inteligentnih sistemov. Demonstracija bo v živo z namenom, da se razširi uporaba tega prosto dostopnega programa. Podana bo tudi informacija, kako se sistem namesti na internetnih straneh šole.

Ključne besede: inteligentni pomočniki, komunikacija v naravnem jeziku, pedagoško orodje

Abstract

The developers at the Department of intelligent systems, Institute "Jozef Stefan", developed the Svizec (Marmora) system with two purposes: as a pedagogic tool in elementary and high school and as a tool for 40.000 members of the SVIZ union. Svizec will be presented through the set of integrated applications/services for teachers and pupils alike. The system is also capable of conversation in natural language (in Slovene) and is thus following the direction of intelligent user-friendly communication. The demonstration will be presented alive with the purpose to

present and extend use of the freely available system. Svizec can also be integrated into internet pages of each school.

Keywords: Intelligent assistant, Natural-language Communication, Pedagogical tool

(e)Šola v oblaku ali ko sodobna šola sreča sodobno tehnologijo

School in the Cloud or When Modern School Meet the Modern Technology

Dušan Himelrajh
Unistar LC d.o.o. Slovenija
dusan.himelrajh@unistarlc.si

Povzetek

Zbliževanje svetov skozi globalizacijo, nastajanje družbe znanja in velike spremembe pri dojemanju sveta pri mladih zahteva drastične spremembe izobraževalnega sistema, ki v svoji sedanji obliki ne zadovoljuje potreb po znanju v 21. stoletju. Sodobna informacijska tehnologija, predvsem pa računalništvo v oblaku ponuja odlične tehnološke temelje, na katerih lahko zgradimo novo (e)šolo z vsemi potrebnimi vsebinskimi in organizacijskimi spremembami. Sodobna generacija mobilnih učencev potrebuje mobilno (e)šolo, ki jim bo omogočala dostop do pravih znanj, krajevno in časovno neomejeno. Današnja tehnologija to omogoča. Na snovalcih izobraževalnega sistema je, da to izkoristijo in učencem ponudijo ustrezne izobraževalne oblike in vsebine.

Ključne besede: računalništvo v oblaku, (e)šola 21.stoletja

Abstract

Converging worlds through globalization, the emergence of the knowledge society and accelerated change in the perception of the world for young people requires drastic changes in the educational system which in its current form does not meet the skills needs in the 21st century. Modern information technology, especially cloud computing offers excellent technological foundation on which we can build a new (e)school with all the necessary substantive and organizational changes. The new generation of mobile learners need mobile (e)school that will allow them access to the right skills without place and time limit. Today's technology makes it possible. It's up to the drafters of the education system to take advantage of it and offer appropriate training format and content to students.

Keywords: Cloud computing, 21. Century (e)school

Doseganje učnih ciljev preko foruma v spletni učilnici

Achieving Goals in Teaching Through a Bulletin Board in an E-Classroom

Mojca Janžekovič
OŠ Toma Brejca Kamnik, Slovenija
mojca.janzekovic@guest.arnes.si

Povzetek

Pri pouku skušamo učence naučiti tudi, da znajo določene informacije uporabiti v vsakdanjem življenju, da znajo kritično razmišljati in iskati argumentirane odgovore na aktualna vprašanja. Z uporabo foruma v spletni učilnici lahko izvedemo uro, kjer lahko učenci z nekaj vaje vse te cilje dosežejo. Namen prispevka je motivirati učitelje, da se bolj zavzeto odločijo uporabljati forum v spletni učilnici zaradi prednosti, ki ga tako poučevanje prinese. Predstavljen je primer uporabe foruma pri pouku geografije, podan je kriterij ocenjevanja in zapisane so prednosti in morebitne pasti takšne uporabe.

Ključne besede: spletna učilnica, forum, kritično mišljenje, argumentacija

Abstract

While giving a class, every teacher will try to teach their students to use a certain piece of information in every-day life, to develop critical thinking and to search for and find answers to topical subjects with convincing arguments. Using a bulletin board in an e-classroom, a teacher can perform a lesson where pupils can achieve all these goals. The aim of the paper is to motivate teachers to develop a liking for the use of a bulletin board. The paper presents a case study of the bulletin board in geography class, assessment criteria and finally pros and cons of the afore described teaching method.

Keywords: E-Classroom, Bulletin Board, Critical Thinking, Argument

Spletni portal za sodelovanje učiteljev in razvijalcev elektronskih učnih gradiv

Web Portal for Teacher – Developer Collaboration in Electronic Learning Materials Production

Alenka Kavčič
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani, Slovenija
alenka.kavcic@fri.uni-lj.si

Matevž Pesek
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani, Slovenija
matevz.pesek@fri.uni-lj.si

Ciril Bohak
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani, Slovenija
ciril.bohak@fri.uni-lj.si

Matija Marolt
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani, Slovenija
matija.marolt@fri.uni-lj.si

Povzetek

V članku predstavljamo novo idejo za izdelavo uporabnih e-gradiv, pri kateri so v sam proces razvoja izobraževalnih aplikacij neposredno vključeni učitelji, ki bodo na koncu glavni uporabniki razvitih aplikacij. Ideja, ki smo jo predstavili kot projekt Edoo, je naletela na dober odziv predvsem med učitelji, ki pri svojem delu vedno znova naletijo na probleme zaradi pomanjkanja ustreznih gradiv ali težavnega prilagajanja obstoječih gradiv posebnostim njihove učne ure in ciljne skupine učencev. Projekt Edoo je namenjen povezovanju uporabnikov e-gradiv (učiteljev) z izdelovalci teh gradiv (programerji) preko namenskega spletnega portala in spletne učilnice. Tako bomo obema skupnostma omogočili lažje sodelovanje in izmenjavo idej, hkrati pa z boljšim medsebojnim razumevanjem tudi zmanjšali prepad med njima. Končni cilj je ustvarjanje kakovostnih didaktičnih računalniških programov na način, ki omogoča neposreden vpliv učiteljev na končni izdelek že v času razvoja, kar bi vodilo v izdelavo sodobnih, prilagodljivih, modularnih in prosto dostopnih gradiv.

Ključne besede: e-izobraževanje, izmenjava znanja, sodelovanje uporabnika pri razvoju programske opreme, elektronska učna gradiva

Abstract

The paper presents a new idea in the development of the electronic learning materials, where the teacher as the end user of the developed application is directly involved in the development process. The idea was presented within the Edoo project and was well received among the teachers, who have numerous problems in their work because of the lack of suitable learning materials or difficulties with their adaptation to suit their specific needs of the class and targeted students. The Edoo project aims at connecting the users of electronic learning materials (teachers) with the producers (programmers) through the web portal and online learning site, specially designed for this purpose. Our goal is to assist in easier cooperation of both communities, sharing the ideas, mutual understanding, and consequently narrowing the gap between them. The main final objective is the creation of quality didactic computer programs in a way where the teachers can directly influence the final product during the development process and thus leading to development of modern, adaptive, modular and freely accessed materials.

Keywords: E-Learning, Knowledge Exchange, User Involvement in Software Development Process, Learning Materials

Tekmovanje za naj športnika šole

Best Athlete Competition of School

Gaber Klinar
Osnovna šola Toneta Čufarja Jesenice, Slovenija
gaber.klinar@gmail.com

Povzetek

Na Osnovni šoli Toneta Čufarja Jesenice že nekaj časa uporabljamo računalniški program Gymeye za spremljavo športnih dosežkov posameznikov in oddelkov. Sam program omogoča vrednotenje posameznih dosežkov, tako da lahko med seboj tekmujejo učenci različnih razredov in oddelkov. Na koncu šolskega leta dobimo najboljšega športnika šole. Prav tako se lahko seštevajo rezultati posameznih oddelkov in tako dobimo še naj športni oddelek. Program omogoča tudi vpisovanje rezultatov za Športno vzgojni karton in jih tudi izvozi v excel v pravilni obliki (primer: tek na 600 m; rezultat 1,55 min pretvori v 115 s). Sami lahko nastavljamo discipline in njihovo točkovanje, v primeru pa da neko disciplino večkrat izvajamo upošteva boljši rezultat. Učitelji športne vzgoje smo ugotovili, da so učenci, od kar izvajamo tekmovanje za naj športnika šole s pomočjo tega programa, precej bolj motivirani pri urah športne vzgoje, predvsem pri tekih.

Ključne besede: športna vzgoja, tekmovanje za naj športnika

Abstract

For a while now the primary school Tone Čufar Jesenice has been using the computer software Gymeye to monitor sport achievements of individuals as well as classes. This software enables the grading of individual achievements, so that students from different grades and classes can compete with each other. At the end of the school year the best school athlete is revealed. Similarly, the results of individual classes are compared as well and this way we also get the best athlete class. Gymeye also enables adding data to the physical education card and exports the data to an excel file in the proper form (e.g. 600 m run; result 1.55 min is converted into 115 s). Users of this software can edit the disciplines and their scoring. In case one discipline is performed several times the best result is taken into account. Physical education teachers have determined that students have been more

motivated (especially in the running discipline) since this software has been used for the best school athlete competition.

Keywords: Physical education, Best athlete competition

Uporaba pristopa živih laboratorijev v pedagoškem procesu

The Use of Living Laboratory Approach in Pedagogy

Mirjana Kljajić Borštnar
Univerza v Mariboru, Fakulteta za organizacijske vede, Slovenija
mirjana.kljajic@fov.uni-mb.si

Andreja Pucihar
Univerza v Mariboru, Fakulteta za organizacijske vede, Slovenija
andreja.pucihar@fov.uni-mb.si

Gregor Lenart
Univerza v Mariboru, Fakulteta za organizacijske vede, Slovenija
gregor.lenart@fov.uni-mb.si

Povzetek

Živi laboratorij je naravno okolje, v katerem uporabniki, raziskovalci, podjetja in ostali deležniki soustvarjajo in preskušajo nove proizvode in storitve. V zadnjih letih vse bolj uveljavljen pristop odprtega inoviranja je uspešen tudi v poučevanju. V prispevku predstavljamo večletne izkušnje uporabe pristopa živih laboratorijev v učnem procesu na Fakulteti za organizacijske vede UM, kjer skupine študentov, profesorjev in podjetij sodelujejo pri sooblikovanju novih rešitev s področja informacijskih sistemov. Skupine v realnem okolju identificirajo izzive, iščejo možnosti reševanja s pomočjo informacijske tehnologije, razvijejo delujoče prototipne rešitve in jih preskusijo. Prednost pristopa je, da študentu omogočimo stik z realnim okoljem, sodelovanje s potencialnimi delodajalci ter preskušanje pridobljenega znanja na realnih problemih. Študentje so, v primerjavi s klasičnimi načini poučevanja, bolj motivirani, kar se kaže tudi na učnem uspehu. Uspešnost pristopa je odvisna od odprte komunikacije in angažiranja vseh udeležencev.

Ključne besede: učenje na primeru, živi laboratorij, metoda prototipiranja

Abstract

A Living Lab is a natural environment in which users, researchers, businesses and other stakeholders co-create and test new products and services. This more and more established approach to open innovation, has shown to be successful in teaching as well. In this paper we present years of experience of living labs approach in the teaching process at the Faculty of Organizational Sciences University of Maribor, where groups of students, professors and companies are involved in the creation of new solutions in the field of information systems. Groups of students identify challenges in a real world environment, and try to find solutions with the help of information technology. The result is a working prototype solution. This approach allows students to work and learn in a real environment, engaging with potential employers and testing of the acquired knowledge to solve the real problems. Compared to traditional methods of teaching, the students are more motivated, which is also reflected on the learning outcomes. The success of the approach depends on open communication and engagement of all participants.

Keywords: Case based learning, Living laboratory, Prototyping

E-gradivo za učenje desetprstnega slepega tipkanja

E-Learning Material for Touch Typing

Miha Koncilja
Univerza v Mariboru, Fakulteta za organizacijske vede, Slovenija
miha.koncilja@gmail.com

Branislav Šmitek
Univerza v Mariboru, Fakulteta za organizacijske vede, Slovenija
brane.smitek@fov.uni-mb.si

Povzetek

Tipkanje potrebujemo vsak dan, tako pri delu kot tudi pri osebni rabi. Določena delovna mesta celo zahtevajo poznavanje metod tipkanja, kot je desetprstno slepo tipkanje. Desetprstno slepo tipkanje namreč omogoča hitro in učinkovito komunikacijo z računalnikom s pomočjo tipkovnice. Gre verjetno za najpopularnejšo metodo, ki omogoča hitrejši in natančnejši vnos podatkov. Z uporabo omenjene metode zmanjšamo tudi telesni napor, ki je potreben pri tipkanju. Zaradi omenjenih prednosti je uporabnikom spleta smiselno predstaviti omenjeno metodo tipkanja in spodbujati njeno uporabo. Za namen učenja desetprstnega slepega tipkanja smo izdelali celovito e-gradivo, ki omogoča spoznavanje teoretičnih osnov in tudi praktično vadbo. Desetprstnega slepega tipkanja se namreč ne moremo naučiti brez vaje, tako kot se brez vaje ne moremo naučiti igranja glasbenega inštrumenta. E-gradivo lahko uporabimo tudi za testiranje svojih trenutnih sposobnosti tipkanja, za tekmovanja ali pa za pridobivanje zbirnih podatkov posameznih uporabnikov e-gradiva. Ima mnogo funkcionalnosti in ponuja obsežno ter natančno povratno informacijo o tipkanju.

Ključne besede: desetprstno slepo tipkanje, e-izobraževanje, e-gradivo

Abstract

Typing skills are needed every day both at work and for personal use. Certain jobs even require the mastery of typing methods such as touch typing. Touch typing enables rapid and efficient communication with the computer using the keyboard. It is probably the most popular method that allows faster and more accurate data entry. It also reduces the physical effort required when using the keyboard. Due to these

advantages, it makes sense to introduce the touch typing method to internet users and to promote its use. For the purpose of learning how to touch type, we created an e-learning material which enables users to learn theoretical foundations of touch typing and a practical exercise. Touch typing cannot be learned without practical exercise, just as we cannot learn how to play a musical instrument without drill. E-learning material can also be used to test the current typing skills, for competitions or for the collecting data of how users use e-material. It has many features and offers comprehensive and accurate feedback on typing.

Keywords: Touch typing, E-Learning, E-Learning material

Priprava na medpredmetni potep z IKT

Preparing a Cross-Curricular Field Trip Using ICT

Maja Kosmač Zamuda
Šolski center Ljubljana, Gimnazija Antona Aškerca, Slovenija
maja.kosmac1@guest.arnes.si

Povzetek

V članku sem predstavila priprave na ekskurzijo s projektnim delom v razredu, ki smo ga z dijaki 3. letnika izpeljali v mesecu oktobru in novembru 2012. Namen priprave je bil predstaviti jezik, kulturo, običaje Rezijancev ter pokrajino in zgodovino območja, kjer leži Rezija. Dijaki so pri pripravi na ekskurzijo aktivno sodelovali s seminarskimi nalogami oziroma s predstavitvami v Preziju in Glogsterju. Pri načrtovanju poti v Rezijo so si pomagali z Google Maps Maker. Po ekskurziji, ki smo jo izpeljali po zaključku priprave v razredu, so pripravili predstavitev z Movie Makerjem in Animaps. Tako so dijaki imeli možnost spoznavanja uporabnosti različne IKT tehnologije in so se po uporabi v anonimni anketi opredelili do smiselnosti uporabe le-teh.

Ključne besede: IKT, ekskurzija, medpredmetne povezave

Abstract

My article deals with a project task which we carried out with the students of the 3rd grade in October and November 2012. The purpose of the project was to present the language, culture and customs of the Resians as well as the land and history of the Resia Valley. The students were actively involved in the project with their seminar papers, to wit, presentations by means of Prezi and Glogster. While preparing the itinerary of our visit to Resia they made use of the Google Maps Maker. After the field trip following the completion of the project they prepared the presentation by means of Movie Maker and Animaps. This way students could test how useful different ICT technologies are and they answered anonymous survey about it.

Keywords: ICT, Field trip, Cross-curricular links

Po IKT učni poti v svet znanja

Following the ICT Educational Path into the World of Knowledge

Maja Kosmač Zamuda
Šolski center Ljubljana, Gimnazija Antona Aškerca, Slovenija
maja.kosmac1@guest.arnes.si

Povzetek

V članku predstavljam učno pot Sporazumevanje, ki sva jo s kolegico z Gimnazije Bežigrad pripravili in izpeljali z dijaki 1. letnika v šolskem letu 2012/2013. Namen učne poti je bil povezati dijake dveh gimnazij v skupno spletno učilnico pri obravnavi zahtevnejše snovi v 1. letniku. Dejstvo je, da tak način izboljša kakovost dela v razredu in dijake tudi bolj motivira za učenje. Namen je bil narediti snov zanimivejšo za naslovnika. Sodelovala sta oddelek 1a z Gimnazije Antona Aškerca in 1 c z Gimnazije Bežigrad. Učno pot je predvidela različne dejavnosti dijakov: ogled filma, reševanje učnih listov, forum, klepet, oddajanje dokumenta, reševanja vprašalnika. Ob zaključku učne poti sva se s kolegico povezali preko spletne konference Vox in preverili znanje dijakov v obeh oddelkih.

Ključne besede: učna pot, spletna učilnica, spletna konferenca vox

Abstract

The article deals with the educational path Communication which my colleague from the Bežigrad Grammar School and I prepared and followed through with the students of the first grade in the academic year 2012/2013. The purpose of the educational path was to join the students of the two grammar schools in a common online classroom when more demanding themes are being discussed in the first grade. The fact is that by working in such a way the quality of work during classes is improved and the students are more motivated to learn. The purpose was to make the subject matter more interesting for them. The classes 1a from the Anton Aškerc Grammar School and 1c from the Bežigrad Grammar School were involved in the project. The educational path foresaw various activities by the students: watching a film, doing work sheet exercises, a forum and a chat, handing in the document, filling in the questionnaire. Upon the conclusion of the educational path my colleague and I linked via vox conference and checked the knowledge of the students of both classes.

Keywords: Educational path, Online classroom, Vox conference

Primerjava učnih ciljev in kurikulumov računalništva in informatike

Comparison of Learning Objectives and Curricula of Computer Science

Nataša Kristan
Univerza v Ljubljani, Fakulteta za računalništvo in informatiko
natasa.kristan@fri.uni-lj.si

Andrej Brodnik
Univerza v Ljubljani, Fakulteta za računalništvo in informatiko
Univerza na Primorskem, Fakulteta za matematiko, naravoslovje in informacijske tehnologije
andrej.brodnik@fri.uni-lj.si

Povzetek

Vseskozi se pogovarjamo kako učiti računalništvo in informatiko v današnjem času, kako primerno uporabiti IKT ter s kakšnimi metodami in oblikami dela primerno predstaviti računalniške vsebine. Še vedno pa nismo razjasnili KAJ bi se moralo učiti v šolah. Ko bomo razjasnili KAJ bi se moralo učiti oziroma z drugimi besedami, kaj bi moral učenec po zaključenem sklopu znati, se bomo tudi lažje in bolj smiselno odločili, kako to snov razložiti in pripraviti. Primerjali smo svetovno znane CSTA K-12 kurikulum standarde in angleško The Royal Society poročilo z našimi trenutnimi učnimi načrti in cilji, z namenom, opaziti bistvene razlike. Ugotovili smo, da si učni cilji niso bistveno različni, saj je slovenski učni načrt precej odprt. Je pa res, da nekatere vsebine niso pokrite v slovenskih gimnazijah. Bistvena razlika se je pokazala pri vsebinah algoritmov in programiranja, kjer so te vsebine obvezne (ali izbirne) v Ameriki in Angliji, v Sloveniji pa so večinoma izbirne in precej bolj skope.

Ključne besede: kurikulum, učni načrt, računalništvo in informatika, srednja šola

Abstract

We are discussing how to teach Computer Science, what is the proper use of ICT, and what are the appropriate methods and forms to present computing content. However, we still did not clarify WHAT should be taught in schools. Once we clarify what should be taught or in other words, what students should achieve at each level,

then we can decide how to explain and prepare the content. Therefore we compared CSTA K-12 Computer Science Standards and English Royal Society Report with the current Slovenian curriculum and learning objectives to find out significant differences. We found out that learning objectives are not significantly different, since the Slovenian curriculum is quite open, although some contents are not covered in Slovenian secondary schools. The major difference has been found in the topics of algorithms and programming, which are mandatory (or optional) in United States and England, but in Slovenia these topics are mostly optional and much more limited.

Keywords: Curriculum, Computer Science, Secondary school

Splet 2.0 kot podpora poučevanju in širše

Using Web 2.0 in the Classroom and Beyond

Petra Matkovič
Osnovna šola Vide Pregarc, Slovenija
matkovic.petra@gmail.com

Katja Kodelja
Osnovna šola Vide Pregarc, Slovenija
kodelja.katja@gmail.com

Povzetek

V prispevku predstavljava zbirnik aplikacij (http://splet2-0.blog.arnes.si/) iz sklopa spleta 2.0. Cilj zbirnika je zagotoviti podporo poučevanju in ostalim delovnim nalogam učitelja. V obilici različnih spletnih aplikacij in orodij se učitelj težko znajde oziroma porabi ogromno časa za preverjanje in preizkušanje, zato bo zbirnik aplikacij dobrodošla pomoč. Učiteljem bo na voljo nabor uporabnih aplikacij, imeli pa bodo tudi možnost komentiranja že objavljenih aplikacij. Na ta način bodo lahko z ostalimi obiskovalci spletnika delili svoje izkušnje in primere dobre prakse. Vsaka aplikacija v zbirniku je predstavljena tako, da je najprej izpostavljen način uporabe ter prednosti in slabosti programa. Dodali sva tudi hiperpovezave do domače strani aplikacije in video vodiče. Za izdelavo zbirnika sta bili uporabljeni dve aplikaciji in sicer; spletnik v programu Wordpress in Diggo, aplikacija za shranjevanje zaznamkov. Dodana vrednost takega zbirnika se kaže predvsem v tem, da imajo učitelji na enem mestu na voljo nabor različnih aplikacij, ki jih lahko vsakodnevno uporabljajo.

Ključne besede: splet 2.0, zbirnik aplikacij, digitalna pismenost, sodelovalno učenje, spletnik

Abstract

This paper presents the web 2.0 application database (http://splet2-0.blog.arnes.si/). The purpose of the database is to provide the support for teaching as well as the support for other tasks teachers perform at schools. It is difficult to sort among the vast variety of different web applications and tools especially due to lack of time. This database will provide a range of useful web 2.0 applications, the visitors to our blog will also be able to post comments and evaluate the applications presented on our blog. This will give them the opportunity to share their experiences and examples of

good pratice. We decided to present each application in the following way: we provide the instructions on how to use the application, its advantages and disadvantages. A hyperlink to its web page and video tutorial was also added. We used two web 2.0 application for our database, namely Wordpress blog and Diggo, a social bookmarking site. An advantage of such database lies mainly in the fact that a variety of applications will be collected in one place for teachers to use at their convenience.

Keywords: Web 2.0, Application database, Digital literacy, Cooperative learning, Blog

IKT povezala osnovnošolce in starejše

ICT Connected Pupils and Elderly Population

Miroslava Minić
OŠ Dobje, Slovenija
mira.minic@osdobje.si

Povzetek

Po vsej Sloveniji poznamo projekt Simbioza, katerega poslanstvo je, s pomočjo medgeneracijskega sodelovanja poskrbeti za dvig računalniške pismenosti starejših. Računalniške delavnice smo organizirali tudi na Osnovni šoli Dobje. Projekt je bil tako dobro sprejet, da izobraževanje starejših še naprej poteka v okviru projekta Popestrimo šolo s prostovoljno pomočjo učencev naše šole. V prispevku je predstavljeno, kako smo na naši šoli projekt Simbioza nadgradili. Dobil je nove razsežnosti ter s pomočjo IKT medgeneracijsko povezal učence, upokojence in učitelje. Postal je izziv za upokojence, ki radi raziskujejo in jim ni dovolj, da bi se predali »enoličnemu vsakdanu«, učence, ki so radi »za računalnikom«, in tudi izziv za učitelja, da s pomočjo učinkovitega komuniciranja in sodelovanja več generacij uči skupaj, išče ustrezna gradiva, jih oblikuje in tako ustvarja nova znanja, ob katerih osmisli rabo IKT.

Ključne besede: medgeneracijsko sodelovanje, dvig računalniške pismenosti

Abstract

Project Simbioza, whose mission is to provide an intergenerational cooperation and raise the computer literacy of older people, is known throughout Slovenia. The computer workshops are also organized in our elementary school Dobje. The project was so well received that the education of older people with the voluntary help of our pupils is continuing as a project Popestrimo šolo. This article presents how the Simbioza project was upgraded in our school. Even more, the project got the new dimensions and with the help of the ICT connected students , pensioners and teachers intergenerationally. It has become a challenge for seniors, who like to explore and don't want to leave themselves to monotony of everyday life, students who like computers and also the challenge for the teachers, who through communication and cooperation teach different generations together. A teacher also has a chance to look for appropriate material, transforms it and in that way creates a

new knowledge, something that previously did not exist and at the same time gives meaning to ICT.

Keywords: Intergenerational participation, Raising the computer literacy

Vpeljava mrežnih projektov v zgodnje poučevanje tujega jezika

Introduction of Web-Based Projects in Early Foreign Language Teaching

Tanja Müller
Osnovna šola Franceta Prešerna, Slovenija
tanja.mueller@sfpkr.si

Povzetek

Kako mlajše učence motivirati za učenje tujega jezika ter jim učenje le-tega tudi osmisliti? Kaj zanima učence in kaj radi počnejo? Ta vprašanja so me pripeljala do iskanja novosti in inovativnosti pri zgodnjem poučevanju tujega jezika. Tako sem se odločila, da v izvedbo pouka vpeljem nekaj zanimivih projektov. Združila sem poučevanje angleščine in uporabo informacijsko komunikacijske tehnologije ter motivirala učence za sodelovanje s svojimi vrstniki po svetu. Z učenci smo sodelovali v različnih projektih, med njimi tudi v Projektu medvedek in Izmenjava voščilnic, ki sta dva izmed mednarodnih mrežnih projektov organizacije iEARN, ki spodbujajo pismenost in medkulturno sporazumevanje. Namen prispevka je prikaz umestitve mrežnih projektov pri pouku zgodnjega poučevanja angleščine, predstaviti pozitivne in negativne izkušnje, ki sem jih pridobila s temi projekti in motivirati ostale učitelje za sodelovanje v iEARN-projektih. Učenci radi sodelujejo v različnih projektih, še posebej, če preko njih spoznajo in dobijo nove prijatelje, prav tako pa je pouk veliko bolj zanimiv.

Ključne besede: mrežni projekti, zgodnje poučevanje angleščine, e-izobraževanje, IKT

Abstract

How to motivate young learners to learn a foreign language and how to make learning of language reasonable? What are young learners interested in and what do they like to do? These are the questions that led me to searching for novelties and innovations in foreign young-learners language teaching. Therefore I decided to implement few interesting projects into my lessons. I combined teaching English with the use of information communication technology and motivated students to co-operate with peers around the world. The projects The Teddy Bear Project and Holiday Card Exchange are two of many international web-based projects of the

iEARN organisation which encourages literacy and intercultural communication. The aim of the presentation is to present how to implement web-based projects into the early language teaching process, to present positive and negative experiences I have gained through these projects, and to motivate other teachers to participate in iEARN projects. The students like to work in different projects, especially if they can meet and get new friends, they also gain a lot of experiences, and the lessons are more interesting.

Keywords: Web-based projects, Early English language teaching, E-Learning, ICT

INFORMACIJSKA DRUŽBA – IS'2013
11. oktober 2013
VZGOJA IN IZOBRAŽEVANJE V INFORMACIJSKI DRUŽBI

Razvijanje socialnih veščin z uporabo interaktivnih književnih likov

Developing Social Skills by Using Interactive Literary Characters

Tina Pajnik
OŠ Vide Pregarc, Slovenija
tina.pajnik@gmail.com

Povzetek

Socialne veščine se začnejo razvijati že v zgodnjem otroštvu. Ker so tesno povezane z vzgojo v šoli, se jih da načrtno razvijati. Mladi šolarji veliko težav in skrbi prinašajo iz različnih okolij. V želji, da bi razvijali ustrezne komunikacijske veščine, smo se v drugem in tretjem razredu načrtno lotili izvedbe delavnic na temo klasičnih Grimmovih pravljic. Interaktivni književni liki so preko identifikacije omogočili analizo odnosov ter transfer na področje vsakodnevnih konfliktov v primarnem in sekundarnem okolju. Interaktivno šolsko okolje se je izkazalo za zelo uspešno, omogočilo je prenos književnega časa in prostora v sodoben čas ter prikazalo problematiko družinskih odnosov na način, ki so ga mladi šolarji zlahka sprejeli.

Ključne besede: socialne veščine, interaktivni književni liki, interaktivne delavnice

Abstract

Social skills begin to develop in early childhood. As they are closely related to the education in school, we can systematically develop them. Young pupils bring many of the problems and concerns from a variety of backgrounds. In order to develop appropriate communication skills we have systematically prepared workshops on the themes of the classic Grimm fairy tales in the second and third grade. Through the identification of interactive literary characters and analysis of the relations transfer was made in the field of everyday conflict in the primary and secondary environment. Interactive school environment has proved to be very successful as it allowed the transfer of literary time and space into the modern time. At the same time it showed the issue of family relationships in a way that young schoolchildren easily accepted.

Keywords: Social skills, Interactive literature characters, Interactive workshops

E-portfelj kot orodje dijakove predstavitve in refleksije

E-Portfolio as a Means of Secondary-School Student's Presentation and Reflexion

Dejan Paska
Srednja šola za oblikovanje Maribor, Slovenija
dejan.paska@ssom.si

Katja Kokol
Srednja šola za oblikovanje Maribor, Slovenija
katja.kokol@ssom.si

Povzetek

E-portfelj je elektronska zbirka del in refleksij posameznika skozi čas, ki kaže na njegov razvoj in napredek, v učnem procesu pa predstavlja možno orodje za evalvacijo dijakovega dela in refleksijo njegovega učnega napredka. Z namenom, da bi dijakom olajšali spremljanje le-tega in jim omogočili lažje vključevanje na trg delovne sile smo na Srednji šoli za oblikovanje Maribor v sodelovanju s projektnimi partnerji zasnovali lastno aplikacijo za pripravo portfeljev. Ta dijaku (in iskalcu zaposlitve) omogoča nadzor nad objavljenimi vsebinami, ponuja podrobna navodila, kako pripraviti predstavitev sebe in svojega dela, hkrati pa je namenjena tudi delodajalcem, ki lahko s pomočjo iskalnika iščejo primerne kadre. V članku opišemo teoretična izhodišča projekta, njegovo implementacijo ter predlog integracije e-portfelja v učni proces.

Ključne besede: e-portfelj, srednje šolstvo, refleksija, iskanje zaposlitve, video predstavitev

Abstract

E-portfolio is an electronic library reflecting the individuals work and progress through time, and can as such be used during the learning / teaching process to evaluate and reflect back on the students learning progress. With the intent of simplifying the process of entering the job market for students and enable them to monitor their progress while still in school, the Srednja šola za oblikovanje Maribor, together with our European partners developed an innovative application for preparation and maintenance of e-portfolios. The application allows students (and job seekers) to monitor their published work, contains detailed instructions and "how tos" on

preparing an e-portfolio and personal presentation, while at the same time enables participating companies to find suitable prospective employees. In this article we present the theoretical background of the project, as well as its' implementation together with a detailed plan of introducing the e-portfolio into the learning / teaching process.

Keywords: e-portfolio, High school, Reflection, Employment search, Video promotion

Iz ilustracije v interaktivno instalacijo: interaktivna miza »Mačja šola«

From Illustration to Interactive Installation: Interactive Table »Mačja šola«

Erika Pavlin
Akademija za likovno umetnost in oblikovanje, Univerza v Ljubljani, Slovenija
erika.pavlin@vdc.si

Žiga Elsner
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani, Slovenija
ziga.elsner@gmail.com

Tadej Jagodnik
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani, Slovenija
tadej.jagodnik@gmail.com

Borut Batagelj
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani, Slovenija
borut.batagelj@fri.uni-lj.si

Franc Solina
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani, Slovenija
franc.solina@fri.uni-lj.si

Povzetek

Predstavljena je interaktivna igra z dvema sestavljankama v obliki posebej oblikovane mize z vgrajenim računalniškim zaslonom na dotik. Za likovno predlogo obeh sestavljank služita sliki, ki jih je izdelala oseba z motnjo v razvoju. Uporaba mize zahteva fino-motorične spretnosti in vajo, vendar tudi zabavo in je namenjena mlajši populaciji in/ali predvsem osebam s posebnimi potrebami.

Ključne besede: likovna vzgoja, igra

Abstract

An interactive game consisting of two puzzles in the form of a specially designed table with an integrated touch screen is presented. Pictures painted by a mentally retarded person are used as templates for both puzzles. To play the game fine motor skill and practice are needed. Young children and/or in particular persons with mental retardation can enjoy the game.

Keywords: Art education, Game

INFORMACIJSKA DRUŽBA – IS'2013
11. oktober 2013
VZGOJA IN IZOBRAŽEVANJE V INFORMACIJSKI DRUŽBI

Bližnje srečanje duha in telesa v okolju IKT

A Close Encounter of Body and Mind in the ICT Environmet

Peter Prhavc
Gimnazija Ledina, Ljubljana, Slovenija
peter.prhavc@gmail.com

Maja Lebar Bajec
Gimnazija Ledina, Ljubljana, Slovenija
maja.lebar@guest.arnes.si

Povzetek

Eden izmed prastarih problemov tako rekoč kateregakoli sistematičnega miselnega sistema, bodisi zahodnega bodisi vzhodnega ali sploh kakršnegakoli, je vprašanje načinov (so)obstoja in medsebojne (ne)odvisnosti dveh radikalno različnih oblik bivajočega, ki se razpirata pod okriljem izrazov zavest, duh, duša, duševnost, doživljanje... oz. telo, materija, physis, (prostorska) razsežnost... Avtorja tega prispevka sva to temo poskusila zajeti na točki presečišča v človeškem telesu, in sicer na dveh nivojih: notranjem - doživljajskem, introspektivnem, in zunanjem - vedenjskem, ekstraspektivnem. Skupaj z dijaki tretjega letnika gimnazije smo se lotili joge, tai chija, relaksacije, meditacije, telepatije, mode, reklam, body buildinga, plesa, filozofske refleksije, internetnih predavanj, (telesne) samopodobe in doživljanja glasbe v telesu. IKT je bil ključni modus, ki je psihologiji in angleščini omogočil izvedbo projekta. Poglavitna ugotovitev je bila, da se srečanje telesa in duha v različnih kontekstih izraža precej podobno. Bolj vsebinsko rečeno: soočenje duha in telesa se kljub navidezno zelo različnim pristopom (zahodni/vzhodni, statični oz. pasivni/dinamični oz. aktivni, usmerjen k cilju/usmerjen k poti brez eksplicitnega cilja, telo kot nereflektirana gmota/telo kot objekt refleksije...) pokaže kot vzrok in posledica (samo)zavedanja in posameznikove partikularne eksistence.

Ključne besede: telo, doživljanje, IKT, digitalna kompetenca, refleksija, aktivnost, pasivnost

Abstract

One of the basic problems of any systematic thought system, be it Eastern or Western, is the coexistence and (in)dependence of two radically diverse ways of existence, which can be found under the terms consciousness, mind, soul, experience…or body, matter, physis, (spatial) dimension. We tried to assemble

aforementioned at their intersection – in the human body. We focused on two levels: the internal one – i.e. experience, introspection, and the external one – i.e. behaviour, extrospection. The third grade high school students executed research on yoga, tai chi, relaxation, meditation, telepathy, fashion, advertisements, bodybuilding, dance, philosophical reflection, the Internet speeches, body image and music. The ICT operated as the key method, thus enabling us to join two school subjects, Psychology and English. The major conclusion was that the encounter of body and mind in different contexts is expressed in a very similar manner. In other words: the confrontation of body and mind is, despite virtually very different approaches (Eastern/Western, static/dynamic, goal-oriented/goalless…), shown as the cause and result of (self)awareness and the particular existence of an individual.

Keywords: Body, Experience, ICT, Digital competences, Reflection, Active, Passive

INFORMACIJSKA DRUŽBA – IS'2013
11. oktober 2013
VZGOJA IN IZOBRAŽEVANJE V INFORMACIJSKI DRUŽBI

Učenje in računalnik med včeraj in jutri

Learning and Computer Between Yesterday and Tomorow

Vanda Rebolj
vodja projektov, svetnica, Slovenija
vanda.rebolj@gmail.com

Povzetek

Okvir prispevka predstavlja uporaba informacijske tehnologije v izobraževanju. Predstavljamo nekatere globalne spremembe, ki so nastale pod njenim vplivom. Zlasti nas zanima didaktični napredek, vsebina uporabe računalnikov in nove oblike učenja in poučevanja. Izpostavljamo splošni napredek v formalnem izobraževanju in kognitivne spremembe pri učencu. Ker je pri nas malo raziskav, smo pretežno uporabljali izsledke tujih raziskav in tuje izkušnje. Učence obravnavamo v treh starostnih skupinah: malčke, šolarje in adolescente, ki se pripravljajo na kariero in mesto v informacijski družbi. S tem želimo prikazati, da so učinki IT konceptualni in globoki. Želimo razlikovati prave in napačne poti do boljše šole, do učinkovitega pouka in do uveljavljanja računalniške gerneracije v družbi.

Ključne besede: didaktika, digitalno učenje, formalno izobraževanje, informacijska družba, informacijska tehnologija, kognitivni razvoj

Abstract

The scorpe of the work is using information technology in education. In this paper are represented some global changes to be caused with IT. Mostly we are interesting in didactic progress, the contents where computer is used and the new forms of teaching and learning in formal education. We represent generalised approach as well the cognitive approach of students. In our country we have only few scientific researches in this field. This is the reason for using foreign european and american sources and experiences. The students are discussed in three groups: infants, scolars and adolescents which are preparing for their place in information society. We intend to expose that effect of IT is conceptual and deep. We distinguish the proper and wrong way to better school and more efficient computer supported learning in future.

Keywords: Didactics, Digital learning, Formal education, Information society, Information technology, Cognitive improvement

Učenje + računalnik = sodobna šola

Learning + Computer = Moderen School

Lea Senica
Osnovna šola Dobje, Slovenija
senica.lea@gmail.com

Povzetek

Računalništvo v oblaku je oblika IKT-ja, ki omogoča enostaven dostop do deljenja računalniških virov, kot so omrežja, strežniki, storitve in programska oprema. Slednje se lahko koristno uporabi tudi pri pouku s t.i. metodo učenja v oblaku, kjer učitelj deli naloge preko spleta, učenec pa jih rešuje in se tako uči. V prvem delu prispevka želim predstaviti postopno zgodnje uvajanje učencev v računalništvo v 1. triletju, v drugem pa v letošnjem šolskem letu izvedeno nadgradnjo znanj učencev 5. razreda z metodo učenja v oblaku. Z učenci smo po korakih usvojili storitev Google+ (elektronska pošta, spletna raba, video konferenca), ki nam je omogočila kakovostnejše delo pri pouku. Uporaba le-te nam je pokazala številne prednosti, ki jih takšen način učenja prinaša s sabo: večja motivacija za delo, rednejše pisanje domačega dela, samostojnejše delo zaradi enostavne uporabe storitve, širši spekter pridobivanja informacij, pridobitev novih kompetenc, dostop do nalog kjerkoli in kadarkoli ter manjša poraba papirja za učne liste.

Ključne besede: IKT, metode učenja

Abstract

Cloud computing is form of ICT, which enables an easy access to division of computer sources (networks, servers, services and computer equipment). It can be also used at school, where online exercises are given by a teacher and done by a pupil. In the first part of the article I would like to present early E-learning in the first triennium. In the second part I write about improving the fifth graders' computing knowledge, with the help of teaching in the clouds. In this school year we gradually adopted the Google+ services (e-mail, web use, video conference), which enabled us more quality learning. By using Google+ services we found out, that this kind of learning has many advantages: greater work motivation, more regular writing of homework, more independent work because of the simple use of the services, wider

spectrum of information flow, getting new competences, easier access to all exercises and less paper consumption.

Keywords: ICT, Teaching methods

Z IKT na poučni poti do zakladov znanja

With the ICT on the Educational Path to the Treasures of Knowledge

Simona Senica
Osnovna šola Planina pri Sevnici
Planina pri Sevnici, Slovenija
simona.senica2@gmail.com

Urška Tisel
Osnovna šola Planina pri Sevnici
Planina pri Sevnici, Slovenija
urska.tisel@guest.arnes.si

Povzetek

V prispevku želimo predstaviti način, kako otrokom v prvih letih šolanja približati zahtevnejše in manj zanimive teme z uporabo IKT in tako doseči trajnejše znanje poznavanja kulturno zgodovinskih znamenitosti domačega kraja. Učenci so na poučni poti (iskanje skritega zaklada) ob uporabi pisnih virov, mobilnega telefona in fotoaparata zbirali podatke ter slikovno gradivo, ki so jih uporabili za oblikovanje fotozgodbe, ob kateri so se urili za lokalnega turističnega vodiča. Z uporabo IKT, medpredmetnim povezovanjem in projektnim delom smo dosegli, da so bili učenci soustvarjalci pouka, da so bili aktivni, kreativni in da so bili motivirani za teme, ki so jim sicer večinoma manj privlačne. Svoje končne izdelke so lahko uporabili ne le pri pouku, temveč tudi kot predstavitev domačega kraja učencem gostujočih šol in drugim obiskovalcem.

Ključne besede: medpredmetno povezovanje, kulturno zgodovinske znamenitosti, domači kraj, mobilni telefon, fotozgodba, turistični vodič

Abstract

In this paper we want to present the way how we can approach pupils demanding and less interesting topics in the first years of schooling with the use of ICT and achieve lasting knowledge of cultural and historical sites of hometown. Pupils collected data and pictures on the educational path (treasure hunt) by means of written sources, a mobile phone and a camera. They used them for creating a photo

story at which they were trained for a local tourist guide. With the use of ICT, cross-curricular activities and project work we have achieved that the pupils were co-creators of teaching and that they were active and creative. Furthermore, they were motivated by topics that are usually less attractive. They could use their final products not only in the classroom, but also as a presentation of their hometown to the pupils of visiting schools and other visitors.

Keywords: Cross-curricular activities, Cultural and historical sites, A hometown, A mobile phone, A photo story, A tourist guide

Z računalnikom je pot do kompetenc lažja

Virtual Stories and Life-Long Competences Working Hand in Hand Extract

Mateja Slevec
OŠ Marije Vere, Kamnik, Slovenija
mateja.slevec@os-marijevere.si

Povzetek

V prispevku opisujem uporabo IKT pri delu v podaljšanem bivanju (PB). Praktični del v obliki usmerjenega prostega časa je bil izpeljan v četrtih razredih z uporabo programa za interaktivne animacije ALICE3. Program je brezplačen in dostopen na svetovnem spletu. Uspešnost vodenih dejavnosti pa sem preverila z analizo izdelanih animacij in z anketo med učenci. Tako kot nam informacijsko komunikacijska tehnologija (IKT) pomaga v vsakdanjem življenju, lahko pomaga tudi učitelju podaljšanega bivanja pri zagotavljanju kvalitetnejšega in zanimivejšega pouka. Najpomembnejše je, da je uporabljena v prid učencev. IKT učiteljem ponuja veliko možnosti na področju razvijajanja kompetenc učencev, ne samo digitalnih temveč tudi vseh ostalih t. i. vseživljenjskih. Učenci so ciljno naravnano delo za računalnikom pohvalili ter poudarili, da igranje računalniških igric v PB ne pogrešajo in si želijo spoznati še kakšen program, več kot polovica je bila mnenja, da imajo še ogromno idej za izdelavo interaktivnih zgodbic.

Ključne besede: Kompetence, projektno delo, interaktivne pravljice

Abstract

The information communication technology nowadays helps the teachers in the Daily extension care to prepare more interesting and useful lessons. This technology is very useful in everyday life as well. It is very important to use the technology in the pupils' advantage, because it enhances, not only digital, but more importantly general and life-long competences. Teachers have many possibilities to use different methods and strategies in the classroom which allow the pupils to develop the previously mentioned competences. In my article I'm trying to describe the use of the technology in the classroom. For the practical part of the research I used the program for the interactive animation ALICE 3 with the group of the 4th grade pupils. The program is free and available on the World Wide Web. Later on, I checked the

results of the monitored activities by analysing the created animations and comparing the pupils' survey results. More than half of the opinion was that there's a lot of ideas to create interactive stories.

Keywords: Competences, Interactive stories

Razvijanje matematične pismenosti z IKT v 3. razredu osnovne šole

Developing Mathematical Literacy with ICT in the Third Grade of Elementary School

Anita Smole
Osnovna šola Vide Pregarc, Slovenija
anita.smole@gmail.com

Sonja Strgar
Osnovna šola Vide Pregarc, Slovenija
sonja.strgar@gmail.com

Povzetek

V prispevku je predstavljena dejavnost, katere osrednji cilj je bil razvijanje matematične pismenosti pri učencih 3. razreda s pomočjo uporabe IKT-ja. Dejavnosti so bile izvedene pri rednem pouku in pri urah dodatnega pouka. Učiteljici sta z učenci izvedli dejavnosti, pripravljene z brezplačno aplikacijo, imenovano Kubbu, ki omogoča pripravo e-dejavnosti za učence (reševanje različnih kvizov, križank, preverjanj znanja ipd.). Učenci so bili pri delu zelo aktivni in za delo motivirani. V prispevku razložene dejavnosti predstavljajo le nekaj izkoriščenih možnosti, ki jih ponuja program. Program omogoča še več – med drugim je uporaben tudi na drugih predmetnih področjih, prav tako pa bi bil primeren za delo s starejšimi učenci.

Ključne besede: matematična pismenost, realistični problemi, Kubbu, e-dejavnosti

Abstract

In this paper we present an activity, which central aim was to develop the mathematical literacy for students of the third grade with use of ICT. Activities were carried out in the lessons and supplementary instructions. Teachers and students carried out activities which have been prepared with free application called Kubbu. It allows the preparation of e-activities for learners (solving quizzes, crossword puzzles, knowledge checks, etc). Students were very active and motivated at work. In paper presented activities represent only some of the possibilities offered by the program.

The program allows more – among other it is useful in other school subjects and suitable for older students.

Keywords: Mathematical literacy, Realistic problems, Kubbu, E-Activities

Uporabnost orodja Tools for Educators za učitelje v različnih etapah učnega procesa

The Usefulness of the Tools Tools for Educators for Teachers in the Various Stages of the Learning Process

Anita Smole
Osnovna šola Vide Pregarc, Slovenija
anita.smole@gmail.com

Sonja Strgar
Osnovna šola Vide Pregarc, Slovenija
sonja.strgar@gmail.com

Povzetek

Učitelji si pri načrtovanju učnega procesa pomagamo z različnimi pripomočki. Vedno pa pridejo prav tudi orodja, ki učitelju omogočajo pripravo zanimivih dejavnosti, uporabnih pri delu z učenci. V prispevku so predstavljeni z brezplačnim orodjem Tools for Educators izdelani primeri dejavnosti, ki so bile uporabljene v različnih fazah učnega procesa – v fazi motivacije, v osrednjem delu, pri utrjevanju znanja in celo pri preverjanju. Prav tako pa so izdelani pripomočki prišli prav pri urah dopolnilnega pouka.

Ključne besede: orodje Tools for Educators, učitelj, etape učnega procesa

Abstract

Teachers help themselves in the planning of the learning process with a variety of accessories. Educational tools always come in handy as teachers prepare interesting activities that are useful when working with students. This paper presents examples of activities made with free tool Tools for Educators. School activities were used in the various stages of the learning process – at the stage of motivation, in the central part in consolidating and checking the knowledge. Widgets that we've made, we also used for supplementary lessons.

Keywords: Tool Tools for Educators, Teacher, The various stages of the learning process

Animirani film v osnovni šoli je super

Animated Film in Primary School is Great

Marko Šebrek
OŠ Kungota, Slovenija
foto.marko.foto@gmail.com

Povzetek

Animacija oziroma animirani film je od šolskega leta 2011/2012 v rednih učnih načrtih končno našla prostor v tretji triadi predmeta likovna vzgoja ter pri izbirnem predmetu likovno snovanje. Gre torej za disciplino, ki je sodobna v tem smislu, da je interdisciplinarna, povezuje različna področja in omogoča celostno razumevanje in dojemanje sveta. V projektu smo z učenci izdelali svoj animirani film v tehniki 3D stop-motion animacije. Spoznali smo pot od ideje do izdelka: izbiranje ideje za zanimivo zgodbo, zapis scenarija zgodbe, izdelovanje scene in animiranih likov, priprava in uporaba IKT naprav, pripomočkov ter programske opreme, snemanje animacije - video, snemanje zvoka - avdio, izdelava končnega izdelka - montaža. Končni izdelek je zahteval uporabo različnega orodja, pripomočkov, IKT naprav in materialov.

Ključne besede: animirani film, stop-motion animacija, IKT, multimedija, medpredmet-ne povezave, ustvarjalnost

Abstract

Since 2011/2012 animation and the animated film is in the primary school part of the regular curriculum in subject »Likovna vzgoja« (visual art education). We teach it also in the selected school subject »Likovno snovanje« (art planning). It is therefore a discipline which is modern in the sense that it is interdisciplinary, linking the areas and provides a comprehensive understanding and perception of the world. During this project the pupils created their animated film in the technique of 3D stop-motion animation. They got to know the way from idea to product: selecting ideas for an interesting story, the record of the screenplay, making the scene and animated characters, preparing/using ICT devices, accessories and software, recording of the animation - video recording, audio recording and making the final product - editing. The final product required the use of various tools, devices, ICT equipment and materials.

Keywords: Animated film, Stop-motion animation, ICT, Multimedia, Cross curricular links, Creativity

Primer uporabe tabličnih računalnikov pri pouku v osnovni šoli

Example of use of Tablet Computers in Classroom in Primary School

Iztok Škof
iztok.skof@guest.arnes.si
OŠ Toma Brejca, Kamnik

Povzetek

Na trgu so se leta 2010 pojavili prvi tablični računalniki, ki so hitro postali zelo popularni pri vsakdanjem delu in zabavi. Šole po svetu so kmalu ugotovile potencial ki ga ponujajo. Z uporabo IKT orodij pri pouku, pri vseh učnih urah smo želeli spremeniti način kako se učenci učijo. Poleg doseganja predmetnih učnih ciljev, želimo da učenci pridobijo kompetence, kot so digitalna pismenost in kritično razmišljanje, zato smo se odločili za uvajanje uporabe tabličnih računalnikov v pouk. Učenci imajo pri običajnem pouku stalen dostop do šolskih virov, spletnih virov, različnih načinov komunikacije. Želeli bi imeti več izobraževalnih gradiv, e-učbenikov s inovativno in privlačno interaktivno izobraževalno vsebino. Nekaj učiteljev je ravno zaradi tega začelo z izdelavo lastnih interaktivnih vsebin.

Ključne besede: tablični računalniki, osnovna šola, digitalna pismenost

Abstract

Tablet computers proved very popular in our daily work and entertainment after emerging on the markets in 2010. Schools all around the world quickly identified their potential. We enabled the use of ICT tools in the classrooms in the hopes of changing the way students study. By allowing the use of tablet computers, students were not only familiarized with the classes' learning objectives, but also advanced their skills in critical thinking and digital literacy. Students were given access to educational and online resources along with various methods of communication. We wish for more educational materials and e-books that include attractive, innovative and interactive educational content. The change also led to teachers creating their own interactive content.

Keywords: Tablet PCs, Primary school, Digital literacy

Učenje uporabe kataloga šolske knjižnice OŠ Prule

Learning the Use of the School Library Catalog of Primary School Prule

Gregor Škrlj
Osnovna šola Prule, Ljubljana, Slovenija
gregor.skrlj@guest.arnes.si

Povzetek
V prispevku je predstavljeno poučevanje učencev v osnovni šoli za uporabo spletnega kataloga šolske knjižnice in samostojno iskanje različnih virov (knjižnih, neknjižnih) v katalogu COBISS/OPAC šolske knjižnice. Opredeljen je katalog šolske knjižnice, njegov namen ter učenje iskanja gradiva po katalogu in policah knjižnice. Avtor predstavi uro pouka z naslovom knjižnični katalog, ki jo izvede z učenci v sedmem razredu.

Ključne besede: šolska knjižnica, katalog, knjižnično informacijsko znanje

Abstract
This paper presents how to teach the use the school library online catalog to pupils in primary school and how to search for resources (books, non-book materials) in the COBISS/OPAC catalog. It describes the definition and the meaning of the school library catalog, its purpose and how to learn the searching skills for the use of the catalog and browsing the shelves. The author describes library lesson titled Library catalog for the seventh grade pupils.

Keywords: School library, Catalogue, Library information skills

Kako v dijaškem domu uporabljamo pametne mobilne telefone za učenje tujih jezikov

How Do We Use Smart Mobile Phones in a Boarding School to Learn Foreign Languages

Barbara Štingl
Dijaški dom Drava Maribor, Slovenija
barbara.stingl@dddrava.si

Povzetek

Novodobne tehnologije tako učiteljem kot učencem omogočajo hiter in pregleden dostop do učnih vsebin s številnimi raznovrstnimi pripomočki. K slednjim spadajo tudi multifunkcijske naprave - pametni mobilni telefoni; število uporabnikov teh eksponentno narašča (Finance, 2013). Že zdaj v svetu tovrstne naprave postajajo zanimive tudi za potrebe izobraževanja. Rokovanje z njimi je enostavno in zabavno, hkrati pa nam na vsakem koraku omogočajo hiter dostop do raznovrstnih informacij. V prispevku je predstavljen primer dobre prakse uporabe pametnega mobilnega telefona pri prostočasni vzgojno-interesni dejavnosti nemščina v dijaškem domu. V okviru dejavnosti smo na platformi Android uporabljali mobilno aplikacijo German 50Languages, ki se je izkazala kot uporabnikom zanimiva, enostavna in razumljiva za nekoliko drugačno usvajanje znanja tujega jezika.

Ključne besede: pametni mobilni telefoni, android,mobilne aplikacije, učenje tujih jezikov

Abstract

The modern technology of today provides a quick and transparent access to learning contents through a number of diverse devices – as well for teachers and students.These include a multi-functional devices - such as smart mobile phones, where the number of users nowadays is growing exponentially (Finance, 2013) and such devices are already becoming interesting for educational purposes. Handling is easy and fun and at every step we are allowed for quick access to many information. This paper presents an example of good practice in the use of smart mobile phone at leisure German educational extra curricular activities in the boarding school. In the context of the Android platform, we use the mobile application German 50Languages, which proved to be a user-interesting and easy to understand for a slightly different acquisition of foreign language knowledge.

Keywords: Smart mobile phones, Android, Mobile applications, Learning foreign languages

Odločitveni model za pomoč pri oceni odklonskega vedenja pri osnovnošolcih

Decision Support Model for Assessing Behavioral Disorders in Primary School

Urška Šuštaršič
Fakulteta za računalništvo in informatiko, Slovenija
ursha.sustarsic@gmail.com

Vladislav Rajkovič
Fakulteta za organizacijske vede, Slovenija
vladislav.rajkovic@gmail.com

Povzetek

V članku je predstavljen razvoj večparametrskega odločitvenega modela, ki predstavlja pomoč pri ocenjevanju in prepoznavanju otrok s posebnimi potrebami (v nadaljevanju OPP) v osnovni šoli. Izdelali smo modele za pomoč pri prepoznavanju šestih kategorij posebnih potreb po klasifikaciji Svetovne zdravstvene organizacije – WHO (World Health Organization) in Zakona o usmerjanju otrok s posebnimi potrebami in sicer: motnje pozornosti s hiperaktivnostjo, anksiozne motnje, motnje avtističnega spektra, čustveno-vedenjske motnje, depresija in učne težave. Odločitvene modele smo izvedli s pomočjo dveh programskih orodij, in sicer na podlagi metode DEX v programu DEXi in na podlagi metode MAUT v programu HiView. Odločitveni model na podlagi 43 ocenjenih kriterijev poda oceno prisotnosti posebnih potreb pri otroku. Ta ocena učiteljem in svetovalnim delavcem predstavlja podporo pri odločitvi o nadaljnjem poteku obravnave. Modeli za podporo odločanju so se izkazali kot uporabni in zanesljivi. Z obsežnejšimi testiranji, izboljšavami s pomočjo vključitve različnih strokovnjakov v postopek izdelave modela in s povezavo s podatkovno bazo, bi bil model dober začetek sistematičnega prepoznavanja otrok s posebnimi potrebami v slovenskih osnovnih šolah.

Ključne besede: otroci s posebnimi potrebami, odločitveni model, DEXi, HiView, večkriterijsko odločanje

Abstract

The article presents a development of a multi-parameter decision support model that offers aid to identify and assess children with special needs in primary schools. We developed models to help to identify six categories of special needs according to the classification of the World Health Organization - WHO and the Placement of children with special needs. The categories are: attention deficit hyperactivity disorder, anxiety disorder, autism spectrum disorders, emotional and behavioral disorder, depression and learning difficulties. Decision models were developed with two software tools. First is based on the method of DEX in the DEXi program and second with Maut method in the HiView. Multi-parameter decision support model is based on 43 criteria of an assessed child. This assessment provides teachers and counselors support in deciding on further course of treatment. Models for decision support have proven to be useful and reliable. Extensive testing, improvements through the introduction of various experts in the design and manufacturing process and the connection to the database would be a good start to model the systematic identification of children with special needs in Slovenian primary schools.

Keywords: Children with special needs, Decision support system, DEXi, HiView, Multi-atribute decision making

Premagovanje primanjkljajev s pomočjo socialnega omrežja

Overcoming Disabilities with Social Network

Urška Topolovec
OŠ Gustava Šiliha Maribor, Slovenija
urska.topolovec@guest.arnes.si

Dejan Dinevski
Pedagoška fakulteta, Univerza v Mariboru, Slovenija
dejan.dinevski@uni-mb.si

Povzetek

Številni otroci ne zmorejo v celoti izkoristiti tradicionalnih metod poučevanja, saj jim njihovi primanjkljaji onemogočajo pridobivanje novih znanj. Za te otroke je računalnik najpomembnejši pripomoček za učenje, s katerim lažje zadovoljujejo različne potrebe. Obstajajo tehnologije, kot so na primer socialna omrežja, ki jim omogočajo, da postanejo aktivni učenci tako kot njihovi vrstniki. V članku izpostavljamo vlogo, ki jo igra socialno omrežje pri izobraževanju otrok s posebnimi potrebami in hkrati navajamo načine njegove uporabe pri poučevanju učencev s posebnimi potrebami v osnovni šoli s prilagojenim programom in nižjim izobrazbenim standardom. V empiričnem delu predstavljamo rezultate krajše raziskave glede razširjenosti, priljubljenosti in uporabe socialnih omrežij med učitelji, ki poučujejo učence s posebnimi potrebami.

Ključne besede: informacijsko-komunikacijska tehnologija, socialno omrežje, učenci s posebnimi potrebami, motivacija

Abstract

Many children are not able to make full use of traditional teaching methods because their disabilities prevent them to obtain new knowledge. For these children, computers are the most important instruments for learning, which help children to meet different needs easier. There are technologies such as social networks that help them to become active learners as their peers. In the article, we highlight the role of social network in the education of children with special needs. Furthermore,

we write about how social network is used by teachers in primary school with adapted program at a lower level. In the empirical part, we present the results of a short survey on prevalence, popularity and use of social networks among teachers who teach pupils with special needs.

Keywords: Information-communication technology, Social network, Pupils with special needs, Motivation

Učenje programiranja z interaktivno metodo

Learning Programming Interactively

Marko Urh
Univerza v Mariboru, Fakulteta za organizacijske vede, Slovenija
marko.urh@fov.uni-mb.si

Miha Rekar
miha@rekar.eu

Eva Jereb
Univerza v Mariboru, Fakulteta za organizacijske vede, Slovenija
eva.jereb@fov.uni-mb.si

Povzetek

Prispevek prikazuje možnost učenja programiranja s pomočjo interaktivne metode, katere značilnost je izredno enostavno, hitro in učinkovito osvajanje znanja programiranja. V prvem delu prispevka so prikazane značilnosti e-izobraževanja, ki je zaradi svojih prednosti vedno bolj razširjen. V nadaljevanju so predstavljene posamezne glavne faze razvoja spletnih aplikacij, ki so bile uporabljene pri izgradnji interaktivne metode učenja programiranja. Vmesnik za učenje programiranja JavaScripta z interaktivno metodo vsebuje osnovni in napredni del in je bil razvit s pomočjo tehnologij kot so PHP, JavaScript in HTML. Sledi prikaz poizkusa, ki je bil izveden s pomočjo študentov Fakultete za organizacijske vede. Dobljeni rezultati učenja programiranja z interaktivno metodo so izredno pozitivni tako s pedagoškega kot komercialnega vidika in so podrobno predstavljeni v zaključku prispevka, kakor tudi priporočila za nadaljnje delo na omenjenem področju.

Ključne besede: e-učenje, model, programiranje, JavaScript

Abstract

The article presents the opportunity to learn programming using interactive methods, characterized by an extremely simple, fast and effective gain of programming skills. Shown in the first part of the paper are the characteristics of increasingly popular e-learning. The main phases of web application development that were used for the

model are presented next. Interface for interactive learning of JavaScript has a basic and an advanced part and has been developed with technologies such as PHP, JavaScript and HTML. Following that we present the experiment that was run on students of the Faculty of Organizational Sciences. The results obtained with an interactive learning programming method were extremely positive from both educational and commercial standpoint and are discussed in the conclusion of the contribution, as well as recommendations for further work in this area.

Keywords: E-Learning, Model, Programing, JavaScript

Spletno nasilje in šola

Cyber Bullying and school

Maja Vreča
Arnes, Slovenija
arnes@arnes.si
maja.vreca@arnes.si

Povzetek:

Mladostniško spletno nadlegovanje in nasilje je naraščajoč problem, s katerim se soočajo vse bolj ali manj razvite družbe. V nekaterih primerih vodi tudi do tragičnih posledic, ko je bil npr. medijsko zelo odmeven primer najstnice iz Velike Britanije. V Sloveniji imamo sicer, v primerjavi z drugimi evropskimi državami, dobro zastavljen sistem osveščanja na področju internetne varnosti, a bi bilo, zlasti na področju preprečevanja spletnega nasilja, potrebno storiti še več.

Ključne besede: spletno nasilje, spletno nadlegovanje, virtualno nasilje, virtualno nadlegovanje, varna raba interneta, SAFE-SI, Arnes

Abstract:

Cyber Bullying is a growing issue in most countries. In some cases it can even result in a tragedy. There was tragic ending in a case of bullying in Great Britain that was covered by all of the world media. In Slovenia we have, in comparison to the rest of Europe, rather good covering when it comes to internet safety awareness rising, but the growing amount of Cyber Bullying cases is still something that should be addressed more thoroughly.

Keywords: Cyber Bullying, Internet safety, SAFE-SI, Arnes

Prenova in informatizacija inventurnih procesov na OŠ LA Grosuplje

The Renovation and Informatization of Inventory Process at The Louis Adamič Primary School Grosuplje

Alenka Zabukovec
OŠ LA Grosuplje, Slovenija
alenka.zabukovec@guest.arnes.si

Dejan Cvitkovič
BIC Ljubljana, Slovenija
dejan.cvitkovic@bic-lj.si

Povzetek

Na OŠ LA Grosuplje smo odločili, da bomo prenovili in informatizirali procese inventure. V prispevku je opisana pot prenove: analiza obstoječih postopkov, zastavljeni cilji prenove in informatizacije, predstavljena je pot k izboljšanju procesov. Inventuro smo tudi izvedli po prenovljenih postopkih. Cilje prenove in informatizacije inventure smo dosegli, saj smo skrajšali in poenostavili posamezna opravila, povečali kakovost baz podatkov in zmanjšali nezadovoljstvo vpletenih v procese.

Ključne besede: prenova procesov, informatizacija procesov v šolstvu, inventura.

Abstract

At The Louis Adamič Primary School Grosuplje we decided to renovate and informatizate inventory processes. The article describes the process of renovation: analysis of existing procedures, the goals of improvement and steps of the process. We also implemented new procedures to inventory. We have achieved the objectives of the renovation and informatization of inventory because we shortened and simplified specific tasks, enhanced the quality of databases and reduced the dissatisfaction of employees.

Keywords: Renovation processes, Informatization processes in education, Inventory

IKT in projektno delo pri fiziki

ICT and Projects at Physics

Sebastjan Zamuda
Gimnazija Bežigrad, Slovenija
sebastjan.zamuda@gimb.org

Povzetek

V prispevku je predstavljeno projektno delo, ki so ga dijaki izvajali pri pouku fizike v gimnaziji. Dijaki so si izbrali temo ter načrtovali in izvedli poskus. Na koncu so potek dela in ugotovitve predstavili sošolcem. Dijakom sem pomagal pri nekaterih delih projekta, predvsem pri izbiri teme, določitvi smiselnega poskusa in pripravi predstavitve. V prispevku so prikazani štirje primeri projektov, ki so jih izvedli dijaki z uporabo IKT. V dveh primerih gre za uporabo video analize (odboj žoge in iztekanje vode iz plastenke). V naslednjih dveh primerih sta prikazana določanje hitrosti zvoka in merjenje tlaka pri spreminjanju višine. Projekti so bili pomembna in dragocena izkušnja za dijake. Zame kot učitelja pa so predstavljali velik izziv zaradi časovne zahtevnosti in nujne dobre organizacije.

Ključne besede: IKT, fizika, računalniško podprte meritve

Abstract

In the article projects that students performed at physics in high school are presented. Students have chosen a topic, planned and performed an experiment. After that they presented their work and findings to their classmates. I helped the students at some parts of the project, mainly at choosing the topic, determining the appropriate experiment and preparing the presentation. In the article there are four examples of projects at which students used ICT. At two examples video analysis is used (ball bounce and water flowing out of plastic bottle). At the next two examples determining speed of sound and measuring pressure at different altitudes are presented. Projects were an important and invaluable experience for the students. For me, as a teacher, projects presented a huge challenge because they were time consuming and good organization was needed.

Keywords: ICT, Physics, Computer based measurements

INFORMACIJSKA DRUŽBA – IS'2013
11. oktober 2013
VZGOJA IN IZOBRAŽEVANJE V INFORMACIJSKI DRUŽBI

Tablični računalniki pri slovenščini

Tablet Computers in Slovene Language Class

Andreja Žavbi Kren
OŠ Toma Brejca, Slovenija
andrejazavbi@gmail.com

Povzetek

V prispevku je opisano, kako sem uporabila tablične računalnike pri uri slovenščine pri književnosti v 5. razredu. Učenci so morali obnoviti prebrani odlomek v obliki stripa. Tisti, ki so želeli, so lahko uporabili tablične računalnike in s pomočjo aplikacije Strip Designer izdelali strip. Ugotovila sem, da so učenci s tabličnim računalnikom izdelek naredili hitreje, bili bolj produktivni, za delo bolj motivirani, izgled končnega izdelka ni bil bistven in učenci so poleg učnih ciljev osvojili še kompetence in ostale spretnosti in veščine računalniške pismenosti. Učencem sem v aplikaciji predstavila le osnovne funkcije, ostalo pa so se naučili sami preko preizkušanja oziroma so za informacije poprosili ostale učence. Čeprav je delo potekalo individualno, se je pokazalo, kako lahko sodelovalno učenje pomaga pri razvoju samostojnosti. Za učence je bilo delo zanimivo, ker je potekalo drugače in ker radi delajo z digitalnim orodjem. Uporaba IKT opreme je pomemben dejavnik pri izboljšanju kakovosti pouka. Ker smo v dobi računalništva, naj računalniki oziroma drugi računalniški pripomočki ne bodo ovira, ampak orodje, ki učiteljem in učencem omogoča boljše in zanimivejše delo v razredu. Kompetence pa pomagajo pri razvijanju boljšega razumevanja priložnosti in izzivov z novimi tehnologijami.

Ključne besede: tablični računalnik, digitalna pismenost, motivacija, kompetence

Abstract:

The paper describes the use of tablet computer in Slovene language class (literature) in the fifth grade. The pupils had to summarize a fragment of the text in the form of a strip cartoon. The ones who wished were given the possibility to use tablet computers in order to design the comic with the help of the application Strip Designer. The findings have shown that the pupils who used tablet computer instead of the regular pen and paper method performed the given task quicker. They also performed more productively and were more motivated for work. The pupils have not only handed in a final product but also reached a new level of computer literacy

competence. The students were given only basic instructions about tablets' functionality; the rest was learned through trying or by asking their colleagues for help and information. Although each pupil has performed the work individually, the results have shown how cooperative learning increases pupils' independence. The pupils perceive the work with tablet computers interesting, as it presents a new form of learning.The use of ICT is an important factor in the improvement of lesson quality. In the computer era the ICT tools should not be seen as a hindrance. Instead they should be treated as a tool that enables teacher and pupils a better and more exciting work in the classroom. The newly achieved competences will help learners to evolve a healthy attitude towards understanding opportunities and challenges presented by the new technologies.

Keywords: Tablet computer, Digital literacy, Motivation, Competences

Zbornik 16. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2013

Proceedings of the 16th International Multiconference

INFORMATION SOCIETY – IS 2013

Srednjeevropska konferenca o uporabnem teoretičnem računalništvu (MATCOS 2013)

Middle-European Conference on Applied Theoretical Computer Science (MATCOS 2013)

Uredil / Edited by

Andrej Brodnik

http://is.ijs.si

7. oktober 2013 / October 7th 2013
Koper, Slovenia

PREDGOVOR / PREFACE

Dragi bralec!

Pred vami je zbornik 4. konference MATCOS. Ob zaključku MATCOS-10 smo se odločili, da dvignemo kakovost konference in jo poskusimo narediti še bolj mednarodno. Zato smo ustanovili Glavni odbor konference in prav zato ena prvih odločitev, ki jih je sprejel odbor, je bila sprememba pomena črke M v akronimu konference. Spremenjeno ime je tako *The Middle-European Conference on Applied Theoretical Computer Science*.

Oblika konference je v ostala nespremenjena: dvodnevni dogodek, kjer je prvi dan namenjen študentskim predstavitvam, drugi dan pa predstavitvi običajnih člankov. Prvi dan je namenjen še vabljenemu predavanju, ki je letos predavanje Silvana Martella. Ta navidezna dvojnost konference naredi dogodek še posebej privlačen za mlade raziskovalce, saj se ne srečajo samo z bolj izkušenimi kolegi, ampak jim tudi predstavijo svoje delo in se o tem pogovorijo z njimi in kolegi iz drugih univerz.

Avtorji so poslali 36 prispevkov na konferenco in vsakega so pregledali vsaj trije neodvisni recenzenti. Programski odbor je na koncu povabil 12 študentskih člankov in 15 rednih člankov za predstavitev na konferenci. V tem zborniku so predstavljeni le razširjeni povzetki posameznih običajnih člankov, medtem ko še iščemo možnosti za objavo izbranih celotnih prispevkov – vključno s študentskimi članki – v posebnem zborniku.

Kot je področje teoretičnega računalništva bogato in raznoliko, tako so tudi objavljeni prispevki. Letošnji prispevki posegajo na klasična področja kot so operacijske raziskave, kompleksnosti in teorije grafov ter tudi zanimivo področje obdelave slik in signala. Programski odbor meni, da je bila odločitev glavnega odbora dobra in je odločilno prispevala k višji kakovosti poslanih prispevkov.

Koper, 30. september 2013

Gábor Galambos in Andrej Brodnik

Dear reader,

welcome to the proceedings of the 4th conference MATCOS. At the end of MATCOS-10 we made a decision to further increase the quality of the conference and make it even more international. To underline the decision a steering committee was formed, and one of the decisions it made was the change of meaning of letter M in the acronym of the conference. This resulted in a conference name *The Middle-European Conference on Applied Theoretical Computer Science*.

The format of the conference remained more or less unchanged: a two days event where the first day is devoted for students to present their papers and the second day for regular papers. On the first day there is also an invited lecture, which was this year brought by Silvano Martello. This virtual dichotomy makes event particularly attractive also for younger researchers as they can not only meet their senior colleagues, but also present their work and discuss it with them and also with colleagues from other universities.

Authors submitted 36 papers to conference and all of them were reviewed by at least three reviewers. The programme committee at the end invited 12 student papers and 15 regular papers for presentation at the conference. In this proceedings are presented only extended abstracts of individual papers, while we are looking for the possibility for publishing the full versions of selected papers – including student papers – in a separate proceedings.

As the area of theoretical Computer Science is rich and colorful so are the accepted papers. This year we have papers from classical areas such as operations research, complexity and graph theory and also an interesting area of signal and image processing. The Program Committee believes that the decision that steering committee made was good and also resulted in a higher quality of presented work.

Koper, September 30th, 2013

Gábor Galambos and Andrej Brodnik

Invited lecture

Silvano Martello: Two-Dimensional Packing Problems in Telecommunications

Student papers

Algorithms - Applications

Nándor Németh: An Algorithm for Recognition of Position Repetition in Chess
Simon Mezgec: Traffic Sign Symbol Recognition with the D2
Balázs Dávid: A model and heuristic for the multiple depot bus rescheduling problem

Algorithms – Efficiency

Monika Vigula: Efficient algorithms solving subgraph isomorphism problem in cheminformatics
Pavel Veselý: Competitiveness of Fit Algorithms for Black and White Bin Packing
Marko Grgurovič: Adaptive Algorithms For Dynamic Programming With Applications to Bioinformatics

Algorithms - Data structures

Andrej Bukošek: A system for parallel execution of data-flow graphs
Matevž Jekovec: Theoretical aspects of ERa, the fastest practical suffix tree construction algorithm
Tine Šukljan: Comparison between a cache-oblivious range query data structure and a quadtree

Algorithms - Software

Tatyana Kandryukova: On numerical simulation of filtration gas combustion processes on the shared memory machines
András Németh: Processable Erlang Data in C++
Gergely Suba: A new method for transforming algorithm into VHDL by starting from a Haskell functional language description

Regular papers

Integer and Discrete Programming

Ulrich Pferschy and Rostislav Staněk: Using Pure Integer Solutions to Solve the Travelling Salesman Problem
Achim Hildenbrandt, Gerhard Reinelt and Olga Heismann: Integer Programming Models for the Target Visitation Problem
Attila Toth, Timo Knuutila and Olli Nevalainen: Machine configuration and workload balancing for multi-product PCB assembly
József Békési, Gábor Galambos, Michael Jung, Marcus Oswald and Gerhard Reinelt: Exact Algorithms for the General Coupled Task Scheduling Problem

Algorithms and Complexity

Domen Mongus and Borut Žalik: Detection of ground in point-clouds generated from stereo-pair images
Ekaterina Berveno, Alexander Kalinkin and Yuri Laevsky: Simulation of two-phase fluid filtration with nonuniform media clusters
Jurij Mihelič: Enumerating algebraic expressions generated by context-free grammars
Alexander Gilbers: Barrier Resilience of Visibility Polygons

Graph Theory

Elmar Langetepe, Andreas Lenerz and Bernd Brüggemann: Strategic deployment in graphs
Olga Heismann and Ralf Borndörfer: The Random Hypergraph Assignment Problem
Vincenzo Currò, Vincenzo Cutello and Salvatore Mario Nolassi: The Roman Domination Problem on Grid Graphs
Stefan Wiesberg and Gerhard Reinelt: Relaxations in Practical Clustering and Blockmodeling

Signal and Image Processing

Peter Rogelj: Estimation of cervix cancer spatial distribution for brachytherapy applicator analysis
Shruti Sehgal and Garima Vyas: Recognition of Repeating Segment from an Audio Using Vector Quantization and K-means algorithm
Gašper Fele-Žorž: A Faster Algorithm for Calculating the Sample Entropy

Using Pure Integer Solutions to Solve the Traveling Salesman Problem

[Extended abstract]

Ulrich Pferschy
Department of Statistics and Operations Research
University of Graz
Universitätsstraße 15, 8010 Graz, Austria
pferschy@uni-graz.at

Rostislav Staněk
Department of Statistics and Operations Research
University of Graz
Universitätsstraße 15, 8010 Graz, Austria
rostislav.stanek@uni-graz.at

ABSTRACT

The *traveling salesman problem* (*TSP*) is one of the most widely studied combinatorial optimization problems. Given a complete graph with nonnegative distances on the edges the *TSP* asks for a shortest tour with respect to the distances.

There are many approaches to solve the TSP to optimality. The most successful of them are based on the *ILP* formulation and use the *branch-and-bound-and-cut* technique. Usually the *integrality constraints* are relaxed first and all separation processes are done on *fractional solutions* (see e.g. [1, 2]).

In our approach we never interfere with fractional solutions but leave those to the ILP-solver. Considering that current ILP-solvers have an impressive performance, we only relax the *subtour constraints* and solve the remaining problem to optimality. Then we add the violated subtour constraints and repeat the process until a feasible solution is found. Furthermore, in order to speed up the algorithm and to decrease the number of necessary executions of the ILP-solver, we introduce more preprocessing strategies which find some of the needed subtour inequalities.

After outlining our approach, we present some computational results on the instances taken from the TSPLIB95.

Categories and Subject Descriptors

G.1.6 [**Numerical analysis**]: Optimization—*integer programming*; G.2.1 [**Discrete Mathematics**]: Combinatorics—*combinatorial algorithms*; G.2.2 [**Discrete Mathematics**]: Graph Theory—*graph algorithms*

General Terms

Mathematics of Computing

Keywords

Traveling salesman problem, branch-and-cut, ILP

1. INTRODUCTION

The *TSP* is one of the most widely studied problems in combinatorial optimization. Given a complete graph $G = \big(V(G), E(G)\big)$ with $\big|V(G)\big| = n$, $\big|E(G)\big| = m$, and nonnegative distances d_e for each edge $e \in E(G)$, the *TSP* asks for a shortest tour with respect to the distances d_e. Even though many effective heuristics are known for this strongly NP-hard problem (see e.g. [3, 4]), it is important to look for an algorithm which is able to solve the problem to optimality in a reasonable computational time. To do so, we use the *traveling salesman polytope* (see e.g. [3]):

$$\min \quad \sum_{e \in E} d_e x_e \tag{1}$$

$$\text{s.t.} \quad \sum_{e \in \delta(v)} x_e = 2 \qquad \forall v \in V, \tag{2}$$

$$\sum_{e \in E(G[X])} x_e \leq |S| - 1 \qquad \emptyset \neq X \subset V, \tag{3}$$

$$x_e \in \{0, 1\} \qquad \forall e \in E. \tag{4}$$

(1) defines the *objective value function*, (2) the *assignment constraints*, (3) the *subtour constraints* and finally (4) the *integrality constraints*.

The most effective branch-and-bound-and-cut approaches relax the integrality constraints (4) and treat the exponential number of subtour constraints (3) by separation during the solution process. The separation of the subtour constraints (3) can be solved in $O(n^3)$ (see [3]) and is also used by the *Concorde* code (see [1, 2]). Since the integrality constraints (4) are relaxed, these approaches deal with fractional solutions and employ a wide array of additional valid inequalities. In contrast, the algorithm presented here never relaxes the integrality constraints (4) and thus can find violated subtour constraints in a trivial way instead of using the complicated $O(n^3)$ separation algorithm. Furthermore, no additional inequalities are added.

2. NEW APPROACH TO SOLVE THE TSP TO OPTIMALITY

2.1 Main Idea

The main idea of our approaches is fairly easy and can be summarized as follows. We relax all subtour constraints (3) from the model first and then solve the remaining ILP model (in this phase the ILP model corresponds to the *weighted 2-matching problem*). After that we check if the obtained solution contains some subtours. If not, the solution is an optimal TSP tour. In the other case we find all subtours and add the corresponding subtour constraints to the model. Then the solving process starts again until an optimal TSP tour is obtained. This approach is presented in Algorithm 1.

Input: TSP instance
Output: an optimal TSP tour
1: relax all subtour constraints in the ILP model;
2: **repeat**
3: solve the current problem to optimality by using an ILP solver;
4: **if** there exists one or more subtours in the solution **then**
5: find all subtours and introduce the corresponding subtour constraints into the model;
6: **else**
7: set the solution as the optimal tour
8: **end if**
9: **until** an optimal tour found;

Algorithm 1: Main idea of our approach

Every run of the ILP solver (see pseudocode line 3) we will call an *iteration*. We define the *set of violated subtour constraints* as the set of all included subtour constraints which were violated in an iteration (see pseudocode line 5).

This algorithm uses an ILP solver as a "black box". If we have the possibility to see all integral solutions taken into account during the solving process of the ILP solver, we can add all corresponding constraints into the model too. These constraints will be considered as an integral part of the set of violated subtour constraints from now on.

2.2 Preprocessing Strategies

Of course we want to minimise the number of needed iterations (i.e. the number of needed ILP solver runs) and therefore we propose some preprocessing strategies which generate some subtour constraints contained in the set of violated subtour constraints. We will call them *preprocessing subtour constraints*. In general, more preprocessing subtour constraints than necessary can be generated, but including too many inequalities into the model at the beginning can slow down the ILP solver.

2.2.1 Main Preprocessing Idea

One possibility to generate some inequalities included in the set of violated subtour constraints is to divide the graph into *clusters*, then solve the TSP for every cluster one after another and then take all violated subtour constraints from all clusters. Furthermore, we can use the optimal tour from every cluster to generate a corresponding subtour constraint for the original instance.

The most important properties of the clustering algorithm which should be fulfilled are:

- The clustering algorithm has to run in a reasonable amount of time relative to the amount of time needed by the main part of the approach.
- The obtained clusters should respect the graph structure.
- The obtained clusters should not be too big, otherwise it could take too much time to solve them.
- The obtained clusters should not be too small, otherwise the preprocessing would generate too few subtour constraints.

Clearly, there is a large number of applicable clustering algorithms in the literature. We chose the following approach which does not depend on the representation of vertices as points in a Euclidean space.

Let $G_0 = (V_0, E_0)$ with $V_0 = V$ and $E_0 = \emptyset$ be a graph containing only isolated vertices and let $e_1 = (u_1, v_1), e_2 = (u_2, v_2), \ldots, e_m = (u_m, v_m)$ be the edges sorted with respect to the distances d_{e_i} between the vertices u_i and v_i for $i = 1, 2, \ldots, m$. Then we can add the $1 \leq k \leq m$ first edges (with respect to this order) to the graph G_0 and obtain a new graph $G_k = (V_k, E_k)$. This graph G_k consists of c connected components which define the clusters. We have m possibilities to choose the parameter k, but note that we can obtain only n different clusterings with $1 \leq c \leq n$ clusters.

We also obtain an easy Greedy based algorithm with one parameter k or c (the algorithm is just stopped if the specified number of c clusters is reached in this case). The computational results (see Subsection 2.3) show that this approach speeds up the whole algorithm for most choices of the parameter c and is not very sensitive to the actual choice of c.

2.2.2 Post-Phase of the Preprocessing

Although this clustering algorithm decreases the computational time of the whole solving process, it has many disadvantages; e.g., the assignment constraints (2) guarantee that every vertex is always included in a subtour. But our algorithm can also generate isolated points and clusters containing only two vertices. And since these vertices are included in a subtour after every iteration, the subtours generated in an other ("neighbor") cluster do not correspond to the violated subtour constraints needed by the main algorithm. Thus we do not want to generate clusters of size one and two. One way how to avoid them is to continue in the above described merging process, but to merge the clusters only if one of the end vertices of the edge $e_i = (u_i, v_i)$, $1 \leq i \leq m$, lies in a cluster (i.e. in a connected component) which contains at most two vertices. We obtain a clustering with the minimum size of a cluster 3 in this case. The computational results (see Subsection 2.3) show that the algorithm yields better results for the minimum cluster size of 4.

During this *post-phase of the preprocessing* the number of clusters c' decreases and, in general, $c' \leq c \leq n$ holds. This post-phase of the preprocessing can also be seen as a separate preprocessing algorithm if we choose $c = n$. But we cannot determine the real number of clusters c' in this case.

2.2.3 Improvement Strategy of the Preprocessing

The main idea of the preprocessing strategy (i.e. without the post-phase) can be improved by generating a tree representing all possible clustering which can be obtained from the preprocessing. The leaves consist of clusters of size 1 and if two clusters merge, a new tree vertex is always created in such a way that the clusters building this new vertex are the child vertices of the newly created vertex. An example of one such tree is shown in Figure 1.

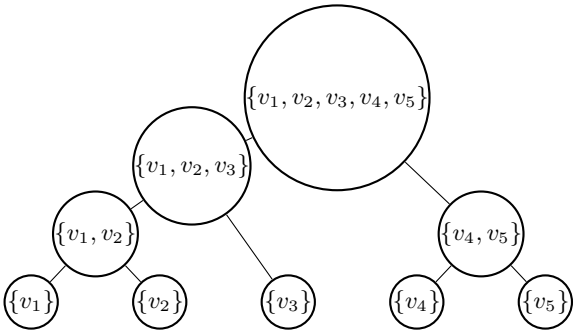


Figure 1: Example illustrating the representation of all clusterings in tree structure.

Now, we can go through the tree from the leaves to the root and solve the TSP for all clusters (which are represented by the tree vertices) on this unique path and propagate all obtained preprocessing subtour constraints. The advantage of this strategy is the step-by-step construction of the preprocessing subtour constraints. The disadvantage is that many constraints can make sense in the local context but not in the global one and we can generate too many constraints this way. Another disadvantage is the computation time spent by the preprocessing even if we propagate the subtour constraints from the subclusters. The latter problem can be solved by setting a bound on the maximum size of cluster which will be solved. The computational results (see Subsection 2.3) show us, that $4\frac{n}{\log_2 n}$ can be a good bound.

Let us now look the problem of including too many subtour constraints which are redundant in the global graph context. Of course the theoretically "best" way would be to check which of the propagated subtour constraints were not used during the runs of the ILP solver and drop them. To do this, it would be necessary to get this information from the ILP solver which is usually not possible. But this behaviour can be approximately simulated in the following way: All generated subtour constraints are marked as *considered subtour constraints* first. Then by solving of the predecessor vertex in the tree we do not use them and only those one which are generated again are fixed to be used in all further predecessors (i.e. clusters containing this particular cluster).

2.3 Computational Results

instance	p. of used s. c.		p. of covered s. c.	
	MP	MP_{P_4}	MP	MP_{P_4}
kroB150	0.1452	0.3284	0.5298	0.3988
u159	0.0603	0.1000	0.7143	0.7347
kroB200	0.1578	0.2093	0.5868	0.5207
a280	0.0427	0.0759	0.5347	0.4444
lin318	0.1713	0.2482	0.6106	0.5882
mean	0.1155	01924	0.5952	0.5374

Table 1: Proportion of used preprocessing subtour constraints and the proportion of covered needed subtour constraints for all possible clusterings taken 1) without the post-phase and 2) with the post-phase with the minimum size of a cluster 4.

Let us now discuss the computational results for the mentioned approaches. All instances used for the test purposes were taken from the TSPLIB95 [5] and all tests ran on the following computer: Intel(R) Core(TM) i5-3470 CPU @ 3.20GHz with 16 GB RAM.

First, Figure 2 illustrates the progress of the amount of computation time t in seconds on the number of clusters c for the instance *kroB150*. The post-phase of the preprocessing is not used in this case. It can be seen, that for $c = 1$ the preprocessing takes no time and the whole amount of time uses the main part of the approach. For other small values of c we find the opposite behavior to be true – the main part of the amount of used time takes the preprocessing, because we have only a few clusters and at least one of them is large. In the other part of this Figure we observe that the parameter c does not have to be determined precisely – the speed up is still considerable.

A summary for some instances is shown in Table 2 for the following variants of our algorithm:

- $\boldsymbol{M}$ – only the main idea of the algorithm (see Subsection 2.1)
- $\boldsymbol{MP\ c = \lfloor \frac{n}{5} \rfloor}$ – preprocessing without the post-phase for $c = \lfloor \frac{n}{5} \rfloor$ (see Subsection 2.2.1)
- $\boldsymbol{MP_{P_4}\ c = \lfloor \frac{n}{5} \rfloor}$ – preprocessing with the post-phase for $c = \lfloor \frac{n}{5} \rfloor$; the minimum size of a cluster is 4 (see Subsection 2.2.2)
- $\boldsymbol{MP_{P_4}\ c = n}$ – preprocessing with the post-phase for $c = n$; the minimum size of a cluster is 4 (see Subsection 2.2.2)
- $\boldsymbol{MP_R\ u = 4\frac{n}{\log_2 n}}$ – preprocessing with the propagation of the constraints for bigger clusters; the constraints can be dropped and the maximum size of a solved cluster is $u = 4\frac{n}{\log_2 n}$ (see Subsection 2.2.3)

The results show that the preprocessing strategies speed up the algorithm for all included instances and the improvement is sometimes significant (e.g. for the instance *lin318*). Furthermore, the approach which uses only the main preprocessing idea without the post-phase and without the improvement strategy yields worse results than the advanced preprocessing strategies.

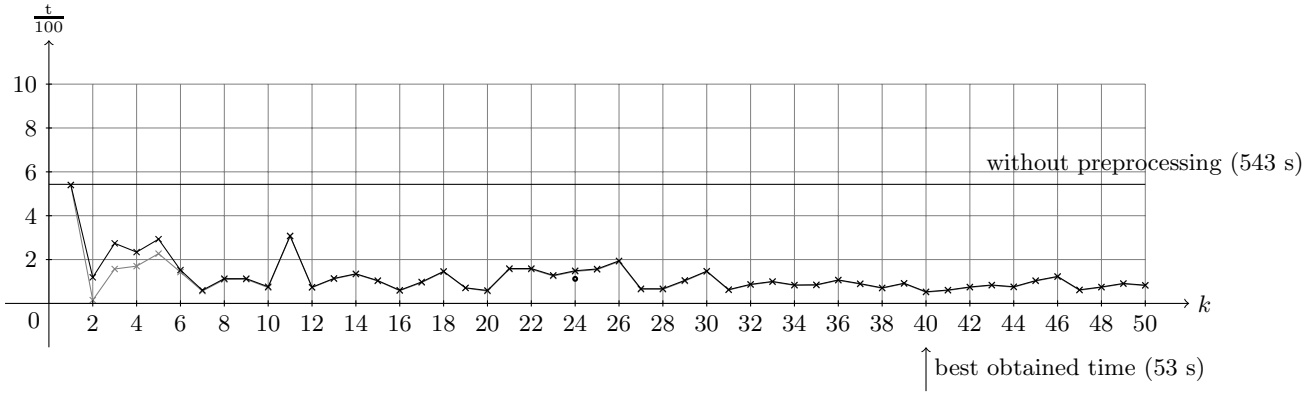


Figure 2: Progress of the amount of computation time t in seconds on the number of clusters k for the instance *kroB150*. The post-phase of the preprocessing is not used. The gray line shows the progress of the amount of computation time on the number of clusters spent by the main phase. The small circle marks the result for the case of starting the post-phase of the preprocessing for $c = n$; in this case we obtain 24 clusters.

instance	M			$MP\ c = \lfloor \frac{n}{5} \rfloor$			$MP_{P_4}\ c = \lfloor \frac{n}{5} \rfloor$			$MP_{P_4}\ c = n$			$MP_R\ u = 4\frac{n}{\log_2 n}$		
	t.	**#i.**	**#c.**	**t.**	**#i.**	**#c.**	**t.**	**#i.**	**#c.**	**t.**	**#i.**	**#c.**	**t.**	**#i.**	**#c.**
kroB150	248	8	165	67	4	211	58	6	199	41	4	143	**27**	**4**	**187**
u159	9	4	49	9	4	140	**6**	**2**	**153**	7	3	91	14	4	157
kroB200	43	6	129	39	5	148	**27**	**4**	**114**	41	5	137	30	4	156
a280	201	11	139	157	8	298	206	8	348	**116**	**6**	**280**	172	8	320
lin318	7138	8	357	558	7	342	660	7	426	3169	7	426	**202**	**4**	**360**
gr431	2897	10	618	3303	9	744	2185	8	555	**2117**	**9**	**721**	2504	8	733
pcb442	3466	16	571	3657	16	757	**3092**	**15**	**638**	3492	18	695	3690	15	1065
gr666	19663	8	668	35082	7	990	23949	7	972	**14965**	**6**	**784**	23048	6	1194

Table 2: Comparison between different variants of our approach. "t." is the time in seconds, "#i." the number of iterations and "#c." the number of subtour constraints added to the ILP for the last iteration.

Table 1 illustrates the theoretical possibilities of the preprocessing strategies. For every listed instances all clusters for all values $1 \leq c \leq n$ were created, solved and then all obtained violated subtour constraints (i.e. taken from all clusters for all choices of the parameter c) were compared with the violated subtour constraints generated by the main idea approach only. It can be seen that theoretically there is the possibility to find about 50 % of all needed violated subtour constraints. Using preprocessing without the post-phase, the cardinality of the set of all found subtour constraints is larger than if the post-phase is used, which is due to the bigger number of different clusters in the first case.

3. CONCLUSIONS

Of course all presented algorithms could be improved by adding starting heuristics or lower bounds or by adding additional cuts, but this work aims to present a new basic concept for solving the TSP and not to create a new praxis oriented solver. A combination of this technique and the other known techniques which also use fractional cuts could be explored in the future.

Acknowledgments

The research was funded by the
Austrian Science Fund (FWF): [P 23829-N13].

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Integer Programming Models for the Target Visitation Problem

Achim Hildenbrandt*
Institut für Informatik,
Universität Heidelberg Im
Neuenheimer Feld 368
D-69120 Heidelberg, Germany

Gerhard Reinelt†
Institut für Informatik,
Universität Heidelberg Im
Neuenheimer Feld 368
D-69120 Heidelberg, Germany

Olga Heismann‡
Zuse Institute Berlin
Takustr. 7
14195 Berlin, Germany

ABSTRACT

The target visitation problem (TVP) is concerned with finding a route to visit a set of targets starting from and returning to some base. In addition to the distance traveled a tour is evaluated by taking also preferences into account which address the sequence in which the targets are visited. The problem thus is a combination of two well-known combinatorial optimization problems: the traveling salesman and the linear ordering problem. In this paper we present several possible IP-Models for this problem and compared them to their usability for branch-and-cut approaches.

1. INTRODUCTION

Let $D_{n+1} = (V_{n+1}, A_{n+1})$ be the complete digraph on $n+1$ nodes where we set $V_{n+1} = \{0, 1, \ldots, n\}$. Furthermore let two types of arc weights be defined: weights d_{ij} (*distances*) for every arc (i, j), $0 \leq i, j \leq n$, and weights p_{ij} (*preferences*) associated with every arc (i, j), $1 \leq i, j \leq n$. The *target visitation problem (TVP)* consists of finding a Hamiltonian tour starting at node 0 visiting all remaining nodes (called *targets*) exactly once in some order and returning to node 0. Every tour can be represented by a permutation π of $\{1, 2, \ldots, n\}$ where $\pi(i) = j$ if target j is visited as the i-th target. For convenience we also define $\pi(0) = 0$ and $\pi(n+1) = 0$.

So we are essentially looking for a traveling salesman tour, but for the TVP the profit of a tour depends on the two weights. Namely, the value of a tour is the sum of pairwise preferences between the targets corresponding to their visiting sequence minus the sum of distances traveled, i.e., it is calculated as

$$\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} p_{\pi(i)\pi(j)} - \sum_{i=0}^{n} d_{\pi(i)\pi(i+1)},$$

and the task is to find a tour of maximum value. So we have a multicriterial objective function.

The TVP was introduced in [3] and combines two classical combinatorial optimization problems: the *asymmetric traveling salesman problem (ATSP)* asking for a shortest Hamiltonian tour and the *linear ordering problem (LOP)* which is to find an acyclic tournament of maximum weight. (There is an obvious 1–1 correspondence between acyclic tournaments and linear orders of the node). Computational results of a genetic algorithm for problem instances with up to 16 targets have been reported in [1]. The original application of the TVP is the planning of routes for UAVs (unarmed aerial vehicles). But there is a wide field of applications, e.g., the delivery of relief supplies or any other routing problem where additional preferences should be considered (town cleaning, snow-plowing service, etc.).

Obviously, the TVP is NP-hard because it contains the traveling salesman problem ($p \equiv 0$) and the linear ordering problem ($d \equiv 0$) as special cases.

For convenience we transform the problem to a Hamiltonian path problem and also get rid of the special base node. This transformation is well-known for the ATSP [6] and can be adapted for the TVP as follows.

The key idea is to exploit the fact that each tour has to start at the base and return to it and that no preferences are to be taken into account for the base. In the *TVP-path model* we leave out this node and just search for a Hamiltonian path which visits all targets exactly once.

Following [6] we make the following modifications.

(i) Transform the distance matrix by setting $d'_{ij} = d_{ij} - d_{i0} - d_{0j}$, for all pairs i and j of nodes, $1 \leq i, j \leq n$ $i \neq j$.

(ii) Change the computation of the distance part of the

*achim.hildenbrandt@informatik.uni-heidelberg.de
†gerhard.reinelt@informatik.uni-heidelberg.de
‡heismann@zib.de

objective function to

$$\sum_{i=1}^{n-1} d'_{\pi(i)\pi(i+1)} - \sum_{i=1}^{n} d_{i0} - \sum_{i=1}^{n} d_{0i}.$$

The preferences are not affected by this change. From now on we consider the TVP as finding a Hamiltonian path in the complete digraph $D_n = (V_n, A_n)$ with additional preference costs to be taken into account. The path is described by a permutation π of $\{1, \ldots, n\}$ where $\pi(k)$ is the node at position k.

In this paper we want to present four different IP-models and compare them to there usability for branch-and-cut approaches

2. AN INTEGER PROGRAMMING MODEL FOR THE TVP

Our first approach for obtaining an IP model of the TVP is to combine well-known IP formulations for the ATSP and the LOP. For this purpose we have to introduce the following two types of variables.

The sequence in which the targets are visited is represented by binary *ATSP variables* x_{ij} for $1 \leq i, j \leq n,\ i \neq j$, with the interpretation

$$x_{ij} := \begin{cases} 1 & \text{if } i = \pi(k) \text{ and } j = \pi(k+1) \\ & \text{for some } 1 \leq k \leq n-1, \\ 0 & \text{otherwise.} \end{cases}$$

The fact that some target i is visited before some target j is modeled with binary *LOP variables* w_{ij} for $1 \leq i, j \leq n,\ i \neq j$, with the definition

$$w_{ij} := \begin{cases} 1 & \text{if } i = \pi(k) \text{ and } j = \pi(l) \text{ for some } 1 \leq k < l \leq n, \\ 0 & \text{otherwise.} \end{cases}$$

Using this variables we can formulate the following IP-model for the TVP, which we will denote by TVP-IP$_1$

$$\max \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} p_{ij} w_{ij} - \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} d_{ij} x_{ij} \tag{1}$$

$$\sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} x_{ij} = n - 1, \tag{2}$$

$$\sum_{i \in S} \sum_{\substack{j \in S \\ j \neq i}} x_{ij} \leq |S| - 1,\ S \subseteq \{1, \ldots, n\}, 2 \leq |S| \leq n-1, \tag{3}$$

$$\sum_{\substack{i=1 \\ i \neq j}}^{n} x_{ij} \leq 1, \qquad 1 \leq j \leq n, \tag{4}$$

$$\sum_{\substack{j=1 \\ j \neq i}}^{n} x_{ij} \leq 1, \qquad 1 \leq i \leq n, \tag{5}$$

$$w_{ij} + w_{jk} + w_{ki} \leq 2,\ 1 \leq i, j, k \leq n,\ i < j, i < k\ j \neq k, \tag{6}$$

$$w_{ji} + w_{ij} = 1, \qquad 1 \leq i, j \leq n,\ i \neq j \tag{7}$$

$$x_{ij} - w_{ij} \leq 0, \qquad 1 \leq i, j \leq n,\ i \neq j \tag{8}$$

$$x_{ij}, w_{ij} \in \{0, 1\}, \quad 1 \leq i, j \leq n,\ i \neq j \tag{9}$$

Constraints (2)–(5) model the directed Hamiltonian paths where inequalities (3) are the *subtour elimination constraints*. Acyclic tournaments are modelled by the *3-dicycle inequalities* (6) and the *tournament equations* (7). Inequalities (8) connect the solutions of both problems. Together with the integrality conditions (9) this obviously constitutes a 0/1 model of the TVP.

As an interesting fact we note that the subtour elimination constraints are actually not needed. If (w, x) satisfies (2) and (4)–(9), but not all inequalities (3) then there is some subtour on $k \geq 2$ nodes. W.l.o.g. we can assume that the node set is $\{1, 2, \ldots, k\}$ and the subtour is given as $\{(1,2), (2,3), \ldots (k-1, k), (k, 1)\}$. Hence $x_{12} = x_{23} = \ldots = x_{k-1,k} = x_{k1} = 1$, implying because of (8) that $w_{12} = w_{23} = \ldots = w_{k-1,k} = w_{k1} = 1$. This is a contradiction to the requirement that the w-variables represent an acyclic tournament.

So we can eliminate the exponentially many constraints (3) and obtain a TVP formulation with a polynomial number (cubic in n) of constraints.

Note that because of the tournament equations we can substitute an LOP variable w_{ij}, $j > i$, by $1 - w_{ji}$. Now the 3-dicycle inequalities are turned into $1 \geq w_{ij} + w_{jk} - w_{ik} \geq 0$ for all $1 \leq i < j < k \leq n$ and the part of the objective function for the LOP variables reads $\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} [(p_{ij} - p_{ji}) w_{ij} + p_{ji}]$.

3. THE EDGE-NODE-FORMULATION

The key idea of the next model is to combine the w and x variables of the first model to new three index variables which state the relation between a node n and an fixed edge

(i,j). More precisely we define:

$$w_{ij}^k := \begin{cases} 1 & \text{if } k=\pi(a),\ i=\pi(b) \text{ and } j=\pi(b+1) \\ & \text{for some } 1 \le a \le b \le n-1 \\ 0 & \text{otherwise.} \end{cases}$$

and analogously:

$$w_k^{ij} := \begin{cases} 1 & \text{if } i=\pi(a),\ j=\pi(a+1) \text{ and } k=\pi(b) \\ & \text{for some } 1 \le a < b \le n \\ 0 & \text{otherwise.} \end{cases}$$

A valid IP model based one these variables can be formulated as follows. We denote this model by TVP-IP$_2$.

$$max \sum_{i=1}^{n}\sum_{\substack{j=1\\ i\neq j}}^{n} p_{ij}(\sum_{\substack{m=1\\ m\neq j}}^{n} w_{mj}^i) + \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij}(w_{ij}^{\Omega} + w_{\Omega}^{ij}) \tag{10}$$

$$s.t.$$

$$\sum_{i=1}^{n}\sum_{j=1}^{n}(w_{ij}^{\Omega} + w_{\Omega}^{ij}) = n-1, \tag{11}$$

$$\sum_{i=1}^{n}(w_{ij}^{\Omega} + w_{\Omega}^{ij}) \le 1, \quad j \in V \tag{12}$$

$$\sum_{j=1}^{n}(w_{ij}^{\Omega} + w_{\Omega}^{ij}) \le 1, \quad i \in V \tag{13}$$

$$\sum_{\substack{l=1\\ l\neq j}}^{n} w_{lj}^i + \sum_{\substack{l=1\\ l\neq k}}^{n} w_{lk}^j + \sum_{\substack{l=1\\ l\neq i}}^{n} w_{li}^k + (w_{ik}^{\Omega} + w_{\Omega}^{ik}) \le 2, \quad i,j,k \in V \tag{14}$$

$$w_{ij}^k, w_k^{ij} \in \{0,1\},\ i,j,k \in V \tag{15}$$

Please note that that $\Omega \in V$ could be chosen arbitrarily for each summand in (10) -(13) but must be $\neq j$ and $\neq i$ in each case. It is the same in (14) but here Ω must not be equal i or k. For the sake of uniqueness we always choose the Ω in general as small as possible.

4. THREE DISTANCE MODEL

Another idea for constructing an IP-model for the TVP has been made by Prof. E. Fernandez from the UPC Barcelona. The key idea of this approach is the use of distance variables. In detail we define variables z_{ij}^t which describe the fact whether there exists a path of length t between i an j or not. More formally we state:

$$z_{ij}^t = \begin{cases} 1 & \text{if the solution contains a path with } t \text{ arcs} \\ & \text{from } i \text{ to } j, \\ 0 & \text{otherwise.} \end{cases}$$

Since we do not longer distinguish between distance and ordering variables we have to adjust the coefficients in the following way:

$$w_{ij}^t = \begin{cases} c_{ij} - d_{ij} & \text{if } t=1, \\ c_{ij} & \text{otherwise.} \end{cases}$$

With this modification we are now able to formulated a TVP model with distance variables, which we are denote by TVP-IP$_3$.

$$\max \sum_{i\in N}\sum_{j\in N\setminus\{i\}}\sum_{t\in N\setminus\{n\}} \overline{w}_{ij}^t z_{ij}^t \tag{16}$$

$$\sum_{\substack{i=1\\ i\neq j}}^{n} z_{ij}^1 \le 1 \qquad j \in N, \tag{17}$$

$$\sum_{\substack{j=1\\ j\neq i}}^{n} z_{ij}^1 \le 1 \qquad i \in N, \tag{18}$$

$$\sum_{i=1}^{n}\sum_{\substack{j=1\\ j\neq i}}^{n} z_{ij}^k = n-k \qquad k \in V \tag{19}$$

$$z_{ij}^{t_1} + z_{jk}^{t_2} \le z_{ik}^{t_1+t_2} + 1,$$
$$i,j,k \in N, t_1, t_2 \in N\setminus\{n\}, i\neq j\neq k, t_1+t_2 < n, \tag{20}$$

$$\sum_{t=1}^{n-1} z_{ij}^t + z_{ji}^t = 1 \qquad i,j \in N, i\neq j, \tag{21}$$

$$z_{ij}^t \in \{0,1\} \qquad i,j \in N, i\neq j, t \in N\setminus\{n\}. \tag{22}$$

As one can see, we only have just one type of variables in this model but nevertheless the $z_{i,j}^1$ variables play still a special role in the objective function.

4.1 Extended Formulation of the Basic Model

Our last model is an extended formulation of our first model

The use of extended formulations is a common technique for to strengthen the LP formulation of a combinatorial optimization problem. The key idea of this approach is to add new variables and constraints to a given IP formulation in order to reduce the gap between the solution of the LP relaxation and the optimal integral solution.

In the case of TVP we can obtain an extended formulation by adding three-indexed variables, which are a generalization of the linear ordering variables of the first model. In detail these new variables w_{ijk} are defined as follows:

$$w_{ijk} := \begin{cases} 1 & \text{if } i=\pi(a),\ j=\pi(b) \text{ and } k=\pi(c) \\ & \text{for some } 1 \le a < b < c \le n \\ 0 & \text{otherwise.} \end{cases}$$

So as one ca see this new type of variables is a straight forward extension of the w_{ij}-variables. In the objective function we assign zero coefficients to the new variables. In order to extend our standard model we also need to introduce two new classes of constraints to make sure that the solution of the new variables matches with the old x_{ij} and w_{ij} variables. In detail the extended formulation (denoted by TVP-IP$_4$) looks as follows:

$$\max \sum_{i=1}^{n}\sum_{\substack{j=1\\j\neq i}}^{n} p_{ij}w_{ij} - \sum_{i=1}^{n}\sum_{\substack{j=1\\j\neq i}}^{n} d_{ij}x_{ij} \tag{23}$$

$$s.t.$$

$$\sum_{i=1}^{n}\sum_{\substack{j=1\\j\neq i}}^{n} x_{ij} = n-1, \tag{24}$$

$$\sum_{i=1}^{n} x_{ij} \leq 1,\ 1 \leq j \leq n, \tag{25}$$

$$\sum_{j=1}^{n} x_{ij} \leq 1,\ 1 \leq i \leq n, \tag{26}$$

$$w_{ij} + w_{jk} + w_{ki} \leq 2,\ 1 \leq i,j,k \leq n,\ i<j, i<k\ j \neq k, \tag{27}$$

$$w_{ij} + w_{jik} + w_{jki} + w_{kji} = 1,\ 1 \leq i,j,k \leq n, i<j \tag{28}$$

$$x_{ij} - w_{ijk} - w_{kij} \leq 0,\ 1 \leq i,j,k \leq n, i<j \tag{29}$$

$$x_{ij} - w_{ij} \leq 0,\ 1 \leq i,j \leq n, \tag{30}$$

$$w_{ij}, x_{ij} \in \{0,1\},\ 1 \leq i,j \leq n, \tag{31}$$

$$w_{ijk} \in \{0,1\},\ 1 \leq i,j,k \leq n. \tag{32}$$

5. COMPUTATIONAL RESULTS

One very important criterion for the usability of a given IP model in a cutting plane or branch-and-cut approach is the gap between the LP relaxation and the optimal solution of the IP. For this purpose we tested our models on several instances (taken from [4]), which were randomly created (coefficient matrices have entries between 0 and 10, uniformly distributed). The results can be seen in Table 1.

Instance	Opt.	TVP-IP$_1$	TVP-IP$_2$	TVP-IP$_3$	TVP-IP$_4$
HP13	410	430.8	426.0	478.5	416.8
HP16	604	631.0	622.2	702.2	611.7
HP19	894	921.4	913.9	1038.0	903.1
HP21	1046	1077.6	1070.0	1246.2	1057.1
HP23	1302	1333.0	1321.7	1512.8	1313.8

Table 1: Comparison of root bounds of the different TVP models

As one can see the gap of the model TVP-IP$_1$ is larger than for the TVP-IP$_2$ model. The extended formulation TVP-IP$_4$ has as expected a much better gap. The model with distance variables has in the average a really large gap. Considering the fact that this model also contains a really large number of constraints this model seems to be not so practical unless we find a way to strengthen the LP-relaxation and develop a fast separation algorithm for constraints number (20). We like to point out that these results remain also true if we are considering real world instances.

Another interesting point is the comparison of the polyhedral description for small polytopes of the different models. So we compute such small polytopes for the remaining three polytopes with PORTA[2] and classify the facets due to symmetry with the help of HUHFA[5]. The results could been seen in Table 1.

Polytope	Dim.	# Facets	# Facet-Classes
TVP-IP$_1$	4	1280	48
TVP-IP$_2$	4	512	24
TVP-IP$_3$	4	144	7

Table 2: Key facts of the different TVP-Polytopes

For the the model TVP-IP$_1$ we were able to prove that $w_{ij} + w_{jk} + w_{ki} + x_{ik} \leq 2$ is a facet for all n. So we can strengthen this model by replacing the normal three cycles by this facet. The resulting root bounds are now nearly as good as for the TVP-IP$_2$ model.

HP13	HP16	HP19	HP21	HP23
427.4	621.6	914.4	1069.9	1322.8

Table 3: Rootsbound for TVP-IP$_1$ with the use of the extended three cycle

As thing last we implemented a branch-and-cut for the three models. We made the following observations: The TVP-IP$_1$ model behaves much better than the TVP-IP$_2$ model which is no surprise since the first one has a quadratic number of variables. It is also much faster compared to the last model. Unfortunately this remains also true if you add pricing to the algorithm. So nevertheless the last model has much better root bounds we are currently not able to use this fact efficiently.

So if one sums up all this information, the first model still seems the one which is most suitable for practical computations. Nevertheless the other two model have an interesting structure and are worth further theoretical studies.

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Machine configuration and workload balancing for multi-product PCB assembly

Attila Tóth
Institute of Applied Science
Juhász Gyula Faculty of Education
University of Szeged
Boldogasszony sgt. 6, 6725, Szeged, Hungary
attila@jgypk.u-szeged.hu

Timo Knuutila
SF-20014 University of Turku
Finland
knuutila@utu.fi

Olli S. Nevalainen
Department of Information Technology
SF-20014 University of Turku
Finland
olli.nevalainen@utu.fi

ABSTRACT
Modular component placement machines of gantry-type are popular in PCB assembly manufacturing due to their great flexibility to the needs of different production plans. A two-step optimization method for the machine reconfiguration and workload balancing in the case of multiple PCB types is given in the present study. The proposed algorithm is iterative and applies integer programming for the workload balancing along with an evolutionary algorithm which performs the machine configuration.

Keywords
Printed circuit board, Modular machines, Machine configuration, Mixed-model workload balancing, Integer programing, Genetic algorithm

1. INTRODUCTION
In electronics industry the assembly of electronic components on printed circuit boards (PCB) is a crucial task consisting of several consecutive phases [1][2]. Since the design of the boards is various, production volumes are large and high precision is needed, automatic assembly machines are required. For raising the productivity, assembly lines are built from several machine modules interconnected by a conveyor belt and working concurrently. The most time consuming assembly step is the component placement operation of the surface mounted devices. The characteristics of these mounting machines are various and for suitable optimization methods appropriate classification of the machine types have been introduced [3]. One of the most popular machine types is currently the so-called modular gantry-type placement machine. Each of the machine modules contains a feeder unit holding the reels or trays of different component types, a moveable arm with a changeable rotary head and several changeable nozzles in the head (see e.g. Fuji NXT or Siemens Siplace) [4]. The main advantage of this machine type is its flexibility in the configuration, since the feeder unit, the head and the nozzles can be adjusted to the requirements of the product type.

When a machine module has finished its work with a PCB, the product can be moved forward to the next module. Obviously, the fully connected conveyor belt must wait until every module has finished its work. This waiting time is called as the cycle-time and it is defined by the slowest machine module (called the bottleneck machine module) in the line. In electronics industry, the machine line is usually built up for a long production planning period so the number of modules is fixed and the efficiency is improved by increasing the production rate.

The method for designing the production process depends on the characteristics of the assembly line, machine types, the number of the product types and the similarity of their characteristics [5]. The case when only one PCB type is produced without changing the set-up of the line is called the single-model case. When the products are similar enough to manufacture without reconfigurating the production is called as the mixed-model strategy. Whereas, if the assembly line needs any changes in its set-up (feeder allocation, head assignment, nozzle assignment) during the production, the products need to be grouped into families so that a machine set-up operation (or reconfiguration) is performed only between the families [6][7]. This case is called as the multi-model strategy.

In this study we concentrate to the machine module configuration and line balancing of multiple products with the mixed-model strategy. The optimization problem is divided into two sub-problems; find an efficient module-configuration and balance the workload among the modules. The configuration problem also appears in the single and mixed models since configuring the assembly line for production is not trivial and needs optimization [8][9]. However, many research articles omit the set-up operation and suppose a fixed line configuration. The line balancing of more than two machines is a well-known NP-hard problem in single-model [10] and mixed-model [11] cases.

The main difference between the PCB manufacturing line balancing and the general line balancing is that in electronic industry the precedence between the component placements is not so important and it is usually ignored. However, the characteristic of the assembly machine modules and the compatibility rules between the equipment and the component types are here more complex.

Many solution approaches have been published for the mixed-model case the solution method includes integer programing [12], branch-and-bound [13], Lagrange relaxation [14] and heuristics [15][6][16]. The line configuration and machine set-ups are fixed in the above mentioned studies.

We consider the Machine Configuration and (Work) Load Balancing (MCLB) problem for modular gantry-type placement machines. The problem was originally introduced in [9] for one product type. In this study we optimize the machine configuration and the load balance simultaneously in a multi-product case. We give a hybrid metaheuristic which combines a genetic algorithm for

generating the machine line configuration and an integer programming solution for the line balancing sub-problem. The solutions are evaluated by the total assembly time of the production plan.

2. PROBLEM DEFINITION

In the MCLB problem, a production line with m reconfigurable gantry-machine modules is given (set of machine modules is M). Each module has a changeable placement head which can hold a number of vacuum nozzles. There are in total h head types (H) and n nozzle types (N). A compatibility relation is defined between the head types and nozzle types (HN_{ij}). Each head type has a nozzle capacity (C_i). A feeder unit is connected to each machine module. The feeder unit has a capacity as given by the number of component tape slots it has (F). Each head needs time for picking an electronic component from the feeder unit and putting it to the board. This is called as the pick-and-place time ($T^{pp}{}_i$) which can be different for different head types. Additionally, average traveling time is defined for each head type ($T^{tr}{}_i$).

Our problem formulation of MCLB is a generalization of the single PCB type case [8]. In particular, the production plan includes a component types (A) and b PCB types (B). Each component type has a width, i.e. the number of slots in the feeder unit occupied by the component reel (W_k). There are in total n different nozzle types and a compatibility relation is defined between the component types and the nozzle types. For each PCB type q the production plan defines the batch size P_q, i.e. the number of PCBs of the same type be produced. For each PCB type the numbers of placements of each component type k are also given R_{qk}. We suppose that there is available sufficient number of each nozzle types and head type.

The aim in the MCLB problem is to determine, for a given set of PCB types with known batch sizes, a joint machine module configuration and a component-to-machine assignment fulfilling the compatibility constraints and the feeder capacities such that the total processing time of the production plan is minimal, i.e. the workload of the bottleneck module is minimal. By the machine configuration we mean the head assignment to machine modules, the nozzle assignment to the heads and the feeder allocation (i.e. which component types are inserted to the feeder unit of the modules).

3. SOLUTION METHOD

When solving the MCLB problem, two sub-problems appear: first generating a machine module configuration including head assignment, nozzle assignment and feeder allocation, and second for each PCB type creating a component-to-module assignment minimizing the total production time. A natural approach is to solve the two sub-problems sequentially.

3.1 Initial configuration of machine modules

We say that a configuration of machine modules *covers* a component type if there is at least one machine module for which the feeder unit contains the component type and the assigned head contains at least one compatible nozzle. For each machine module each component type has a *covered-value* which is the number of compatible nozzles in the head of the machine. A configuration is compatible with a PCB type if it covers with a positive covered-value all component types of the board. Finally, a configuration is *feasible* if it is compatible with all PCB types in the production plan.

Head and nozzle assignment

First, those component types which are compatible with only one nozzle type are considered sequentially. For a component of this type, a nozzle is inserted to the first compatible head (already assigned to a machine module). If there is no head for the component then a compatible head type with higher nozzle relevance is assigned to an empty machine module. If, however, there is not an empty machine module the component type is just skipped resulting an infeasible machine configuration. At the second step each uncovered component type is compatible with more than one nozzle type. To select from these nozzle types a new parameter is introduced called *nozzle-relevance (nr)*. This value describes how many component placements can be done with this particular nozzle type compared to the total number of component placements in the production plan.

$$nr_j = \frac{\sum_{q \in B}\left(P_q \sum_{k \in A} R_{qk} AN_{jk}\right)}{\sum_{q \in B}\left(P_q \sum_{k \in A} R_{qk}\right)}$$

The uncovered component types are covered in a random order. For each such type, a compatible nozzle with the highest nozzle-relevance value is assigned to a machine module. When all component types have been covered with at least one nozzle, the remaining empty slots of the heads are filled with nozzles with higher nozzle-relevance value.

Feeder allocation

The component types are ordered ascending by the number of compatible machine modules. Using this sequence, each component type is assigned to the feeder unit of a compatible machine module with the highest covered-value (i.e. the most compatible nozzles). If a component type can not be assigned to any feeder then it is skipped and the configuration is not feasible. The remaining free capacity of the feeder units is filled in the following way. For each machine module, a list of the compatible component types not yet in its feeder is generated. The list is ordered by the covered-values. The component types are assigned to the feeder unit by this order until the feeder unit is filled or there is not any compatible component type left.

The configuration is given by:

mh(l)	the head type assigned to machine module *l*
fn(l,j)	1 if component type *j* is assigned to feeder unit of machine module *l*, 0 otherwise
ha(l,j)	the nozzle type assigned to the *j*th place (i.e. nozzle location) of the head in machine module *l*

Let N'_l be the ordered list of the assigned nozzles in machine module l and N' be the list of nozzles assigned to all machine modules. Note that these structures are not sets but lists of nozzle types, since more than one copy of a particular nozzle type can be inserted into a head.

Since a component type may be compatible with several different nozzle types, it is hard to determine the number of feeder-PCB-feeder tours made by the head. Therefore, we do not assign the component placements simply to the machine modules but to the

nozzles. Because a nozzle can hold only one component at a time, the head must travel around as many times as there are component placements assigned to each particular nozzle. Thus, the number of the cycles performed by the head is determined by the maximum load of its nozzles.

A configuration is infeasible if it does not cover some component type. To increase the covering probability of these components in the next iteration we increase the relevance of the compatible nozzle types.

3.2 Integer programming for workload balancing

The load balancing must be solved for each PCB type and these individual balancing problems are independent from each other. So they will be solved one by one or even simultaneously with parallel computation.

The integer variable σ_{ql} gives the number of cycles of the head in machine module l and variable x_{qkj} gives the number of placements of component type k assigned to the nozzle j producing PCB type q, and Q is a big constant.

For each PCB type $q \in B$

$$\min \max_{l \in M} \sum_{k \in A} \sum_{j \in N_l'} x_{qkj} T^{pp}_{mh(l)} + \sigma_{ql} T^{tr}_{mh(l)}$$

where

$$\min \max_{l \in M} \sum_{k \in A} \sum_{j \in N_l'} x_{qkj} T^{pp}_{mh(l)} + \sigma_{ql} T^{tr}_{mh(l)}$$

$$\min \max_{l \in M} \sum_{k \in A} \sum_{j \in N_l'} x_{qkj} T^{pp}_{mh(l)} + \sigma_{ql} T^{tr}_{mh(l)}$$

$$\min \max_{l \in M} \sum_{k \in A} \sum_{j \in N_l'} x_{qkj} T^{pp}_{mh(l)} + \sigma_{ql} T^{tr}_{mh(l)}$$

$$\min \max_{l \in M} \sum_{k \in A} \sum_{j \in N_l'} x_{qkj} T^{pp}_{mh(l)} + \sigma_{ql} T^{tr}_{mh(l)}$$

$$\min \max_{l \in M} \sum_{k \in A} \sum_{j \in N_l'} x_{qkj} T^{pp}_{mh(l)} + \sigma_{ql} T^{tr}_{mh(l)}$$

A standard way to linearize the minmax objective function is to introduce a new variable τ denoting the maximum processing time, replace the objective with minimizing τ and give new constraints to each machine module ensuring that the processing time is less than or equal to τ. The new objective function is

$$\min \tau$$

with new constraints

$$\sum_{k \in A} \sum_{j \in N_l'} x_{k,j} T^{pp}_{mh(l)} + \sigma_l T^{tr}_{mh(l)} \leq \tau, \text{ for all } l \in M$$

3.3 Genetic algorithm for machine configuration

We apply the genetic algorithm (GA) framework [17] for searching good feasible solutions for the machine module configuration problem.

An *individual* represents a configuration of the machine modules. To evaluate a configuration, the component placement cost must be calculated for each PCB type. If the machine configuration is feasible for a PCB type, the production time of the total number of this type of boards is added to the global *fitness* value. Otherwise, if the configuration is infeasible for a component type the component placement cost is determined without that component type and a penalty is added to the global fitness. The *mutation* operation for each machine module with a predefined low probability changes the head and assign nozzle as in Section 3.1. . In case the head is not changed, the mutation is executed on the nozzles with the same probability. In the *crossover* operation the machine modules are considered pairwise and the head are swapped by tossing a coin. If the head types are the same the nozzles are recombined similarly. To select the individuals for the next generation linear ordering selection is used.

The population size was set to 10. In each generation 10 mutation operations was performed and the probability used was 0.1. Recombination operations were performed 10 times too. The parents for both mating are selected by the roulette-wheel selection due to their fitness value. The stopping criterion was the maximum number of the generation which was set to 1000.

4. COMPUTATIONAL RESULTS

The Multi-model Evolutionary Algorithm (MEA) optimization method is implemented in Java and executed on an Intel Core2Duo 2.33GHz computer. The integer programming problems were solved by CPLEX software. For the evaluation we used the average of 20 independent runs for each problem instances.

The performance is evaluated on problem instances of different sizes. The characteristic of the module configurations reflects to the real life assembly lines.

First, the algorithm is tested with the single PCB production problems published in [8] and [9] and compared to the results of the mentioned metaheuristic and the optimal solution. The proposed algorithm works very well for these problem instances. The production time is equal or really close to the optimum and outperforms the solution of the single-model evolutionary algorithm [9].

In the second phase of testing the problem instance contains four PCB types of medium size (100 component placements) and we tested the effect of the multi-model optimization on the production time of PCBs. For comparison the production times was determined of each PCB when they are produced in single-model environment. When the production plan contains more than one PCB types with the same batch sizes, the generated configuration is designed such that the production time of each PCB type increases smoothly and equally. However, if the batch sizes of the PCB types are different the configuration is adjusted to reduce the assembly time of larger batches usually at the expense of the others.

The algorithm can produce infeasible configurations i.e. infeasible solutions. The nozzle-relevance updating (see Section 3.1) increases the covering probability of these component types by raising the relevance-value i.e. the number of the compatible nozzles in the configuration. Therefore the algorithm tends to

generate feasible solutions and if it founds at least one the final solution will be feasible.

5. CONCLUSION

This study deals with the machine configuration and line balancing problem for reconfigurable machine modules producing two or more PCB types with a common configuration. The machine modules are of the gantry type so, that each of them contains a changeable rotary head with changeable nozzles and a feeder unit for storing the components. Compatibility relations are defined between heads and nozzles and between nozzles and components such that n-to-m relations are allowed. These types of assembly lines are nowadays popular in PCB assembly industry due to the great flexibility of the equipment. In this study an iterative metaheuristic MEA was presented which uses a genetic algorithm for generating line configuration and an integer programming model for the line balancing.

The efficiency of the proposed method was demonstrated by comparisons with optimal solutions in the single product cases. The proposed algorithm found optimal or near optimal results and outperformed an earlier algorithm. The adaptive feature of the algorithm was demonstrated in a multi production plan by varying the batch sizes. Because MEA optimizes the total production time it puts more stress in machine configuration to the PCB type that consume more time due to their complexity or the batch size.

6. ACKNOWLEDGMENTS

The publication is supported by the European Union and co-funded by the European Social Fund. Project title: "Telemedicine-focused research activities on the field of Matematics, Informatics and Medical sciences". Project number: TÁMOP-4.2.2.A-11/1/KONV-2012-0073

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Exact Algorithms for the General Coupled Task Scheduling Problem*

[Extended Abstract]

József Békési
Department of Applied Informatics, Gyula Juhász Faculty of Education
University of Szeged
H-6701 Szeged, POB 396, Hungary
bekesi@jgypk.u-szeged.hu

Gábor Galambos
Department of Applied Informatics, Gyula Juhász Faculty of Education
University of Szeged
H-6701 Szeged, POB 396, Hungary
galambos@jgypk.u-szeged.hu

Michael N. Jung
Institut für Informatik, Fakultät für Mathematik und Informatik
Universität Heidelberg
Im Neuenheimer Feld 368,
D-69120 Heidelberg, Germany
michael.jung@iwr.uni-heidelberg.de

Marcus Oswald
Institut für Informatik, Fakultät für Mathematik und Informatik
Universität Heidelberg
Im Neuenheimer Feld 368,
D-69120 Heidelberg, Germany
marcus.oswald@iwr.uni-heidelberg.de

Gerhard Reinelt
Institut für Informatik, Fakultät für Mathematik und Informatik
Universität Heidelberg
Im Neuenheimer Feld 368,
D-69120 Heidelberg, Germany
gerhard.reinelt@iwr.uni-heidelberg.de

ABSTRACT

The coupled task problem is to schedule jobs on a single machine where each job consists of two subtasks and where the second subtask has to be started after a given time interval with respect to the first one. The problem has several applications and is NP-hard. In this paper we present a branch-and-bound algorithm for this problem and compare its performance with integer programming models.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous

1. INTRODUCTION

In this presentation we consider the so called Coupled Task Scheduling problem. This problem can be defined as follows: we are given n jobs and each job consists of two distinct sub-tasks. The sequence of the sub-tasks is fixed and there is a fixed length delay-time between the two parts. We can denote job J_i by a triple (a_i, L_i, b_i), where the values represent the processing time of the first sub-task, the delay time between the two sub-tasks and the processing time of the second sub-task, respectively. It is required that the second sub-task must be scheduled *exactly* $L_i + a_i$ units after having started the first one. During the delay time the machine is idle, so it is possible to schedule other sub-tasks in this interval. The aim is to schedule the given n coupled-tasks on one machine in such a way that no two job tasks can overlap. We want to minimize the latest finishing time of the jobs. (As usual we call this as the makespan and we denote it by $C_{\max}$). Preemption, i.e., interrupting a task and resuming it later is not allowed.

The general problem (1|Coup-Task|$C_{\max}$) first was investigated by Shapiro [4]. He discussed the practical applications of the problem and presented 3 heuristics for this hard problem. It is proved that this problem is $\mathcal{NP}$-hard (see [3]). Unfortunately, the author did not analyze the heuristics in detail, only experimental results showed their efficiencies. Orman and Potts investigated the problem from complexity point of view (see [2]). Later Sherali and Smith gave a mathematical formulation for the problem [5]. In this presentation we deal with the optimal solution of the general problem. We present a new combinatorial branch-and-bound algorithm, which works without using linear programming or other similar techniques. In addition to this we introduce new 0-1 programming formulations and compare the models computationally to the one given by Sherali and Smith.

*This work was supported by the European Union and the European Social Fund through project " Supercomputer, the national virtual lab" grant no.: TAMOP-4.2.2.C-11/1/KONV-2012-0010.

2. THE BRANCH-AND-BOUND METHOD

The branch-and-bound method works in a combinatorial way. This means that the bounds of the nodes of the B&B tree are calculated from the combinatorial structure of the schedule. Each node represent a subset of the jobs, where the sub-tasks are ordered in a given way. Child nodes are created by inserting a new job to the current list in all possible ways. To decide the feasibility of a given permutation of the sub-tasks a feasibility test algorithm is developed. In case of a feasible schedule the output of the procedure is a set of time windows representing the possible starting times of the sub-tasks. Infeasible schedules are cut-off immediately from the tree. For node selection the *dive-and-best* strategy is applied. Its advantage that it finds good feasible solutions fast and it tries to compute tight bounds. For selecting the next node to be processed the *best-bound-first* strategy is used, i.e. the child node with the best lower bound is selected. For larger problems the tree may contain huge number of nodes. To improve the efficiency of the algorithm different kind of bounding procedures can be applied. In this case we use four specific methods, which can effectively decrease the computational time by pruning the tree. The proposed methods are based on the analysis of the gaps in the schedule and they give specific lower bounds on the makespan. Besides bounding it is also important to exclude nodes with symmetric properties from the tree. This is done by introducing blocks and lexicographic ordering of the schedules. Computational studies prove that this branch-and-bound method is more effective than the mathematical programming approaches.

3. THE INTEGER PROGRAMMING FORMULATIONS

Our presentation contains different 0-1 programming formulations. Here we present the time-indexed formulation, which is common for modeling machine scheduling problems. The basic ideas of this method were already presented in [1].

To get the optimal schedule we want to minimize M, which is an upper bound on the makespan. To do this we define an optimization problem, which decides if all jobs can be scheduled in the interval $[0, M]$. Then we can calculate the optimal value of M by a binary sarch. To give the optimization problem, we need binary variables y_{jt} and z_{jt} for $j = 1, ..., n$ and $t = 0, ..., M$. The interpretation of these variables is the following:

$$y_{jt} = \begin{cases} 1 & \text{job } j \text{ is started at time } t, \\ 0 & \text{otherwise} \end{cases}$$

and

$$z_{jt} = \begin{cases} 1 & \text{a sub-task of job } j \text{ occupies the machine in time interval } [t, t+1], \\ 0 & \text{otherwise.} \end{cases}$$

There is a connection between the variables y_{jt} and z_{jt}, namely

$$z_{jt} = \sum_{s=t-a_j+1}^{t} y_{js} + \sum_{s=t-a_j-l_j-b_j+1}^{t-a_j-l_j} y_{js}, \text{ for } 0 \le t \le M.$$

Note that we ignore the variables y_{js} with $s < 0$ here. Using these notations the corresponding optimization problem is the following:

$$\max \sum_{j=1}^{n} \sum_{t=0}^{M-1} y_{jt}$$

subject to

$$\sum_{t=0}^{M-1} y_{jt} \le 1, \text{ for } j = 1, 2, ..., n \quad (1)$$

$$\sum_{j=1}^{n} z_{jt} \le 1, \text{ for } t = 0, 1, ..., M-1 \quad (2)$$

$$\sum_{j=1}^{n} z_{j0} = 1 \quad (3)$$

$$y_{jt} = 0, \text{ for } t = M - a_j - l_j - b_j + 1, ..., M-1 \quad (4)$$
$$j = 1, ..., n, \quad (5)$$

where inequalities (1) ensure that every job is scheduled at most once and inequalities (2) ensure that no two sub-tasks overlap. Using (3) we enforce that the schedule starts as early as possible and because of constraints (4) each job is started only if it can be completely processed.

According to computational studies this formulation can provide good results for some special instances.

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Detection of ground in point-clouds generated from stereo-pair images

[A morphological approach based on attribute operators]

Domen Mongus*
University of Maribor, Faculty of Electrical Engineering and Computer Science
Smetanova 17
SI-2000 Maribor, Slovenia
domen.mongus@uni-mb.si

Borut Žalik†
University of Maribor, Faculty of Electrical Engineering and Computer Science
Smetanova 17
SI-2000 Maribor, Slovenia
zalik@uni-mb.si

ABSTRACT

This paper proposes a new approach for constructing digital terrain models (DTM) from the point-clouds generated from airborne stereo-pair images. The method uses data decomposition based on the differential attribute profiles and Θ-mapping for the extraction of the most-contrasted connected-components. Their filtering is achieved based on multicriterion threshold function. The method is evaluated by comparing the output DTM with the reference Light Detection and Ranging data.

Categories and Subject Descriptors

I.3.5 [**Computer Graphics**]: Computational Geometry and Object Modeling

General Terms

Theory, Algorithms

Keywords

digital terrain model, mathematical morphology, Θ-mapping

1. INTRODUCTION

Digital terrain models (DTMs) are essential part of various spatial analysis, geographic applications, and virtual reality systems [19, 6, 14]. In recent years, a considerable effort has been directed towards developing efficient approaches for accurate DTM generation.

When considering DTM generation from point-clouds, the most often used approaches can, according to the literature, be classified as slope-based, linear prediction-based, and morphological methods [20, 9]. Slope-based methods [18, 21] achieve point-filtering by comparing the gradients between neighbouring points. Consequentially, they have difficulties filtering points on step slopes and tend to smooth terrain undulations [20, 9]. Linear prediction-based methods, on the other hand, have difficulties filtering small and low objects as they rely on rough surface approximation to establish a liner prediction of the terrain [8, 2]. Actual filtering is usually achieved by observing the points' residuals from the predicted surface. Preservation of sharp terrain details (e.g. ridges) can, therefore, be exposed as another weakness [20, 9]. By applying operations of mathematical morphology [5, 11, 4, 16], morphological filters proved to be fairly resistant to previously exposed drawbacks. However, they are severely dependent on the definition of the structuring element, as large objects (e.g. buildings) cannot be removed using a small structuring element, whilst large structuring element tends to flatten terrain details (e.g. mountain peaks) [20, 9, 5]. Several attempts have been proposed for optimal definition of a structuring element, the most efficient of which are based on a multi-scale filtering. A set of filters of different scales is used for this purpose and different threshold values are usually defined for each of them. A progressive filtering was proposed by Chen et al. [5], where thresholding is applied on height differences achieved by each filter. On the other hand, Mongus and Žalik [11] proposed data-filtering by iterating thin-plate splines towards the ground, where resolution is increased at each iteration by including points, filtered according to their residuals from the previously estimated surface. This, so-called, hierarchical multiresolution filtering has recently been improved by Chen et al. [4]. Pingel et al. [16] have, on the other hand, based their approach on the slope estimation achieved by linearly increasing filtering scale. Since all of these methods are adopted for processing high-resolution point-clouds containing vast amounts of points (e.g. LiDAR data), iterative approaches may not always be appropriate. Mongus and Žalik have [12] proposed an efficient multiscale approach

*Dr. Mongus received the Ph.D. in computer science in 2012. Since 2013, he is Assistant Professor of computer science at the University of Maribor, Slovenia. His research interests include mathematical morphology, pattern recognition, and computational geometry.

†Dr. Žalik received the B.Sc. in electrical engineering in 1985 and the M.Sc. and Ph.D. in computer science in 1989 and 1993, respectively. He is a Professor of computer science at the University of Maribor. His research interests include computational geometry, geometric data compression, and geographic information systems.

that avoids iterations by using attribute filters based on the max-tree data structure. Although the method proves efficient when filtering LiDAR data, its accuracy is not guaranteed when filtering low-resolution point-clouds (such as those generated from stereo-pair images) since it is based on the standard deviation of point heights.

This paper presents a new method for estimation of digital terrain model from point-clouds generated from airborne stereo image pairs. By considering $\Theta-$mapping, the proposed method is an extension of [12], where a different set of attributes is used for the filtering. Section 2 explains theoretical foundation of connected operators from mathematical morphology that allows their efficient estimation. The method is explained in Section 3. Section 4 gives the results, whilst Section 5 concludes the paper.

2. THEORETICAL BACKGROUND

Let $g : E \to \mathbb{R}$ be a regular grid, where $E \subset \mathbb{Z}^2$ and $p \in E$ is a grid point. Consider a level-set $E_l \subset E$ given by the hight-level l as $E_l = \{p \mid g[p] = l\}$. A connected component from E_l is named a flat-zone of g. A filter that acts on flat-zones rather than individual grid-points is named a connected operator [17]. A connected operator can eider remove a flat-zone (by merging it with some other flat-zones) or leave it perfectly preserved, but it cannot brake it. If the decision about which flat-zones to merge is based on some of their attributes, this type of operator is named an attribute filter [1]. Consider a set of all thresholded sets $T = \{T_l\}$ of g, each obtained by

$$T_l = \{p \mid g[p] \geq l\}. \tag{1}$$

A peak connected component $C_l^k \in T_l$ is defined by its height level l and its component-at-level index k . Let an attribute function $A(C_l^k)$ that estimates a particular attribute of C_l^k, e.g. its area, diameter, or bounding-box. For simplicity, let A be increasing, thus, satisfying the condition $C_{l_1}^{k_1} \subseteq C_{l_2}^{k_2} \to A(C_{l_2}^{k_2}) \leq A(C_{l_2}^{k_2})$. An attribute filter γ_a^A acting on g is at a particular point p defined by

$$\gamma_a^A(s)[p] = \bigvee\{l \mid p \in C_l^k,\ A(C_l^k) \geq a\}, \tag{2}$$

where $\bigvee$ is supremum (i.e. the upper-bound). In other words, an attribute filter γ_a^A removes all the peak connected components not satisfying an attribute threshold condition a by assigning to each point p the maximal height-level at which it still belongs to a peak connected component C_l^k with $A(C_l^k) \geq a$. Since $\forall g, \gamma_a^A(g) \leq g$, γ_a^A is an anti-extensive morphological filter named attribute opening. Its dual, an attribute closing ϕ_a^A, is defined as $\gamma_a^A(g) = -\phi_a^A(-g)$.

A decomposition named DAP or differential attribute profile Δ has recently been proposed by Ouzounis et. al. [15]. Δ is based on progressive content reduction by filtering g at an increasing scale. Consider an ordered set of attribute thresholds $\mathbf{a} = \{a_i\}$, where $i \in [0, I]$ and $a_{i-1} < a_i$, Δ is obtained by

$$\Delta_{\mathbf{a}}^A(g) = \{\gamma_{a_{i-1}}^A(g) - \gamma_{a_i}^A(g)\}, \tag{3}$$

where $i \in [1, I]$. Thus, $\Delta_{\mathbf{a}}^A(g)$ is an $I-$long response vector registering the differences introduced by each particular $\gamma_{a_i}^A$, whilst $\gamma_{a_I}^A(g)$ is a grid residual.

Recently, Mongus and Žalik [12] proposed $\Theta-$mapping that registers the most-contrasted connected-components and estimates their arbitrary attributes by observing characteristic values contained in $\Delta_{\mathbf{a}}^A$. Namely, $\Theta-$mapping estimates the most-contrasted connected-components from g by registering the maximal responses from $\Delta_{\mathbf{a}}^A(s)$ and filtering scale at which they are obtained. Formally, $\Theta(g, A, \mathbf{a}) : g \to (g', g^\circ)$, is at p given by

$$g'[p] = \bigvee \Delta_{\mathbf{a}}^A(g)[p], \tag{4}$$

$$g^\circ[p] = \bigwedge i \mid \gamma_{a_{i-1}}^A(g)[p] - \gamma_{a_i}^A(g)[p] = g'[p], \tag{5}$$

where $\bigwedge$ is infinum (i.e. the lower-bound). Consider a set of peak connected-components $C^p = \{C_l^p\}$ containing a point p, i.e. $C_l^p = C_l^k \mid p \in C_l^k$. The most-contrasted connected-component C_{max}^p with the respect to the given $\Delta_{\mathbf{a}}^A(g)$ is identified by

$$max = \bigvee l \mid a_{g^\circ[p]-1} \leq A(C_l^p), \tag{6}$$

where max defines the height-level of the most-contrasted connected-component. Note that possibly no response was obtained at a given p, meaning that the corresponding peak connected-components are not in contrast against their surroundings and, therefore, belong to the grid residual, i.e. background. In any case, an arbitrary attribute of C_{max}^p can then be measured and used as an attribute in multicriterion threshold definition.

3. GROUND EXTRACTION FROM POINT-CLOUDS

The proposed method generates a digital terrain models from point-clouds obtained by stereo-pair images in the following tree steps:

- **Initialization** is the first step of the method were input point-cloud is sampled into a grid,
- **Point filtering** is performed in the space of the most-contrasted connected-components obtained by Θ-mapping, and
- **Construction of DTM** is the final step of the method, where removed points are interpolated.

Each of these steps is discussed in continuation.

3.1 Initialization

In order to apply morphological operators on point-clouds, points are firstly sub-sampled into a regular grid g. The resolution of the grid R_g is defined by the point-density D_L as $R_g = 1.0/D_L$. When a particular grid-cell contains more than one point, the hight level of the grid-point is defined by the lowest one since it has the highest probability of being a ground point. On the other hand, interpolation is used in order to estimate the hight levels of the undefined grid-points $g[p^*] = UNDEF$, obtained when there are no points contained within the corresponding grid-cells. In our case, the height level at p^* is estimated using inverse distance

weighting (IDW) as [10]

$$g[p_n^*] = \frac{\sum_{p_n \in W^{p_n^*}} g[p_n]\ d_{p_n}^{-r}}{\sum_{p_n \in W^{p_n^*}} d_{p_n}^{-r}}, \quad (7)$$

where p_n is a grid-point from the neighbourhood $W^{p_n^*}$ of p_n^*, and d_{p_n} is the Euclidean distance between p_n^* and p_n. Parameter r defines the smoothness of the interpolation. According to the evaluation of the spatial interpolation methods described in [3], accurate results are obtained when $W^{p_n^*}$ contains at least three closest points and $r = 2$.

3.2 Ground filtering

In order to achieve extraction of the most-contrasted connected-components, the underlying definition of DAPs is given first. In compliance with demanded increasing property of the attribute used for grid decomposition, the proposed method constructs DAPs according to the area of the contained peak connected components A. An area threshold vector $\mathbf{a}$ is given as

$$\mathbf{a} = \{20.0 * i\}, \quad (8)$$

where $i \in [0, I]$. Note that $\mathbf{a}$ is given in square-metres, thus, its definition should be adjusted when the input point-cloud is not georeferenced. In any case, the following attributes of the most-contrasted connected-components are estimated by Θ-mapping:

- g' describes the height difference or residual of the most-contrasted connected-component from its background and is estimated by eq. 4,
- g° describes the area of the most-contrasted connected-components according to eq. 5,
- g^c is a function describing shape-compactness of the most-contrasted connected-components and is estimated based on a well-known distance transformation as [13]

$$g^c[p] = \frac{A(C_{max}^p)}{9\pi * \overline{DT}(C_{max}^p)}, \quad (9)$$

where $\overline{DT}(C_{max}^p)$ is a function that estimates the average distance of a grid-point contained within C_{max}^p to the closest background point.

After g', g°, and g^c are estimated, a set of ground grid-points G is recognized with a multicriterion threshold function given by

$$G = \{p \mid g'[p] \leq t^R, g^\circ[p] \leq t^S, g^c[p] \leq t^C\}, \quad (10)$$

where t^R, t^S, and t^C are residual, size, and compactness thresholds, respectively.

3.3 DTM construction

In the final step of the method, DTM is contracted by interpolating the heights of the non-ground points $NG = E/G$ using IDW, as given by eq. 7. However, using $r = 2$ may not always be appropriate as it may produce some sharp unnatural terrain features. Additional smoothing is, therefore, performed based on morphological opening γ_w, where w is a structuring element. In our case, final DTM is obtained by

$$DTM[p] = \begin{cases} g[p] & ; \quad g[p] - \gamma_w(g) \leq R_g/2.0 \\ \gamma_w(g)[p] & ; \quad otherwise \end{cases} \quad (11)$$

where w is box-shaped structuring element of size 5×5.

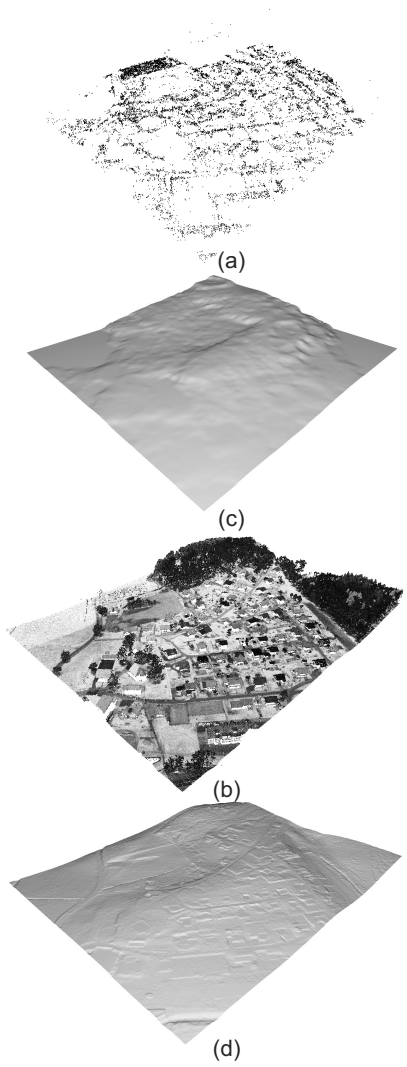


Figure 1: Estimation of DTM from (a and b) stereo-pair images and (c and d) the reference LiDAR data.

4. RESULTS

In order to evaluate the method, a point-cloud has been generated from georeferenced stereo-pair image as proposed in [7] with approximately 17.000 points. Average point spacing was below $3.1m$ and average absolute height error was $5.3m$ in comparison to the reference data (see Fig. 1a). The reference data was acquired with LiDAR technology. The referenced point-cloud contained more than 1.6 millions of points with average point-spacing below than $0.25m$ and average absolute height error below $0.1m$ (see Fig. 1c).

The reference DTM was obtained with [12] and was used

for the evaluation of the proposed method (see Figs. 1b and d). The results show that the proposed method is capable of removing important portion of noise as the average absolute difference of DTMs was lower than the average error of the point-clouds. Namely, the error is reduced to $4.8m$. However, significant portion of DTM's details is missing due to the lower point-cloud resolution.

5. CONCLUSION

The paper proposes a new method for estimation of DTMs from point-clouds, generated by stereo-pair areal images. The method determines non-ground regions by estimating their geometrical characteristics, namely their sizes, shape compactness, and height differences from the background. As confirmed by the results, Θ-mapping provides sufficient solution for this purpose as great majority of errors were introduced by interpolation and lower data accuracy in comparison to LiDAR data.

6. ACKNOWLEDGMENTS

This work was supported by the Slovenian Research Agency under grants $L2-3650$ and $P2-0041$. This paper was produced within the framework of the operation entitled "Centre of Open innovation and Research UM". The operation is co-funded by the European Regional Development Fund and conducted within the framework of the Operational Programme for Strengthening Regional Development Potentials for the period $2007-2013$, development priority 1: "Competitiveness of companies and research excellence", priority axis 1.1: "Encouraging competitive potential of enterprises and research excellence".

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Simulation of two-phase fluid filtration with nonuniform media on clusters

Ekaterina V. Berveno
Institute of Computational Mathematics and Mathematical Geophysics SB RAS
Novosibirsk, Russia
ekaterina.berveno@gmail.com

Alexander A. Kalinkin
Institute of Computational Mathematics and Mathematical Geophysics SB RAS
Novosibirsk, Russia

Yuri M. Laevsky
Institute of Computational Mathematics and Mathematical Geophysics SB RAS
Novosibirsk, Russia

ABSTRACT

This work is related to the simulation of oil recovery. And it is an attempt to come closer to a correct model that describes the flow of a fluid through a porous medium. To examine the question, how the porosity and permeability may influence on the movement of fluids in rocks, an algorithm and its program realization have been constructed.

The key point within the scope of this work is implementation of the problem on clusters which consist of hundreds or thousands of nodes, using MPI technology. The algorithm shows high scalability and efficiency from the standpoint operations and data exchange on multiprocessor systems. Also we will present numerical results that show efficiency of implemented algorithm on cluster with several hundreds of cores.

From the results it is concluded the time of water breakthrough in production wells varies depending on the location of the inhomogeneities. Therefore, this work has a great practical importance.

Categories and Subject Descriptors

G.1.3 [**Mathematics of Computing**]: NUMERICAL ANALYSISNumerical Linear Algebra; D.1.3 [**Software**]: PROGRAMMING TECHNIQUES Concurrent Programming; J.2 [**PHYSICAL SCIENCES AND ENGINEERING**]: Mathematics and statistics, Physics, Chemistry

General Terms

Algorithms, Performance, Experimentation

Keywords

Fluid filtration, Parallel computing, Saturation, Finite element method

1. INTRODUCTION

This article continues proceeds made by collective of authors [1]. It is devoted to the simulation of two-phase incompressible fluid filtration ([2], [3]) and designed in the terms of "velocity-pressure-saturation". Here we need to note the article [4] proposing preconditioner which is spectral equivalent to grid problem on each time step. Main mathematical statement of fluid filtration was set in the work [1].

Current article is devoted to modeling fluid filtration with nonuniform coefficients (porosity and permeability) of media and implementation of the corresponding algorithm on computers with distributed memory. A number of experiments are demonstrated in the last section of this article.

2. ORIGINAL PROBLEM AND ALGORITHM

The conservation laws of phases and Darsy's law give the system:

$$\begin{aligned}
&\frac{1}{k(s)}\mathbf{v} + \nabla\psi = \mathbf{G}(s),\\
&\nabla\cdot\mathbf{v} = 0,\\
&\frac{1}{k(s)}\mathbf{w} = \nabla\sigma(s),\\
&\mathbf{v}_2 - \frac{k_2(s)}{k(s)}(\mathbf{v}-\mathbf{w}) = -k_2(s)\mathbf{G}(s),\\
&m\frac{\partial s}{\partial t} + \nabla\cdot\mathbf{v}_2 = 0,
\end{aligned} \tag{1}$$

where $\mathbf{v_i}$ - velocity of phases, ψ - generalized pressure, k_i - phases permeability, s - saturation of the second phase, $G(s)$ - gravitational vector, m - porosity. Here and further the subscript i indicates the number of phase, wherein $i = 1$ corresponds to the displaced phase (oil), $i = 2$ corresponds to the displacing phase (water).

With correspondent boundary condition

$$\begin{aligned}
&\mathbf{x}\in\Gamma^{ent} : \mathbf{v}\cdot\mathbf{n} = -\frac{Q}{l^{ent}}, \quad \mathbf{v}_2\cdot\mathbf{n} = -\frac{Q}{l^{ent}},\\
&\mathbf{x}\in\Gamma^{ex} \ : \mathbf{v}\cdot\mathbf{n} = \frac{Q}{l^{ex}}, \quad \mathbf{v}_2\cdot\mathbf{n} = \frac{k_2(s)}{k(s)}\frac{Q}{l^{ex}} - k_2(s)\mathbf{G}(s)\cdot\mathbf{n},\\
&\mathbf{x}\in\Gamma^{0} \ : \mathbf{v}\cdot\mathbf{n} = 0, \quad \mathbf{v}_2\cdot\mathbf{n} = 0
\end{aligned} \tag{2}$$

we obtain a closed system of equations.

2.1 Weak formulation of fluid filtration

Based on these equations we could set weak formulation of two-phase incompressible fluid filtration: *For* $s^0 \in L_2(\Omega)$ *one need to find continuous function by* $t > 0$ $s(t) \in L_2(\Omega)$, $\psi(t) \in L_2(\Omega)/\text{const}$, $\mathbf{v}(t)$, $\mathbf{w}(t)$, $\mathbf{v}_2(t) \in \mathbf{H}(\text{div}, \Omega)$: $s(0) = s^0$, $\partial s/\partial t(t) \in L_2(\Omega)$, *the boundary condition (2) take place and* $\forall\, t > 0$, $\forall\, \mathbf{u} \in \mathbf{H}_0(\text{div}, \Omega)$, $\forall\, \xi \in L_2(\Omega)/\text{const}$, $\forall\, \zeta \in L_2(\Omega)$ *next expressions take place:*

$$\begin{aligned}
&\int\limits_\Omega \frac{1}{k(s)}\,\mathbf{v}\cdot\mathbf{u}\,\mathrm{d}\mathbf{x} - \int\limits_\Omega \psi\,\nabla\cdot\mathbf{u}\,\mathrm{d}\mathbf{x} = \int\limits_\Omega \mathbf{G}(s)\cdot\mathbf{u}\,\mathrm{d}\mathbf{x},\\
&\int\limits_\Omega \xi\,\nabla\cdot\mathbf{v}\,\mathrm{d}\mathbf{x} = 0,\\
&\int\limits_\Omega \frac{1}{k(s)}\,\mathbf{w}\cdot\mathbf{u}\,\mathrm{d}\mathbf{x} = -\int\limits_\Omega \sigma(s)\,\nabla\cdot\mathbf{u}\,\mathrm{d}\mathbf{x},\\
&\int\limits_\Omega \mathbf{v}_2\cdot\mathbf{u}\,\mathrm{d}\mathbf{x} - \int\limits_\Omega \frac{k_2(s)}{k(s)}\,(\mathbf{v}-\mathbf{w})\cdot\mathbf{u}\,\mathrm{d}\mathbf{x} = -\int\limits_\Omega k_2(s)\,\mathbf{G}(s)\cdot\mathbf{u}\,\mathrm{d}\mathbf{x},\\
&\int\limits_\Omega m\frac{\partial s}{\partial t}\,\zeta\,\mathrm{d}\mathbf{x} + \int\limits_\Omega \zeta\,\nabla\cdot\mathbf{v}_2\,\mathrm{d}\mathbf{x} = 0.
\end{aligned} \tag{3}$$

Using low degree Raviart-Toma element to approximate $\mathbf{H}_0(\text{div}, \Omega)$ and piece-constant function to approximate $L_2(\Omega)$ we get the following matrix formulation:

$$\begin{aligned}
&D(s)\mathbf{v} + B\psi = \mathbf{G}_1(s),\\
&B^T\mathbf{v} = F_1,\\
&D(s)\,\mathbf{w} = B\,\sigma(s),\\
&D_0\mathbf{v}_2 - D_1(s)(\mathbf{v}-\mathbf{w}) = \mathbf{R}(s),\\
&M\frac{s^{n+1}-s^n}{\tau} - B_1^T\mathbf{v}_2 = G_2(s^n)
\end{aligned} \tag{4}$$

where G_2, F_1, R - some functions of s^n.

2.2 Implementation of the problem

We use explicit difference scheme with predictor-corrector for time-discretization. It's the second order difference scheme and to implement it we need to calculate right hand side only once for each step. It is not necessary to invert the stiffness matrix on several processes for it, and we need to implement only the multiplication, which scales effectively enough. For the same reason the mixed finite element method was chosen as the main way to discretize the original differential system. This algorithm allows to separate the variables in the stiffness matrix, which in turn allows us to implement the preconditioned conjugate gradient method on a cluster effectively [4]. Data exchange occurs only a few times in one time step, and each data exchange is a big "package" but not series of small message, which is much more efficient in terms of implementation. Namely each process makes its work independently from other and all processes communicate by MPI_Alltoall routine. The data transposes between processes during this routine (see Figure 1). In addition, we benefited from the point of view of calculations, since it implements for each process, before and after the global transmission regardless. Finally, since each working array is divided evenly between the processes, we are able to calculate the problem, which can not be calculated on sequential machines because of the natural limitations of random access memory. It's easy to see that first 2 equations of grid problem (4) are a saddle-point system. To solve it we transform it into Schur complement that solved by PCG with preconditioner based on unknown decomposition [4]. All even mentioned above factors have led to the fact that we can currently assume problems of quite big size, on clusters with hundreds of computing nodes, and the greater the problem, the better it is scaled in time. Also to achieve additional performance improvement of the whole problem we use the solution from the previous step as initial data for current one. So to obtain better perfomance on Intel Architecture we use FFT functionality named Intel®MKL.

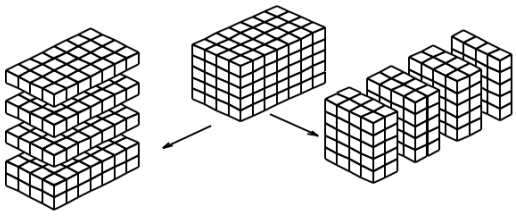


Figure 1: Transposition data between processes

3. RESULTS

One of our main goals was to investigate the pattern water flow in oil reservoir. Within this direction we made calculations for displacement of oil by water in strongly heterogeneous medium, in particular, porosity and permeability of the medium were varied. The calculation results show that the time of water breakthrough in production wells significantly varies depending on the location of the inhomogeneities. As a result, the amount of oil remaining in the reservoir increases. These calculations demonstrate the importance of accurate prediction of structure of collector and investigation of fluid filtration models.

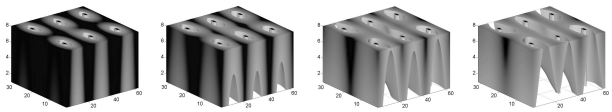


Figure 2: Filtration process with porosity m=0,1

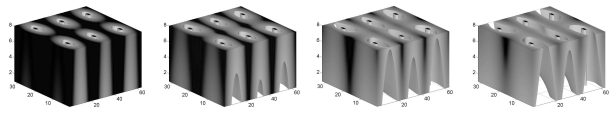


Figure 3: Filtration process with porosity m=0,375

Figures 2-4 shows the results of the calculations for the three-dimensional filtration problem. Porosity is given the same on the whole volume but different in the three cases. In these experiments the following parameters are used: $\Omega = (0, 32) \times (0, 64) \times (0, 8), h_x = h_y = h_z = 1, \tau = 20$. There h and τ is the spatial grid step and the time step respectively.

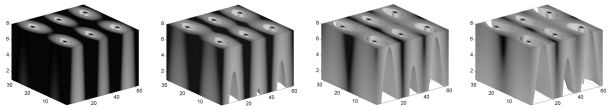


Figure 4: Filtration processwith porosity m=0,9

On figure 5 one can see the type of water flow in the case of including a number of blocks with different m (porosity) parameter in uniform media: in the upper and lower dotted block m=0,1; in the central dotted block m=0,9; other m=0,375. The filtering process is shown in four stages.

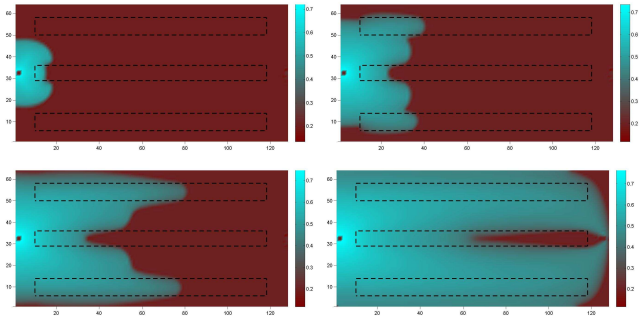


Figure 5: Saturation for nonuniform m

On figure 6 one can see similar situation - we set nonuniform domain in which k_0 (absolute permeability) parameter is changed: in the upper and lower dotted block $k_0 = 3.06 \times 10^{-11}$; in the central dotted block $k_0 = 3.06 \times 10^{-13}$; other $k_0 = 3.06 \times 10^{-12}$.

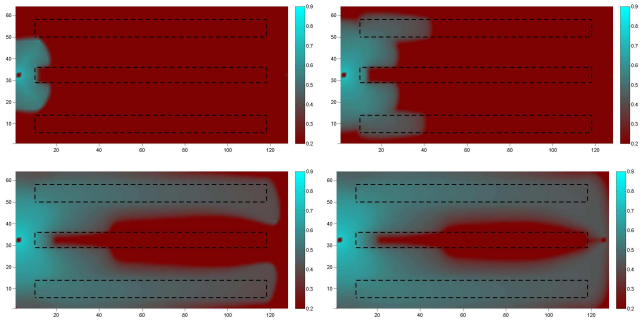


Figure 6: Saturation for nonuniform k_0

To verify the results obtained and compare different disposition of the well we made a number of test with uniform media. Some results are presented on figure 7. One can see that variant c) of figure 7 provides best drilling in. To achieve it we work firstly on 5th point scheme and after add additional wells.

And finally, our last goal is to obtain an algorithm that work efficiently on computers with distributed memory on dozens and hundreds of nodes. We can see from the results that the "single core" MPI is more effective on a small number of processes when the computational load is large enough and data exchanges have no significant effect. Parallelization with using cores with shared memory is more effective

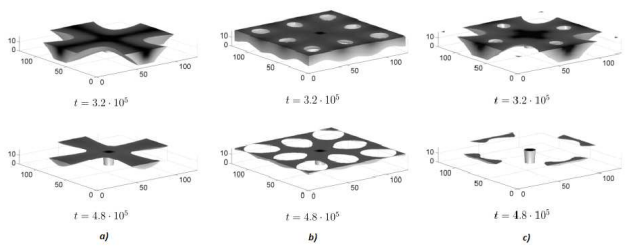


Figure 7: Type of water flow in case of different disposition of wells: a) 5th point disposition, b) 9 point disposition, c) combination

on a large number of processes. Eventually, with increasing the number of processes the speedup factor is grow as fast as the data sent. Sending data to the processes with shared memory is faster, so the speedup "multicore" MPI versions are growing faster than the "single core". The performance results of 2D problem are presented on figure 8. The algorithm can't work on number of processes more than any grid dimension so some sells are empty. Strings corresponde to different mesh size, columns to the number of processes. The coefficient of "speed-up" presented in each sell as ratio of working time on 1 process to working time on p processes.

p / $N \times M$	2	4	8	16	32	64	128	256
32x4	1,47	1,94	-	-	-	-	-	-
64x8	1,79	3,40	4,39	-	-	-	-	-
128x16	1,61	3,06	5,99	8,63	-	-	-	-
256x32	1,98	3,36	6,83	10,38	15,08	-	-	-
512x64	2,07	4,12	4,72	8,65	16,36	20,71	-	-
1024x128	1,78	3,54	7,09	13,84	24,01	34,04	43,31	-
2048x256	2,05	3,44	6,06	12,19	24,53	47,85	67,94	82,98

Figure 8: Coefficients of whole algorithm speed-up depending on number of processes and mesh size

All computations have been run on the Infiniband*-linked cluster consisting of 60 computational nodes; each node contains Intel®Xeon®E5540 processor with 8Gb of RAM per node. We need to underline that all the parameters here and further were obtained from real physical data.

3.1 Conclusions

The proposed algorithm shows good scalability up to 256 processes. The difference of drilling in case of different wells position is presented the best results have been obtained in the case when the number of walls is changing during the main process. The algorithm shows dependency of the water-flow on media parameters. This indicate the importance of correct media statement to propose water-flow in a real oil reservoir. Thereby our system was constructed successfully and functioned correctly.

The final program allows to analyze the risks and minimize them in a timely manner to improve technologies, to justify its strategic direction, to improve production figures, to calculate the best opening intervals and to determine the remaining reserves and dead zones for a specific period of time for development of oil fields.

4. ACKNOWLEDGEMENTS

This work was supported by the Russian Foundation for Basic Research (research grant 12-01-31046, 13-01-00019).

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Enumerating algebraic expressions generated by context-free grammars

Jurij Mihelič
Faculty of Computer and Information Science, University of Ljubljana
Tržaška 25
Ljubljana, Slovenia
jurij.mihelic@fri.uni-lj.si

ABSTRACT

In this paper we use a method based on generating functions for enumerating words and parse trees in the languages of context-free grammars. In the case of ambiguous grammars we enumerate parse trees, and in the case of unambiguous grammars we enumerate words. For various context-free grammars for algebraic expressions we find generating functions and also corresponding power series. Additionally, we also show that the enumeration does not depend on the number of operator priority levels, but only on the number of different operators.

Categories and Subject Descriptors

G.2.1 [**Discrete mathematics**]: Combinatorics—*Counting Problems*

General Terms

Algorithm, Enumeration, Theory

Keywords

algebraic expression, operator, parenthesis, context-free grammar

1. INTRODUCTION

Enumeration of various combinatorial objects is of great importance in mathematics and computer science, particularly in the areas of probability, combinatorics, analysis of algorithms and data structures, computability and computational complexity theory [1, 2, 3]. In combinatorial enumeration generating functions are often used, since they easily and efficiently describe (infinite) sequences (i.e., as the coefficients of a formal power sum). The area of research, which dwelve deeply into this is called *analytic combinatorics* [2].

Context-free grammars are one of the most important tools for describing languages, both natural and artificial [4, 5]. In computer science they are mainly used for describing and parsing of programming languages. Most of the classical programming languages include (among other programming constructs) also algebraic expressions (e.g., arithmetic or logical expressions).

For languages described with an unambiguous context-free grammar, there is a general method for enumerating words (of particular length) which are in the language of the grammar. The method is based on deducing a generating function which admits the grammar. However, in the case of ambiguous grammars, the method results in the enumeration of parse trees (a word may have more than one parse tree). The brief overview of the method is as follows. The particular grammar is first translated into a system of functional equations. The system is then solved and its solution is a generating function of a sequence, where the coefficient of the l-th term is the number of different words of length l.

Several results on counting of arithmetic expressions was already presented in [6]. In this paper we generalize the results to algebraic expressions in the sense that expressions are generated from any (finite) set of binary operators and any set of operands. Additionally, we extend the result for enumerating algebraic expressions with well-formed parentheses generated from unambiguous grammar.

In the next section we give mathematical preliminaries and basic notation. In the third section we consider ambiguous grammars for binary algebraic expressions, and in the fourth section we consider unambiguous grammars. For both kind of grammars we consider expressions with and without parentheses. For all four kinds we give explicit formulas for the number of parse trees of expressions of particular length.

2. PRELIMINARIES

In this paper we employ ordinary generating functions to count algebraic expressions. Let $A(z)$ be such function and let its power-series expansion be (e.g., Taylor or Maclaurin [2, 3])

$$A(z) = \sum_{k \geq 0} a_k z^k. \tag{1}$$

The k-th coefficient a_k at term z^k represents the number of expressions of length k. Sometimes we use $[z^k]A(z)$ to denote a_k.

The algebraic expressions considered in this paper are of odd length. Consequently, the corresponding generating func-

tion has the following form

$$A(z) = \sum_{k\geq 0} a_k z^{2k+1}.$$

Such series is often transformed into a basic form (1). The transformation is based on the following lemma.

LEMMA 1. *Given the following two power series*

$$A'(z) = \sum a_k z^k \quad \textit{and} \quad A(z) = \sum a_k z^{2k+1}$$

it holds $A(z) = zA'(z^2)$ *and* $A'(z) = \frac{A(\sqrt{z})}{\sqrt{z}}$.

We also need several expansions of generating functions to power series. The first is also known as the binomial theorem

$$(1-az)^\alpha = \sum_{k\geq 0} \binom{\alpha}{k} (-az)^k \tag{2}$$

and the second is

$$(z^2 - 2xz + 1)^\alpha = \sum_{k\geq 0} C_k^{-\alpha}(x) z^k \tag{3}$$

where $C_k^\alpha(x)$ is Gegenbauer polynomial. Notice that, $C_0^\alpha(x) = 1$ and $C_1^\alpha(x) = 2\alpha x$.

Let $A(z) = \sum_{k\geq 0} a_k z^k$ and $B(z) = \sum_{k\geq 0} b_k z^k$ be two power series. Convolution $C(z) = A(z)B(z)$ is given as $C(z) = \sum_{k\geq 0} c_k z^k$ where $c_k = \sum_{i=0}^k a_i b_{k-i} z^k$ [1].

3. ALGEBRAIC EXPRESSIONS

In this section we focus on counting of algebraic expressions of length l, where each expression may contain of up to p different binary operators (e.g., +, -), and up to q different (types of) operands (e.g., numbers, identifiers), and, possibly well-formed parentheses. For example, the expression $42+(3*foo)-bar$ is an expression of length of nine symbols, containing three operators and four operands. Observe that we count length in symbols (i.e., tokens), but not in characters.

When counting we also consider all numbers and/or identifiers as the same. To demonstrate this, consider four algebraic expressions: 1+2, 42+123, 1+(2), 1*2, where the first two are the same, and the last two are different from the others.

We denote with l the length of the expression, with m the number of operands, and with n the number of operators. Since we use only binary operators and parentheses the length of the expression is always odd. The length, number of operators and operands are connected with the following formulas:

$$m = \frac{l+1}{2} \quad \text{and} \quad n = \frac{l-1}{2},$$

which are also written as $l = 2n+1$ and $m = n+1$.

3.1 Ambiguous grammars

First let us focus on algebraic expressions generated by an ambiguous context-free grammar. Because of the grammar ambiguity, the enumeration method results in counting of parse trees. In particular, an expression can have more than one parse tree, and we count all of them.

The first grammar that we consider is as follows:

$$\begin{array}{lcl} E & \rightarrow & E\ O\ E \mid N \\ O & \rightarrow & o_1 \mid o_2 \mid \ldots \mid o_p \\ N & \rightarrow & n_1 \mid n_2 \mid \ldots \mid n_q \end{array} \tag{4}$$

It consists of three production rules with the starting symbol E. The rule O generates one of the p possible operators $o_1, o_2, \ldots, o_p$, and rule N generates one of the q possible operands $n_1, n_2, \ldots, n_q$.

The grammar (4) corresponds to the following set of functional equations:

$$\begin{array}{lcl} E(z) & = & O(z)E^2(z) + N(z), \\ O(z) & = & pz, \\ N(z) & = & qz. \end{array}$$

Solving for $E(z)$, which is of our interest (starting symbol), gives the quadratic functional equation

$$pzE^2(z) - E(z) + qz = 0,$$

with the solution

$$E(z) = \frac{1 - \sqrt{1-4pqz^2}}{2pz}.$$

This is the generating function of the sequence, where coefficient $[z^l]E(z)$ represents the number of parse trees of expressions of length l.

Now, we apply Lemma 1, to obtain the generating function for the number of parse tress of expression containing n operators

$$E'(z) = \frac{1 - \sqrt{1-4pqz}}{2pz}.$$

Finally, we expand the square-root term via Binomial theorem (2) and apply several algebraic manipulations (see [1, 7] for details of similar manipulation)

$$\begin{array}{lcl} E'(z) & = & \frac{1}{2pz} - \frac{1}{2pz} \sum_{n\geq 0} p^n q^n (-4)^n \binom{1/2}{n} z^n \\ & = & \sum_{n\geq 0} p^n q^{n+1} \frac{1}{n+1} \binom{2n}{n} z^n. \end{array}$$

Notice that, $\frac{1}{n+1}\binom{2n}{n}$ are the well-known Catalan numbers, which give the number of structurally different binary trees with n internal nodes (in our case operators). The end result of our enumeration is the following theorem

THEOREM 2. *The number of parse trees with n binary operators admitting the context-free grammar* (4) *for algebraic expressions is* $p^n q^{n+1} \frac{1}{n+1}\binom{2n}{n}$.

Now let us change the grammar (4) so that it can also generate expressions with parentheses. In particular, we extend

the production rule of the symbol N.

$$\begin{array}{lcl} E & \to & E\ O\ E \ \mid\ N \\ O & \to & o_1 \ \mid\ o_2 \ \mid\ \ldots \ \mid\ o_p \\ N & \to & n_1 \ \mid\ n_2 \ \mid\ \ldots \ \mid\ n_q \ \mid\ (\ E\ ) \end{array} \quad (5)$$

The grammar corresponds to the following system of functional equations:

$$\begin{aligned} E(z) &= O(z)E^2(z) + N(z), \\ O(z) &= pz, \\ N(z) &= qz + z^2E(z). \end{aligned}$$

which gives the quadratic functional equation

$$pzE^2(z) - (z^2-1)E(z) + qz = 0.$$

Solving for $E(z)$ and transforming (by Lemma 1) to $E'(z)$ gives the generating function

$$E'(z) = \frac{1 - z - \sqrt{z^2 - 2(2pq+1)z + 1}}{2pz}.$$

We can expand $E'(z)$ via Gegenbauer polynomials, which gives the following theorem.

THEOREM 3. *The number of parse trees with n binary operators admitting the context-free grammar* (5) *for algebraic expressions is*

$$\begin{cases} q & n = 0 \\ -\frac{1}{2p}C_{n+1}^{-1/2}(2pq+1) & n \geq 1. \end{cases}$$

PROOF. First, we rewrite generating function $E'(z)$ of the grammar, then we expand it via (3), and finally do some algebraic manipulations.

$$\begin{aligned} E'(z) &= \frac{1-z}{2pz} - \frac{1}{2pz}\left(z^2 - 2(2pq+1)z + 1\right)^{1/2} \\ &= \frac{1-z}{2pz} - \frac{1}{2p}\sum_{n\geq 0} C_n^{-1/2}(2pq+1)z^{n-1} \\ &= \frac{1}{2p}z^{-1} - \frac{1}{2p}z^0 - \frac{1}{2p}C_0^{-1/2}(2pq+1)z^{-1} \\ &- \frac{1}{2p}C_1^{-1/2}(2pq+1)z^0 - \frac{1}{2p}\sum_{n\geq 2} C_n^{-1/2}(2pq+1)z^{n-1} \\ &= q + \sum_{n\geq 1} -\frac{1}{2p}C_{n+1}^{-1/2}(2pq+1)z^n. \end{aligned}$$

□

Table 1: Ambiguous grammars

p,q (oeis) $\setminus$ n	0	1	2	3	4	5
4,1 (A151403)	1	4	32	320	3584	43008
5,1 (A156058)	1	5	50	625	8750	131250
4,2	1	16	256	5120	114688	2752512
4,1 (A133305)	1	5	45	505	6345	85405
5,1 (A133306)	1	6	66	906	13926	229326
4,2	1	18	306	6498	154530	3937266

We give enumeration counts for both grammars in Table 1 (above – without parentheses, below – with parentheses) for various values of p, q and n. The OEIS [10] sequence numbers are given in parenthesis.

3.2 Unambiguous grammar

Let us consider an unambiguous grammar for the same kind of algebraic expressions. To remove ambiguity from grammar (4) we use classical method from [4]. Denote with t the number of priority levels, and with p_i, where $1 \leq i \leq t$ the number of operators on the level i. Operators on the level i are denoted with $o_{i1}, o_{i2}, \ldots, o_{ip_i}$. For each $1 \leq i \leq t$ we have the following production rules (with the starting symbol E_t):

$$\begin{array}{lcl} E_i & \to & E_i\ O_i\ E_{i-1} \ \mid\ E_{i-1} \\ E_0 & \to & n_0 \ \mid\ n_1 \ \mid\ \ldots \ \mid\ n_q \\ O_i & \to & o_{i1} \ \mid\ o_{i2} \ \mid\ \ldots \ \mid\ o_{ip_i} \end{array} \quad (6)$$

The grammar corresponds to the system of functional equations, where $1 \leq i \leq t$:

$$\begin{aligned} E_i(z) &= E_i(z)O_i(z)E_{i-1}(z) + E_{i-1}(z) \\ E_0(z) &= qz, \\ O_i(z) &= p_iz, \end{aligned} \quad (7)$$

Now we state the theorem that the solution $E_t(z)$ of the system depends only on the total number of operators and operands, i.e., the details of the priority levels can be ignored.

LEMMA 4. *Let $p = \sum_{i=1}^{t} p_i$. The solution of the system* (7) *of functional equations is $E_t(z) = \frac{qz}{1-pqz^2}$.*

PROOF. We sequentially insert $E_i(z)$ into $E_{i+1}(z)$ until we get $E_t(z)$. First, observe that $E_1(z) = \frac{qz}{1-p_1qz^2}$ and $E_2(z) = \frac{qz}{1-(p_1+p_2)qz^2}$, and, in general, for any k it holds $E_k(z) = \frac{qz}{1-\sum_{i=1}^{k} p_iqz^2}$. Finally, for $k = t$, we have $E_t(z) = \frac{qz}{1-pqz^2}$ □

Now we prove the following consequence.

THEOREM 5. *The number of algebraic expressions containing n binary operators admitting the context-free grammar* (6) *is p^nq^{n+1}, where $p = \sum_{i=1}^{t} p_i$.*

PROOF. First, use Lemma 1 to get $E'(z)$ from $E_t(z)$

$$E'(z) = \frac{q}{1-pqz}.$$

Then use Binomial theorem (2) to expand $E'(z)$ to power series

$$E'(z) = \sum p^nq^{n+1}z^n.$$

□

Now, similarly as above, we remove the ambiguity from the context-free grammar (5) and obtain the following production rules, where $1 \leq i \leq t$:

$$\begin{array}{lcl} E_i & \to & E_i\ O_i\ E_{i-1} \ \mid\ E_{i-1} \\ E_0 & \to & n_0 \ \mid\ n_1 \ \mid\ \ldots \ \mid\ n_q \ \mid\ (\ E_t\ ) \\ O_i & \to & o_{i1} \ \mid\ o_{i2} \ \mid\ \ldots \ \mid\ o_{ip_i} \end{array} \quad (8)$$

The grammar corresponds to the following system of functional equations, where $1 \leq i \leq t$:

$$\begin{aligned} E_i(z) &= E_i(z)O_i(z)E_{i-1}(z) + E_{i-1}(z) \\ E_0(z) &= qz + z^2 E_t \\ O_i(z) &= p_i z \end{aligned} \tag{9}$$

As above we now state that the solution $E_t(z)$ of the system depends only on the total number of operators and operands.

LEMMA 6. *Let $p = \sum_{i=1}^{t} p_i$. The solution of the system (9) of functional equations equals to the solution of the following quadratic functional equation*

$$pz^3 E_t^2(z) + \left((pq+1)z^2 - 1\right) E_t(z) + qz = 0,$$

with the solution

$$E_t(z) = \frac{1 - (pq+1)z^2 - \sqrt{(pq-1)^2 z^3 - 2(pq+1)z^2 + 1}}{2pz^3}.$$

PROOF. Starting from $E_0(z)$ we sequentially insert $E_i(z)$ into the equation for $E_{i+1}(z)$ until we get only $E_t(z)$'s. First, observe that $E_1(z) = \frac{qz+z^2 E_t(z)}{1-p_1(qz^2+z^3 E_t(z))}$, and for any k we have $E_k(z) = \frac{qz+z^2 E_t(z)}{1-\sum_{i=0}^{k} p_i(qz^2+z^3 E_t(z))}$. Finally, for $k = t$, we have $E_t(z) = \frac{qz+z^2 E_t(z)}{1-pqz^2-pz^3 E_t(z)}$. Rearranging and solving for $E_t(z)$ now gives the quadratic equation and its solution. □

THEOREM 7. *The number of algebraic expressions containing n binary operators admitting the context-free grammar (8) is*

$$\frac{(-1)^{n+1}}{2p} \sum_{k=0}^{n+2} (\sqrt{pq}+1)^{2k} (\sqrt{pq}-1)^{2(n+2-k)} \binom{1/2}{k} \binom{1/2}{n+2-k}.$$

PROOF. First we apply Lemma 1 to $E_t(z)$ to get $E'(z)$. We have

$$E'(z) = \frac{1}{2p} z^{-2} - \frac{pq+1}{2p} z^{-1} - \frac{S(z)}{2pz^2} \tag{10}$$

where $S(z) = \sqrt{(pq-1)^2 z^2 - 2(pq+1)z + 1}$. Now we factor $S(z) = A(z)B(z)$ where $A(z) = \left(1 - \left(\sqrt{pq}+1\right)^2 z\right)^{1/2}$ and similarly $B(z) = \left(1 - \left(\sqrt{pq}-1\right)^2 z\right)^{1/2}$. Using Binomial theorem we expand both to

$$A(z) = \sum_{k \geq 0} (\sqrt{pq}+1)^{2k} (-1)^k \binom{1/2}{k} z^k$$

and

$$B(z) = \sum_{k \geq 0} (\sqrt{pq}-1)^{2k} (-1)^k \binom{1/2}{k} z^k.$$

Denote with $s_n = [z^n]S(z)$. By the convolution of $A(z)$ and $B(z)$ we know that

$$s_n = \sum_{k=0}^{n} (\sqrt{pq}+1)^{2k} (\sqrt{pq}-1)^{2(n-k)} (-1)^n \binom{1/2}{k} \binom{1/2}{n-k}.$$

Observe that $s_0 = 1$ and $s_1 = -(pq+1)$. Consequently, the terms at z^{-2} and z^{-1} cancel out with the first two terms of $\frac{S(z)}{2pz^2}$. Furthermore, we have

$$E'(z) = -\frac{1}{2p} \sum_{n \geq 2} s_n z^{n-2} = -\frac{1}{2p} \sum_{n=0}^{\infty} s_{n+2} z^n.$$

Thus, the n-th coefficient of $E'(z)$ is

$$\frac{(-1)^{n+1}}{2p} \sum_{k=0}^{n+2} (\sqrt{pq}+1)^{2k} (\sqrt{pq}-1)^{2(n+2-k)} \binom{1/2}{k} \binom{1/2}{n+2-k}.$$

□

We give enumeration counts for both grammars in Table 2 (above – without parentheses, below – with parentheses) for various values of $p = \sum_{i=0}^{t} p_i$, q and n. The OEIS [10] sequence numbers are given in parenthesis.

Table 2: Unambiguous grammars

p, q (oeis) \ n	0	1	2	3	4	5
4,1 (A000302)	1	4	16	64	256	1024
5,1 (A000351)	1	5	25	125	625	3125
4,2 (A013730)	2	16	128	1024	8192	65536
4,1 (A059231)	1	5	29	185	1257	8925
5,1 (A078009)	1	6	41	306	2426	20076
4,2	1	18	178	1890	21154	246258

4. CONCLUSIONS

In the paper we enumerated words and parse trees of algebraic expressions generated by several versions of context-free grammars. To do this we employed generating functions and expansions to power series. There are still some open questions, e.g., Gegenbauer polynomials and their connection to combinatorial enumeration.

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Barrier Resilience of Visibility Polygons

[Extended Abstract]

Alexander Gilbers
Institute of Computer Science
University of Bonn
53113 Bonn, Germany

ABSTRACT

We consider the problem of computing the Barrier Resilience of a set of Visibility Polygons inside a Polygon. We show that in simple polygons the problem is solvable in time linear in the number of edges. In polygons with holes the problem is APX-hard, so only for special cases can we provide polynomial time algorithms.

Categories and Subject Descriptors

F.2.2 [**Analysis of Algorithms and Problem Complexity**]: Nonnumerical Algorithms and Problems

General Terms

Algorithms, Theory

1. INTRODUCTION

We consider a special case of the Barrier Resilience Problem. Given a start point s and a target point t as well as the positions and ranges of n sensors, we want to find a path from s to t that minimizes the number of its witnesses (i.e. the sensors that detect the agent travelling on this path). We call an optimal path in this respect a *Minimum Witness Path*.

This problem can be seen from two sides: On the one hand, it is a path planning problem. On the other hand, the minimum possible number of sensors that detect a path of the agent is an important parameter of the sensor network. It is called the *Barrier Resilience* of the network. Sensor Networks with a low Barrier Resilience are more error-prone than those with high Barrier Resilience. In the analysis of a sensor network that is designed to detect an intruder, the Minimum Witness Path points to the network's weak spot. Therefore, to optimize sensor networks it would be very helpful to have an efficient method at hand to compute the barrier resilience of the network or, even better, a Minimum Witness Path.

There are many different types of sensor networks conceivable. We here restrict our attention to the very natural case where the sensor regions are visibility polygons inside polygons. We show that the problem is polynomially solvable in some special cases. On the other hand we prove that the general Barrier Resilience Problem for visibility polygons in polygons with holes is APX-hard. In particular, we get a stronger inapproximability factor than the ones known for line segments.

2. RELATED WORK

In 2005, in the environment of sensor networks Kumar et al. [8] introduce the notion of a *k-barrier coverage*. In their setting, somebody wants to cross a belt region over which a sensor network is deployed. The belt region is called *k-barrier covered* if every path that crosses the belt is detected by at least k sensors.

Bereg and Kirkpatrick [2] introduce the notion of *Barrier Resilience*: Given a collection of geometric objects that model the ranges of sensors and two points s, t in the plane, find the minimum number of objects one has to remove such that s and t are in the same component of the complement of the remaining objects. I.e. the Barrier resilience is the maximum k such that the region is k-covered. They give an approximation algorithm for this problem when the sensor ranges are unit disks. Until today it is unknown if this original problem is NP-hard. In [1] Alt et al. show that the Barrier Resilience Problem for line segments is APX-hard and they also define related problems. In [9] Tseng and Kirkpatrick strengthen the result to *unit* line segments. Gibson et al. [6] give an approximation algorithm for a path that visits multiple points and tries to avoid as many unit disks as possible. Chan and Kirkpatrick [4] give a 2-approximation algorithm for the case of Non-identical Disk Sensors.

One can also view the barrier resilience problem in a very abstract graph-theoretic setting where an agent wants to travel from some start vertex of a graph G to some target vertex. In this setting the barriers are arbitrary subsets of the vertex set of G. The barriers can also be interpreted as colors that are assigned to the vertices. This problem is then called the Minimum Color Path Problem. For this model, Carr et al. [3] show that unless $P = NP$ the optimal solution cannot be approximated to within $O(2^{\log^{1-\delta} n})$ where $\delta = \frac{1}{\log \log^c n}$ for any $c < 1/2$. In [10], Yuan et al. use the Minimum Color Path model to analyze reliablity in Mesh Networks.

3. MINIMUM WITNESS PATHS IN SIMPLE POLYGONS

In our first setting the starting point s and the target point t lie inside a simple polygon P, and we are given a finite set of witness points $W \subset P$. We want to find a path from s to t that is seen by as few as possible witnesses. Let us restate this formally.

DEFINITION 1. *Let a polygon P, two points $s, t \in P$ and a set of so-called witness points $W = \{w_1, \ldots, w_n\} \subset P$ be given. The barrier resilience of W is the minimum cardinality of a subset V of W such that there is an $s-t$-path in P that does not touch any visibility polygon of a point in $W \setminus V$. A path that attains this minimum is called a Minimum Witness Path.*

We use the usual notion of visibility inside simple polygons:

DEFINITION 2. *Let P be a simple polygon. We say that $p_1 \in P$ sees $p_2 \in P$ iff the line segment $\overline{p_1 p_2}$ is a subset of P. We say that a witness point $w \in P$ sees the path π iff there is a point p on π that is seen by w.*

It turns out that in this setting one can find an optimal path very efficiently. The key insight is the following structural lemma.

LEMMA 1. *Let P a simple polygon, points $s, t \in P$ and a witness point $w \in P$. If there is a path π in P from s to t that is not seen by w, then the shortest path from s to t in P is not seen by w.*

Before we prove the lemma, we draw the following conclusions that settle the problem for simple polygons.

THEOREM 1. *Given a simple polygon P with n edges, two points $s, t \in P$ and a set of witness points $W \subset P$, the shortest path between s and t is an optimal solution to the minimum witness path problem.*

PROOF. Let π' denote the shortest path from s to t. By Lemma 1, for every path π between s and t the set $W' = \{w \in W \mid w \text{ sees } \pi'\}$ is a subset of $W(\pi) = \{w \in W \mid w \text{ sees } \pi\}$ and consequently $|W'| \leq |W(\pi)|$. □

COROLLARY 1. *Given a simple polygon P with n edges, two points $s, t \in P$ and a set of witness points $W \subset P$, we can determine a minimum-witness path in time $O(n)$.*

PROOF. The shortest path between two points inside a simple polygon with n edges can be computed in time $O(n)$ [7]. □

The proof of the lemma uses the simple topological structure of the polygon.

PROOF OF THE LEMMA. Let π' be the shortest path between s and t and $w \in P$ a point that sees the point p on π'. If w sees s or t it obviously sees every path from s to t. Otherwise consider the line $L(w, p)$ through w and p. The

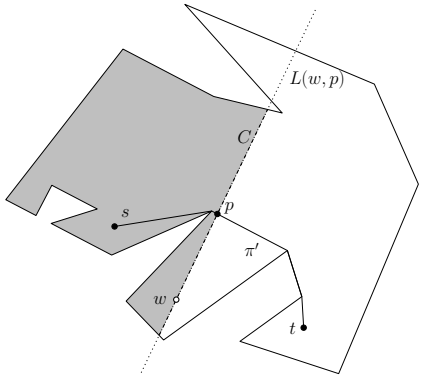


Figure 1: The connected component C of $L(w,p) \cap P$ that contains w and p splits P into two connected components, one containing s, the other containing t.

points w and p lie in the same connected component C of $L(w, p) \cap P$. Now $P \setminus C$ splits into at least two connected components. As π' is the shortest path, s and t lie in different components (otherwise π' could be shortened to a path that is completely contained in the common component of s and t).

It follows that every path from s to t must pass C and is therefore seen by w. □

4. POLYGONS WITH HOLES

The next step is looking at polygons with holes. So now we have a simple polygon P' and a collection of simple polygons $H_1, \ldots, H_m$, called the holes, where every hole lies in the interior of P' and $H_i \cap H_j = \emptyset$ for all $1 \leq i < j \leq m$. The polygon with holes P then is defined to be $P = P' \setminus \bigcup_{i=1}^{m} \mathring{H}_i$, where $\mathring{H}_i$ denotes the topological interior of H_i. Let $|P|$ denote the total number of edges of P. Two points $p_1, p_2 \in P$ *see* each other if and only if the line segment $\overline{p_1 p_2}$ is completely contained in P.

Again we are given two points $s, t \in P$ and witnesses $w_1, \ldots, w_n \in P$ in general position, and we want to find a path π inside P from s to t minimizing the number of witnesses who can see π.

First we show that the problem is APX-hard by a reduction from Vertex Cover that provides a stronger factor than other hardness proofs in the context of Barrier resilience.

THEOREM 2. *Estimating the Barrier Resilience of a set of Visibility Polygons inside polygons with holes is APX-hard. In particular, unless $P = NP$, the Barrier Resilience of Visibility Polygons with holes cannot be approximated within a factor of* 1.3606*. If the Unique Games Conjecture is true, then the Barrier Resilience cannot be approximated within any constant factor better than* 2*.*

PROOF. We show this by an approximation factor preserving reduction from Minimum Vertex Cover.

Let $G = (V, E)$ be an instance of vertex cover. Let $e_1, e_2, \ldots, e_m$ an enumeration of the edges, $v_1, v_2, \ldots v_n$ an enumeration of the vertices.

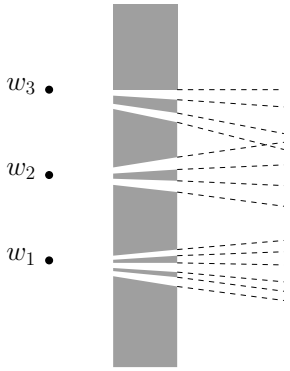


Figure 2: On the left side of the polygon there are only narrow slits between the holes through which the witnesses (which correspond to the vertices) can peek...

We now construct a polygon with holes P in the plane that contains a start point s, a target point t and n witness points $w_1, \ldots w_n$ such that every path from s to t in P corresponds to a vertex cover of G.
To this end we build a big surrounding rectangle $P' = [-2(m+n+1), m+2] \times [-m-n-1, m+n+1]$. We place the start point at the origin, $s = (0, 0)$ and the target point at $t = (m+1, 0)$.
For every edge e_j in E, we add a thin rectangular hole $R_j = [j, j+0.5] \times [-j, j]$.
Then we place the witness points at $w_i = (-2(m+n), i - \lceil \frac{n}{2} \rceil)$. If v_k and v_l (with $k \leq l$) are the vertices incident to edge e_j we define $L(j) = w_k$, $H(j) = w_l$ to be the witnesses corresponding to the vertices with lower and with higher index, respectively. We also define $f\colon \{w_1, \ldots, w_n\} \longrightarrow \{v_1, \ldots, v_n\}$ to be the bijection that maps every w_i to v_i. To construct the holes that model the vertex-edge incidences we proceed as follows:
We start with one rectangle
$Z = [-2(m+n) + 0.5, -2(m+n) + 1] \times [-m-n, m+n]$ and split it into $2m+1$ pieces.
For every edge e_j we define the two triangles

$$TH_j = \Delta(H(j), (j, j-0.25), (j, j-0.5))$$

and

$$TL_j = \Delta(L(j), (j, 0.25-j), (j, 0.5-j)).$$

Now we construct the $2m+1$ holes by simultaneously cutting the interiors of all these triangles out of Z. We set

$$Z' = Z \setminus \bigcup_{j=1}^{m} (\mathring{TH}_j \cup \mathring{LH}_j)$$

We add the connected components of Z' as holes to our scene.
By this construction every witness w_i sees a rectangle R_j iff the vertex v_i is incident to e_j.

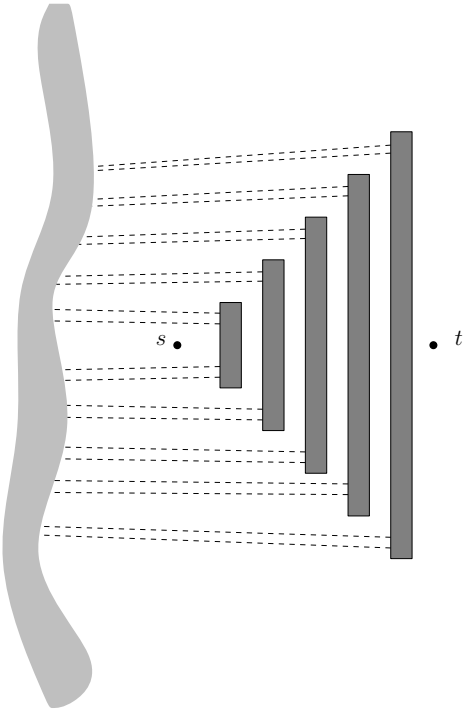


Figure 3: ... Far away on the right side portions of visibility regions hit the rectangles corresponding to edges.

We first notice that this reduction is clearly polynomial-time. The total number of edges of P is $12m + 8$ and the number of points (witnesses and start/target) is n+2, each of which can easily be computed in polynomial time.

To see that every path from s to t that is seen by k witnesses corresponds to a vertex cover of G, observe the following. For every edge e_j the quadrilateral with corners $(j, 0.5-j), (j, j-0.5), H(j), L(j)$ contains s and does not contain t. Thus every path from s to t must cross one of its four sides. One of the sides is the edge of a hole that cannot be crossed. The other three sides are visibility segments of $L(j)$ and $H(j)$, respectively, and thus crossing them means to be seen by $L(j)$ or $H(j)$. Therefore, if π is a path from s to t that is seen by the set of witnesses $W(\pi)$ then the image of $W(\pi)$ under f is a vertex cover of G. As f is a bijection, the set of witnesses has the same cardinality as the resulting vertex cover.
On the other hand, if $C \subset V$ is a vertex cover of G we can construct a path from s to t with at most the same number of witnesses. From s we first go to the point $(1, 0)$. Now we are on the boundary of R_1 that corresponds to edge e_1. By definition, $f(H(1))$ or $f(L(1))$ are in C. If $f(H(1))$ is in C, our path proceeds to $(1, 1)$, crossing the visibility region of $H(1)$ (but no other visibility region), and then to $(1.5, 1)$. Otherwise, the path proceeds to $(1, -1)$ (crossing the visibility region of $L(1)$) and then to $(1.5, -1)$. In both cases, the next waypoint is $(2, 0)$.

We continue in this manner, getting, for every j, from $(j, 0)$ to $(j+1, 0)$ by crossing the visibility region of $H(j)$ if $f(H(j)) \in$

C and crossing the visibility region of $L(j)$ otherwise, until we reach t. The resulting set $W(\pi)$ of witnesses has at most as many elements as C.
It follows, that an α-approximation for the Barrier Resilience yields an α-approximation for vertex cover. Therefore, the factors proven by Dinur and Safra in [5] for MINIMUM VERTEX COVER carry over to our problem. □

Next we show that in the case of one convex hole either one can ignore the hole (Lemma 2) or one can compute two paths, one of which is a minimum witness path (Theorem 3). We omit the simple proof of Lemma 2.

LEMMA 2. *Let P be a polygon with one convex hole H, (i.e. $P = P' \setminus \mathring{H}$ for some simple polygon P' and a convex polygon $H \subset P$). Assume that for every point $h \in H$ and for every pair of line segments $S_1, S_2 \subset P \cup H$ connecting h to $\partial(P \cup H)$, s and t lie in the same connected component of $(P \cup H) \setminus (S_1 \cup S_2)$. Then there is a unique shortest path from s to t in $P \cup H$ and it is a Minimum Witness Path.*

THEOREM 3. *Let $P = P' \setminus \mathring{H}$ a polygon with one convex hole, s, t be start and target point, respectively. Let there be line segments S_1, S_2, each of them connecting a point on an edge (not a vertex) of H to a point on an edge (not a vertex) of the boundary of $P \cup H$, so that s and t lie in different connected components of $P \setminus (S_1 \cup S_2)$. Either the shortest path π_1 from s to t in $P \setminus S_1$ or the shortest path π_2 from s to t in $P \setminus S_2$ is a minimum witness path in P.*

PROOF. Suppose none of them were optimal. Then there exist witnesses w_1, w_2 (possibly $w_1 = w_2$) and a path π', such that w_1, w_2 do not see π', but w_1 sees point p_1 on π_1 and w_2 sees p_2 on π_2. Let T_1 and T_2 denote the line segments from boundary to boundary of $P \cup H$ through w_1 and p_1 and through w_2 and p_2, respectively. The segments S_1 and T_1 together with H as well as S_2, T_2, H separate the points s and t. By the existence of π', T_1, T_2 and H together do not separate s and t. The connected component of s in $P \setminus (T_1 \cup T_2)$ is simply connected and contains t. As π' does not cross T_1, T_2 it crosses both S_1 and S_2. s and t lie in different components of $P \setminus (S_1 \cup S_2)$, so $(S_1 \cup S_2)$ is crossed an odd number of times. Now we can repeatedly replace subpaths between two crossings of the same segment S_i by the direct paths along the segment (this does not add witnesses) until only one crossing is left, contradicting the fact, that π' crosses S_1 and S_2. □

It follows that in this case the barrier resilience can be computed in polynomial time by computing S_1 and S_2 and then the respective shortest paths.
One can show that this also holds if P contains many convex holes that are strictly separated in a sense made precise below.

THEOREM 4. *Let $P = P' \setminus \bigcup_{i=1}^{m} \mathring{H}_i$ a polygon with convex holes, $s, t \in P$, $W = \{w_1, \ldots, w_n\} \subset P$ a set of witness points. Let for every $i \neq j$ there be a line segment $S_{ij} \subset P$ s.t. H_i and H_j lie in distinct connected components of $P' \setminus S_{ij}$ and S_{ij} is not seen by any witness $w \in W$. Then one can find a minimum witness path from s to t in polynomial time.*

We omit the proof due to lack of space.

5. FUTURE WORK

Finding more classes of polygons where the problem is polynomially solvable is one direction of future research. Introducing more sophisticated assumptions on the seperatedness of the sensors is another direction. There are also variations like weighted or mobile sensors waiting to be examined further. It would be interesting to know if the inapproximability result is tight, so probably the most important task is to design an approximation algorithm for the general case of polygons with arbitrarily many holes.

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Strategic deployment in graphs

[Extended Abstract]

Bernd Brüggemann
FKIE, Fraunhofer-Institute
Wachtberg, Germany

Elmar Langetepe
University of Bonn
Department of Computer Science I, Germany

Andreas Lenerz
University of Bonn
Department of Computer Science I, Germany

ABSTRACT

Conquerors of old (like, e.g., Alexander the Great or Ceasar) had to solve the following deployment problem. Sufficiently strong units had to be stationed at locations of strategic importance, and the moving forces had to be strong enough to advance to the next location. To the best of our knowledge we are the first to consider the (off-line) graph version of this problem. While being NP-hard for general graphs, for trees the minimum number of troops and an optimal deployment can be computed in time $\Theta(n \log n)$. Moreover, the optimal solution for the minimum spanning tree of an arbitrary graph G results in a 2-approximation of the optimal solution for G.

Categories and Subject Descriptors

F.2.2 [**ANALYSIS OF ALGORITHMS AND PROBLEM COMPLEXITY**]: Nonnumerical Algorithms and Problems—*Computations on discrete structures*

General Terms

Security, Algorithms, Performance

1. INTRODUCTION

Let $G = (V, E)$ be a graph with non-negative edge end vertex weights w_e and w_v, respectively. We want to minimize the number of agents needed to traverse the graph subject to the following conditions. If vertex v is visited for the first time, w_v agents must be left at v to cover it. An edge e can only be traversed by a force of at least w_e agents. Finally, all vertices should be covered. All agents start in a predefined start vertex $v_s \in V$. In general they can move in different groups.

Despite its obvious importance for strategic troop deployment this problem has, to the best of our knowledge, not received any attention. The problem is not covered by known scheduling, (multi-agent) routing, network-flow or agent-traversal problems. See [3, 10, 8, 4, 5, 1] as an extract of such tasks. The results presented here can also be applied to a problem of positioning mobile robots for guarding a given terrain; see also [2].

In this paper we are proving the following results. The above problem is NP-hard for general graphs G. The optimal strategy for the minimum spanning tree (MST) of G gives a 2-approximation for the minimum number of agents required for G. For trees we can compute the number of agents required in optimal $\Theta(n \log n)$ time.

The problem is denoted as a *strategic deployment problem* of $G = (V, E)$. We deal with two variants regarding a *notification* at the end of the task. The variants are comparable to *routes* (round-trips) and *tours* (open paths) in traveling-salesman scenarios.

(Return) Finally some agents have to return to the start vertex and report the success of the whole operation.

(No-return) It suffices to fill the vertices as required, no agents have to return to the start vertex.

Reporting the success in the return variant means, that finally a set, M, of agents return to v_s and the union of *all* vertices visited by the members of M equals V.

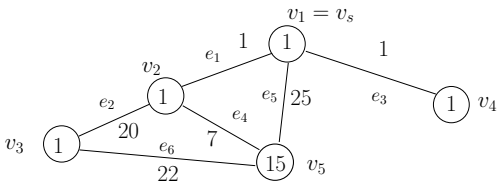


Figure 1: A graph with edge and vertex weights. If the agents have to start at the vertex v_1 an optimal deployment strategy requires 23 agents and visits the vertices and edges in a single group in the order $(v_1, e_1, v_2, e_2, v_3, e_2, v_2, e_1, v_1, e_3, v_4, e_3, v_1, e_1, v_2, e_4, v_5)$. The traversal fulfills the demand on the vertices in the order v_1, v_2, v_3, v_4, v_5 by the first visits w.r.t. the above sequence. At the end 4 agents are not settled.

We give an example for the no-return variant for the graph of Figure 1. It is important that the first visit of a vertex immediately binds some units of the agents for the control

of the vertex. For start vertex $v_s = v_1$ at least 23 agents are required. We let the agents run in a single group. In the beginning one of the agents has to be placed immediately in v_1. Then we traverse edge e_1 of weight 1 with 22 agents from v_1 to v_2. Again, we have to place one agent immediately at v_2. We move from v_2 to v_3 along e_2 of weight 20 with 21 agents. After leaving one agent at v_3 we can still move back along edge e_2 (weight 20) from v_3 to v_2 with 20 agents. The vertex v_2 was already covered before. With 20 agents we now visit v_4 (by traversing e_1 (weight 1) and e_3 (weight 1), the vertex v_1 was already covered and can be passed without loss). We have to place one agent at v_4 and proceed with 19 agents along e_3 (weight 1), e_1 (weight 1) and e_4 (weight 7) to v_5 where we finally have to place 15 agents. 4 agents are not settled.
It can be shown that no other traversal requires less than 23 agents. By the results of Section 3 it turns out that the return variant solution has a different visiting order v_1, v_2, v_3, v_5, v_4 and requires 25 agents.

2. GENERAL GRAPHS

Formally, a deployment strategy on an edge- and vertex-weighted graph $G = (V, E)$ is a schedule for all agents. At any time step an agent decides to move along an outgoing edge of its current vertex towards another vertex *or* the agent decides to stay in its current vertex. We assume that any edge can be traversed in one time step. *Long* connections can be easily modelled by placing intermediate vertices of weigth 0 along the edge. Altogether, groups of agents can arrive at some vertex v at the same time from different edges.

Such a schedule is valid if all agents start in $v_s \in V$ and the schedule fulfills the given conditions. I.e., lower bounds for edge traversals and the requirement of fulfilling the demand at the first visit of a vertex. An *optimal deployment strategy* is a valid schedule that visits all vertices with a minimum number of agents required.

Let $N := \sum_{v \in V} w_v$ denote the number of agents required for the vertices in total. Obviously, the maximum overall edge weight $w_{\max} := \max\{w_e | e \in E\}$ of the graph gives a simple upper bound for the additional agents (beyond N) used for edge traversals. This means that at most $w_{\max} + N$ agents will be required. With $w_{\max} + N$ agents one can for example use a DFS walk along the graph and let the agents run in a single group.

2.1 NP-hardness for general graphs

THEOREM 1. *Computing the optimal number of agents for a strategic deployment problem of a general graph G is NP-hard.*

For the proof of the above result we consider a reduction of the 3-Exact-Cover (3XC) problem which is given as follows. Given a finite ground set X of $3n$ items and a set $\mathbb{F}$ of subsets of X so that any $F \in \mathbb{F}$ contains exactly 3 elements of X. The decision problem of 3XC is defined as follows: Does $\mathbb{F}$ contain an exact cover of X of size n? More precisely is there a subset $F_c \subseteq \mathbb{F}$ so that the collection F_c contains all elements of X and F_c consists of precisely n subsets, i.e. $|F_c| = n$. It was shown by Karp that this problem is NP-hard; see Garey and Johnsson [7].

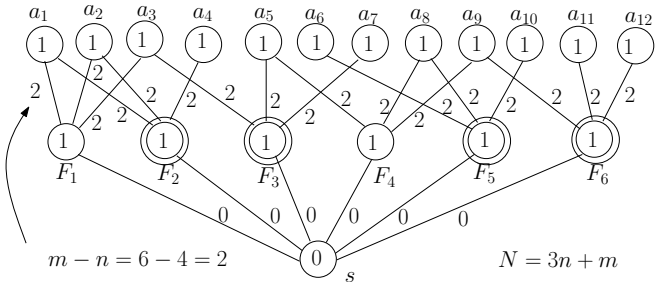


Figure 2: For $X = \{a_1, a_2, \ldots, a_{12}\}$ and the subsets $\mathbb{F} = \{F_1, F_2, \ldots, F_6\}$ with $F_1 = \{a_1, a_2, a_3\}$, $F_2 = \{a_1, a_2, a_4\}$, $F_3 = \{a_3, a_5, a_7\}$, $F_4 = \{a_5, a_8, a_9\}$, $F_5 = \{a_6, a_8, a_{10}\}$ and $F_6 = \{a_9, a_{11}, a_{12}\}$ there is an exact 3-cover with F_2, F_3, F_5 and F_6. To fulfil the task with $3n + m = 18$ agents we first visit the vertices of F_2, F_3, F_5 and F_6 and cover all the elements, ending at a final element vertex a_j. After that $3n + n = 4n = 16$ agents have been placed and $m - n = 2$ still have to be placed. We can move back and cover the remaining 2 agents at F_1 and F_4.

Let us assume that such a problem is given. We define the following strategic deployment problem for $(X, \mathbb{F})$ examplified in Figure 2. Let $X = \{a_1, a_2, \ldots, a_{3n}\}$. For any a_i there is an *element vertex* $v(X)_i$ of weight 1. Let $\mathbb{F}$ consists of $m \geq n$ subsets of size 3, say $\mathbb{F} = \{F_1, F_2, \ldots, F_m\}$. For any $F_j = \{a_{j_1}, a_{j_2}, a_{j_3}\}$ we define a *set vertex* $v(\mathbb{F})_j$ of weight 1 and we insert three edges $(v(\mathbb{F})_j, v(X)_{j_1})$, $(v(\mathbb{F})_j, v(X)_{j_2})$ and $(v(\mathbb{F})_j, v(X)_{j_3})$ each of weight $m - n$. Additionally, we use a sink vertex v_s of weight $w_{v_s} = 0$ and insert m edges $(v_s, v(F)_j)$ from the sink to the set vertices of $\mathbb{F}$. All these edges get weight 0.

The following result holds: *If and only if $(X, \mathbb{F})$ has an exact 3-cover, the given strategic occupation problem can be solved with exactly $N = 3n + m$ agents.*

This is easy to see by the following arguments. If a set cover exists we can always fulfil the task with $N = 3n + m$ agents; Figure 2 shows an example. If there is no set cover, we consider the moment when an arbirary strategy visity the last element vertex. This means that at least 3n agents has been settled at the element vertices. Since there is no set cover, we have visited more than n set vertices before and more than $3n + n = 4n$ agents in total, say $4n + k$, have already been fixed. We can assume that we still have to visit some remaining set vertices. So we have to cross the edge of size $m - n$ now. Here $N - (4n + k) = (3n + m) - (4n + k) = m - n - k$ is not sufficient, altogether we require more than $N = 3n + m$ agents to accomplish the task in this case.

Altogether, we can answer the 3-Exact-Cover decision problem by a polynomial reduction into a strategic occupation problem. The result is independent from the variant (return or no-return).

2.2 2-approximation by the MST

For a general graph $G = (V, E)$ we consider its minimum spanning tree (MST) and consider an optimal deployment

strategy on the MST.

LEMMA 1. *An optimal deployment strategy for the minimum spanning tree (MST) of a weighted graph $G = (V, E)$ gives a 2-approximation of the optimal deployment strategy of G itself.*

PROOF. Let e be an edge of the MST of G with maximal weight w_e among all edges of the MST. It is simply the nature of the MST, that any traversal of the graph that visits all vertices, has to use an edge of weight at least w_e. The optimal deployment strategy has to traverse an egde of weight at least w_e and requires at least $k_{\text{opt}} \geq \max\{N, w_e\}$ agents. The optimal strategy for the MST approach requires at most $k_{\text{MST}} \leq w_e + N$ agents which gives $k_{\text{MST}} \leq 2k_{\text{opt}}$. □

2.3 Moving in a single group

In our model it is allowed that the agents run in different groups. For the computation of the optimal number of agents required, this is not necessary. Note that *group-splitting* strategies are necessary for minimizing the *completion time*. Recently, we also started to discuss such optimization criteria; see the masterthesis [9] supervised by the second author.

THEOREM 2. *For a given weighted graph G and the given minimal number of agents required, there is always a deployment strategy that lets the agents move in a single group.*

PROOF. (Sketch) We can reorganize any optimal strategy accordingly, so that the same number of agents is sufficient. Due to lack of space we give a sketch for trees. The general proof for graphs is a technical case analysis.

Let us assume that at a vertex v a set of agents X is separated into two groups X_1 and X_2 and they separately explore disjoint parts T_1 and T_2 of the tree. Let w_{T_i} be the maximum edge weight of the edges traversed by the agents X_i in T_i, respectively. Clearly $|X_i| \geq w_{T_i}$ holds. Let $|X_1| \geq |X_2|$ hold and let X_2' be the set of non-settled agents of X_2 after the exploration of T_2. We can explore T_2 by $X = X_1 \cup X_2$ agents first, and we do not need the set X_2 there. $|X_1| \geq w_{T_2}$ means that we can move back with $X_1 \cup X_2'$ agents to v and start the exploration at T_1. □

3. OPTIMAL SOLUTIONS FOR TREES

Lemma 1 suggests that for a 2-approximation for a graph G, we can consider its MST. Thus, it makes sense to solve the problem efficiently for trees. Additionally, by Theorem 2 it suffices to consider strategies of single groups.

Let us first consider the tree in Figure 3 and the return variant. Obviously it is possible to use $n + 1$ agents and visit the edges in the decreasing order of the edge weights $n, n-1, \ldots, 1$. Any other order will increase the number of agents. If for example in the first step an edge of weight $k \neq n$ is visited, we have to leave one agent at the corresponding vertex. Since the edge of weight n still has to be visited and we have to return to the start, $n + 1$ agents in total will not be sufficient. So first the edge of weight n has to be visited. This argument can be applied successively.

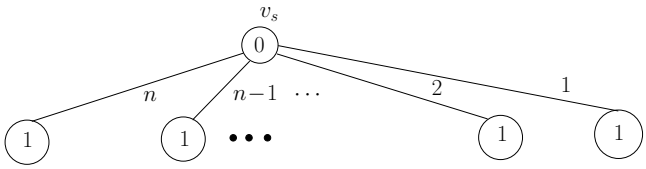


Figure 3: An optimal strategy that starts and ends in v_s has to visit the leafs with respect to the decreasing order of the edge weights. The minimal number of agents is $n+1$. Any other order will lead to at least one extra agent.

Altogether, by the above example there seems to be a computational lower bound for trees with respect to sorting the edges by their weights. Since integer values can be sorted by bucket sort in linear time, such a lower bound can only be given for real edge and vertex weights. This seems to be a natural extension of our problem. We consider the transportation of sufficient material along an edge (condition 1.). Additionally, the demand of a vertex has to be fully satisfied before transportation can go on (condition 2.). How many material is required?

For a computational lower bound for trees we consider the Uniform-Gap problem. Let us assume that n unsorted real numbers $x_1, x_2, \ldots, x_n$ and an $\epsilon > 0$ are given. Is there a permutation $\pi : \{1, \ldots, n\} \to \{1, \ldots, n\}$ so that $x_{\pi(i-1)} = x_{\pi(i)} + \epsilon$ for $i = 2, \ldots, n$ holds? In the algebraic decision tree model this problem has computational time bound $\Omega(n \log n)$; see for example [11].

In Figure 3 we simply replace the vertex weights of 1 by ϵ and the n edge weights by $x_1, x_2, \ldots, x_n$. With the same arguments as before we conclude: If and only if the Uniform-Gap property holds, a unique optimal strategy has to visit the edges in a single group in the order of decreasing edge weights $x_{\pi(1)} > x_{\pi(2)} > \cdots > x_{\pi(n)}$ and requires an amount of $x_{\pi(1)} + \epsilon$ in total. Any other order will lead to at least one extra ϵ.

LEMMA 2. *Computing an optimal deployment strategy for a tree of size n with positive real edge and vertex weights takes $\Omega(n \log n)$ computational time in the algebraic decision tree model.*

3.1 Efficient computation of optimal strategies

The preceding lower bound suggests to visit the edges of the tree in the order of decreasing weights. We introduce the following notations for a tree T with root vertex v_s. For every leaf b_l along the unique shortest path, $\Pi_{v_s}^{b_l}$, from the root v_s to b_l there is an edge $e(b_l)$ with weight $w_{e(b_l)}$, so that $w_{e(b_l)}$ is greater than or equal to any other edge weight along $\Pi_{v_s}^{b_l}$. Furthermore, we choose $e(b_l)$ so that it has the shortest edge-distance to the root among all edges with the same weight. Let $v(b_l)$ denote the vertex of $e(b_l)$ that is closer to the leaf b_l. Thus, every leaf b_l defines a unique path, T_{b_l}, from $v(b_l)$ to the leaf b_l with incoming edge $e(b_l)$ with edge weight $w_{e(b_l)}$. The edge $e(b_l)$ *dominates* the leaf b_l and also the path $T(b_l)$.

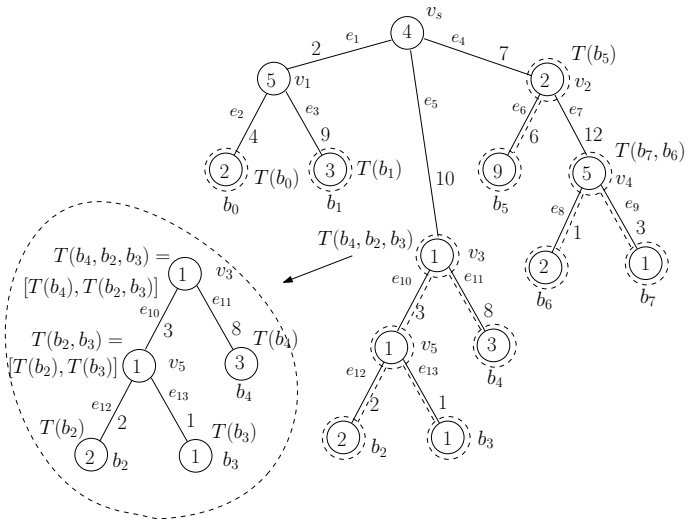


Figure 4: An optimal strategy with start and end vertex v_s visits, fully explores and leaves the collected subtrees $T(b_7, b_6)$, $T(b_4, b_2, b_3)$, $T(b_1)$, $T(b_5)$ and $T(b_0)$ in the order of the weights $w_{e_7} = 12$, $w_{e_5} = 10$, $w_{e_3} = 9$, $w_{e_4} = 7$ and $w_{e_2} = 4$ of the dominating edges. For the no-return variant the required information are computed recursively; see the example for $T(b_4, b_2, b_3)$.

For example in Figure 4 we have $e(b_2) = e_5$ and $v(b_2) = v_3$, the path $T(b_2)$ from v_3 over v_5 to b_2 is dominated by the edge e_5 of weight 10.

If some paths $T_{b_{l_1}}, T_{b_{l_2}}, \ldots, T_{b_{l_m}}$ are dominated by the same edge e, we collect all those paths in a *collected subtree* denoted by $T(b_{l_1}, b_{l_2}, \ldots, b_{l_m})$. The tree has unique root $v(b_{l_1})$ and is dominated by unique edge $e(b_{l_1})$.
For example, in Figure 4 for b_6 and b_7 we have $v(b_6) = v(b_7) = v_4$ and $e(b_6) = e(b_7) = e_7$ and $T(b_7, b_6)$ is given by the tree T_{v_4} that is dominated by edge e_7.

Altogether, for any tree T there is a unique set of disjoint collected subtrees (a path is a subtree as well) as uniquely defined above and we can sort them by the weight of its dominating edge. The trees and their overall vertex weights can be computed efficiently in linear time, for example by DFS. For the tree in Figure 4 we have disjoint subtrees $T(b_7, b_6)$, $T(b_4, b_2, b_3)$, $T(b_1)$, $T(b_5)$ and $T(b_0)$ in this order.

We can show that in the return variant we can visit and leave the subtrees in the decreasing order of the dominating edge weights, the movement inside the trees can be arbitrary. By some additional calculations (for example the sum of the vertex weights of a subtrees) we can also compute the number of agents required efficiently. In the no-return variant only the subtree visited last could differ from the dominating edge order. In this case we can compute the corresponding subtree information recursively and can check all alternatives for the final leaf in parallel; see also Figure 4. Internally we make use of Fibonacci heaps [6] in this case. We can prove the following result for trees, due to lack of space we omit the rather technical proofs here.

THEOREM 3. *An optimal deployment strategy of a tree T in the return variant can visit the disjoint collected subtrees in the decreasing order of the dominating edge weights.*

A corresponding strategy successively visits the root $v(b_{l_1})$ of a tree $T(b_{l_1}, b_{l_2}, \ldots, b_{l_m})$ on a shortest path, fully explore this tree in some order (for example by DFS), leaves the tree over $e(b_{l_1})$ and moves to the next root vertex. Finally, the agents return to the start vertex v_s. A corresponding optimal visiting order of the leafs and the optimal number of agents required can be computed in $O(n \log n)$ time.

In the no-return variant all information required can be computed recursively from bottom to top. An optimal visiting order and the optimal number of agents required can be computed in amortized $O(n \log n)$ time.

4. CONCLUSION

We introduce a strategic deployment problem in weighted graphs that models security or occupation constraints and gives rise to many further extensions and modifications. The problem discussed here is NP-hard in general and can be solved efficiently for trees in $\Theta(n \log n)$. This also gives a 2-approximation for a general graph by the MST.

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The Random Hypergraph Assignment Problem

Olga Heismann
Takustr. 7
14195 Berlin
Germany
heismann@zib.de

Ralf Borndörfer
Takustr. 7
14195 Berlin
Germany
borndoerfer@zib.de

ABSTRACT

The analysis of random instances of a combinatorial optimization problem, especially their optimal values, can provide a better insight into its structure. Such an extensive analysis was theoretically and practically done for the assignment problem ("random assignment problem") and several of its generalizations. For a recent generalization of the assignment problem to bipartite hypergraphs, the hypergraph assignment problem, such results do not exist so far. We consider a random version of the hypergraph assignment problem for the simplest possible complete bipartite hypergraphs. They have only edges and proper hyperedges of size four and follow a special structure, but the hypergraph assignment problem for this type of hypergraphs is, however, already NP-hard. It can be viewed as a combination of two assignment problems. For random hyperedge costs exponentially i. i. d. with mean 1 we show computational results that suggest that the expected value of minimum cost hyperassignments converges to some value around 1.05 with a small standard deviation. The computational results also suggest that the optimal value is most probably attained with half of the maximum possible number of proper hyperedges. The main result of this paper is the proof that the expected value of a minimum cost hyperassignment which uses exactly half the possible maximum number of proper hyperedges if the vertex number tends to infinity lies between 0.3718 and 1.8310 when hyperedge costs are exponentially i. i. d. with mean 1.

Categories and Subject Descriptors

G.2.2 [**Graph Theory**]: Hypegraphs

General Terms

Theory

Keywords

Hypergraph, Assignment

1. INTRODUCTION

A way to gain a better understanding of the structure of a combinatorial optimization problem is to analyze random instances, especially their optimal values. For one of the basic problems in combinatorial optimization, the assignment problem, such results were proposed by computational experiments and then proved theoretically. For a survey of the so-called "random assignment problem" and several of its generalizations, see [3].

In particular, it can be proved that the expected optimal value of the assignment problem for random instances with complete bipartite graphs and costs for each edge uniformly i. i. d. in $[0, 1]$ or exponentially i. i. d. with mean 1 converges to $\frac{\pi^2}{6} = 1.6449\ldots$ if the number of vertices in the bipartite graph tends to infinity. This is known as the Conjectures of Mézard and Parisi [5].

In this paper, we consider a random version of a recent generalization of the assignment problem to bipartite hypergraphs, the hypergraph assignment problem (HAP), where to the best of our knowledge such results do not exist so far. Although we will deal only with the HAP for a special well-structured type bipartite hypergraphs, the HAP for these cases is already NP-hard [1] and therefore interesting to analyze. For this hypergraph type, the hyperedge set consists only of edges and proper hyperedges of size 4, and the hypergraph underlies a structure that makes it easy to view it as a combination of two assignment problems, one consisting only of edges, one other of proper hyperedges viewed as edges. However, the coupling of the two assignment problems is such that it involves a choice over an exponential number of possibilities. We will explain this in more detail in Section 2 after introducing the problem.

For random hyperedge costs exponentially i. i. d. with mean 1 we first show computational results in Section 3 that suggest that the minimum cost of hyperassignments—the corresponding structure to an assignment—converges to some value around 1.05 with a small standard deviation. Our results also suggest that the optimal value most probably is attained with half of the maximum possible number of proper hyperedges. This proposes that the random instances are hard in the sense that even if we assume that the optimal solution contains exactly this number of proper hyperedges, then a choice over an exponential number of possibilities has to be performed before solving the two assignment problems to find an optimal solution.

Then, in Section 4, we prove a lower bound 0.3718 and an upper bound 1.8310 for the expected value of a minimum cost hyperassignment which uses exactly half the possible maximum number of proper hyperedges for vertex number tending to infinity. This will be done using a combinatorial argument for the meaning of the afterwards computed bounds and employing results for the random assignment problem in the computation.

2. THE HYPERGRAPH ASSIGNMENT PROBLEM AND ITS RELATION TO ASSIGNMENTS

For simplicity, we define only bipartite hypergraphs of those type which we will consider in what follows. The HAP can be formulated in the same way for more general bipartite hypergraphs, with less structure and possibly hyperedges which contain more than four vertices, see [1].

Definition 1. Let $G_n = (U, V, E)$ be the *bipartite hypergraph* with *vertex sets*

$$U = \bigcup_{i=1}^{n} U_i, \qquad V = \bigcup_{i=1}^{n} V_i$$

with

$$U_i = \{u_i, u_i'\}, \qquad V_i = \{v_i, v_i'\}$$

and *hyperedge set* $E = E_1 \cup E_2$ where

$$E_1 = \{\{u, v\} : u \in U, v \in V\}$$

are the *edges* and

$$E_2 = \{U_i \cup V_j : i, j \in \{1, \ldots, n\}\}$$

are the *proper hyperedges* of size 4.

For a vertex subset $W \subseteq U \cup V$ we define the *incident hyperedges* $\delta(W) := \{e \in E : e \cap W \neq \emptyset, e \setminus W \neq \emptyset\}$ to be the set of all hyperedges having at least one vertex in both W and $(U \cup V) \setminus W$.

A *hyperassignment* in G_n is a subset $H \subseteq E$ of pairwise disjoint hyperedges that cover U and V, i. e., for all $e_1, e_2 \in H$, $e_1 \cap e_2 = \emptyset$, and $\bigcup H = U \cup V$.

Given a cost function $c : E \to \mathbb{R}$, the cost of a hyperassignment is $\sum_{e \in H} c(e)$.

The hypergraph assignment problem with input (G_n, c) consists of finding a hyperassignment in G with minimum cost w. r. t. c.

For this type of bipartite hypergraphs, the hypergraph assignment problem can be seen as a combination of two assignment problems as follows. Observe that for every hyperassignment H and each $i \in \{1, \ldots, n\}$, $\delta(U_i) \cap H$ and $\delta(V_i) \cap H$ consist either of one proper hyperedge or of two edges. If we fix for every set U_i and V_i whether it has to be incident to one proper hyperedge or two edges in the hyperassignment, we can restrict the hyperedge set of G_n to

- the set of edges connecting pairs of vertices from the U_i, V_i that will be incident to edges—this is the first assignment problem, and
- the proper hyperedges $\{U_i \cup V_j\}$ for U_i and V_j that are fixed as incident to proper hyperedges—viewing U_i and V_j as single vertices and the hyperedges as edges connecting them this is the second assignment problem.

The solution the two assignment problems separately with costs as in the hypergraph assignment problem implies the minimum cost hyperassignment in which the incidence to one proper hyperedge or two edges for each set U_i and V_i is as it was fixed to be.

Thus, the HAP in G_n can be viewed as a decision for sets U_i and V_i that have to be incident to proper hyperedges (same number of sets from U and V, equal to the number of proper hyperedges in a feasible hyperassignment; the other sets U_i and V_i will be incident to edges) and then solving the two assignment problems stated above.

3. COMPUTATIONAL RESULTS

In this section, we shortly present computational results (see Table 1) for the random hypergraph assignment problem in the bipartite graphs G_n, as defined above and cost functions where all $c(e)$ are randomly chosen from independent exponential distributions with mean 1. For every n, we give the mean value and standard deviation for 1000 computations (performed by CPLEX 12.5 with the canonical IP formulation, see [1]).

The computational results propose that the expected optimal value converges to a value around 1.05. Since the standard deviation is relatively small, it suggests that the optimal value for such random HAP instances can be predicted with a high reliability.

Furthermore, in our computational results the optimal value is attained where about half of the maximum possible number of proper hyperedges is used. This proposes that such random HAPs are hard to solve even if one could assume that the optimal hyperassignment is such that about half of the sets U_i and V_i, respectively, are incident to proper hyperedges: The number of such choices for G_{2n} is $\binom{2n}{n}^2$, which is exponential in n. In the next section, we will compute bounds between which the expected optimal value of the minimum cost hyperassignment with such a restriction on the number of proper hyperedges in it lies.

4. BOUNDS

To compute a lower and upper bound on the expected value of a minimum cost hyperassignment in G_{2n} with n proper hyperedges, we will use the following result: For a complete bipartite graph with vertex sets of size m and n and with edge costs exponentially i. i. d. with mean 1 the expected minimum value of the sum of k pairwise disjoint edges (this is called a partial assignment) is

$$E(m, n, k) := \sum_{\substack{i,j \geq 0 \\ i+j \leq k-1}} \frac{1}{(n-i)(m-j)}.$$

Table 1: Results for random hypergraph assignment problems in G_n. The optimal values (column 2) and their standard deviations (column 3) are rounded to the third decimal place. The number of proper hyperedges in the found optimal hyperassignment (column 4) and their standard deviations (column 5) are rounded to one decimal place.

n	optimal value	std. dev.	# prop. hyp.	std. dev.
10	1.019	0.206	5.3	2.0
20	1.039	0.141	10.4	2.8
30	1.049	0.117	15.3	3.4
40	1.045	0.097	20.5	3.9
50	1.054	0.085	25.4	4.3
60	1.050	0.080	30.6	4.7
70	1.053	0.079	35.6	5.1
80	1.054	0.069	40.6	5.4
90	1.053	0.066	45.9	5.8
100	1.057	0.063	50.6	6.3
110	1.054	0.060	56.1	6.4
120	1.052	0.056	61.1	6.7
130	1.054	0.053	66.3	6.9
140	1.053	0.051	71.3	7.1
150	1.051	0.050	76.2	7.5
160	1.054	0.048	81.2	7.6

This was conjectured in [2] and the first proof appeared in [4]. There is also shown that for $m = n = k$ this term can be written as

$$E(n,n,n) = \sum_{i=1}^{n} \frac{1}{i^2}.$$

This expected value of the minimum assignment in a complete bipartite graph with two vertex sets of size n with costs exponentially i. i. d. with mean 1 edge costs is known as Parisi's Conjecture.

THEOREM 1. *For the expected value* $\mathbf{E}$ *of the minimum cost of a hyperassignment in* $G_{2n} = (U, V, E)$ *with* n *proper hyperedges and cost function* c *with* $c(e)$ *exponentially i. i. d. with mean 1 for all* $e \in E$*, for* $n \to \infty$ *the following holds:*

$$0.3718 < \mathbf{E} < 1.8310.$$

PROOF. By definition,

$$E(n) := E(2n, 2n, n) = \sum_{\substack{i,j\geq 0 \\ i+j\leq n-1}} \frac{1}{(2n-i)(2n-j)}.$$

Using $E(n)$, we can bound the expected value of a hyperassignment in G_{2n} with hyperedge costs exponentially i. i. d. mean 1 where half of the maximum possible number of proper hyperedges is used as follows.

For the lower bound, observe that in the best possible hyperassignment the selected n proper hyperedges can be only as good as the n pairwise disjoint proper hyperedges with the least possible cost sum in G_{2n}. Also, the selected $2n$ edges can be only as good as the $2n$ pairwise disjoint edges with the least possible cost sum in G_{2n}. Thus, $E(n)+E(2n)$ is a lower bound.

On the other hand, choosing the n pairwise disjoint proper hyperedges with the least possible cost sum in G_{2n} and finding the best possible edges for the remaining "unused" vertices leads to an upper bound of $E(n) + E(2n, 2n, 2n)$.

To transform the two-indexed sum describing $E(n)$ to a sum with only one index, we calculate the difference $D(n) := E(n+1) - E(n)$ and use the recursive formula

$$E(n) = E(1) + \sum_{i=1}^{n-1} D(i) = 0.25 + \sum_{i=1}^{n-1} D(i). \qquad (1)$$

$$\begin{aligned} D(n) &= E(n+1) - E(n) \\ &= E(2n+2, 2n+2, n+1) - E(2n, 2n, n) \\ &= \sum_{\substack{i,j\geq 0 \\ i+j\leq n}} \frac{1}{(2n+2-i)(2n+2-j)} \\ &\quad - \sum_{\substack{i,j\geq 0 \\ i+j\leq n-1}} \frac{1}{(2n-i)(2n-j)}. \end{aligned}$$

Shifting the index of the first sum to get the same summand type in both sums yields

$$= \sum_{\substack{i,j\geq -2 \\ i+j\leq n-4}} \frac{1}{(2n-i)(2n-j)} - \sum_{\substack{i,j\geq 0 \\ i+j\leq n-1}} \frac{1}{(2n-i)(2n-j)}.$$

We now split the sums to sums with index range $i, j \geq 0$, $i + j \leq n - 4$ so that they can cancel. The remainder is as follows. For the first sum, it is used that it is symmetric in i and j. The term $\frac{(4n+3)^2}{4(n+1)^2(2n+1)^2}$ is the sum of the values where $-2 \leq i, j \leq -1$. This has to be subtracted from the first term as otherwise these values would be counted twice.

$$\begin{aligned} &= 2 \cdot \sum_{\substack{-2\leq i\leq -1, j\geq -2 \\ i+j\leq n-4}} \frac{1}{(2n-i)(2n-j)} \\ &\quad - \frac{(4n+3)^2}{4(n+1)^2(2n+1)^2} - \sum_{\substack{i,j\geq 0 \\ i+j=n-1}} \frac{1}{(2n-i)(2n-j)} \\ &\quad - \sum_{\substack{i,j\geq 0 \\ i+j=n-2}} \frac{1}{(2n-i)(2n-j)} - \sum_{\substack{i,j\geq 0 \\ i+j=n-3}} \frac{1}{(2n-i)(2n-j)}. \end{aligned}$$

Splitting the first sum into two parts with $i + j = n - 3$ and $i + j = n - 2$ (the bounds on i imply that other values for $i + j$ are impossible) and substituting j by $a - i$ where $i + j = a$ yields

$$\begin{aligned} &= \sum_{j=-2}^{n-3} \frac{2}{(2n+1)(2n-j)} + \sum_{j=-2}^{n-2} \frac{2}{(2n+2)(2n-j)} \\ &\quad - \frac{(4n+3)^2}{4(n+1)^2(2n+1)^2} - \sum_{i=0}^{n-1} \frac{1}{(2n-i)(n+1+i)} \\ &\quad - \sum_{i=0}^{n-2} \frac{1}{(2n-i)(n+2+i)} - \sum_{i=0}^{n-3} \frac{1}{(2n-i)(n+3+i)}. \end{aligned}$$

Using the notation $H_n = \sum_{i=1}^{n} \frac{1}{n}$ for the n-th harmonic number and partial fraction decomposition to get denominators linear in n for the last two summations, we get

$$\begin{aligned}
&= \frac{2H_{2n+2} - 2H_{n+2}}{2n+1} + \frac{2H_{2n+2} - 2H_{n+1}}{2n+2} \\
&\quad - \frac{(4n+3)^2}{4(n+1)^2(2n+1)^2} - \frac{2H_{2n} - 2H_n}{3n+1} \\
&\quad - \frac{2H_{2n} - 2H_{n+1}}{3n+2} - \frac{2H_{2n} - 2H_{n+2}}{3n+3} \\
&= \frac{2H_{2n} + \frac{2}{2n+1} + \frac{2}{2n+2} - 2H_n - \frac{2}{n+1} - \frac{2}{n+2}}{2n+1} \\
&\quad + \frac{2H_{2n} + \frac{2}{2n+1} + \frac{2}{2n+2} - 2H_n - \frac{2}{n+1}}{2n+2} \\
&\quad - \frac{(4n+3)^2}{4(n+1)^2(2n+1)^2} - \frac{2H_{2n} - 2H_n}{3n+1} \\
&\quad - \frac{2H_{2n} - 2H_n - \frac{2}{n+1}}{3n+2} - \frac{2H_{2n} - 2H_n - \frac{2}{n+1} - \frac{2}{n+2}}{3n+3}.
\end{aligned}$$

Finally, simplification yields

$$\begin{aligned}
&= -(H_{2n} - H_n)\frac{9n^2 + 11n + 4}{3(n+1)(2n+1)(3n+1)(3n+2)} \\
&\quad + \frac{8n^2 + 13n + 6}{12(n+1)^2(2n+1)^2(3n+2)}.
\end{aligned}$$

To get bounds on $E(n)$ using Equation (1), we first use that

$$\begin{aligned}
\sum_{n=1}^{\infty} \frac{8n^2 + 13n + 6}{12(n+1)^2(2n+1)^2(3n+2)} \\
= -0.25 - \frac{\pi}{\sqrt{3}} + \frac{\pi^2}{9} - \frac{10\ln(2)}{3} + \ln(27). \quad (2)
\end{aligned}$$

Then, observe that $H_{2n} - H_n$ is a non-negative number monotonically increasing with n. Also, this is an alternating harmonic number that for $n \to \infty$ converges to $\ln(2)$. For $n = 80$, $H_{2n} - H_n$ is equal to

$$\frac{8119740843426279518461644384261262504562959619404143919063830759076911767195548790187483789081564136268194698830300314122089797071956800 0},$$

which is > 0.69. Therefore, for $n \geq 80$,

$$0.69 < H_{2n} - H_n < \ln(2) \quad (3)$$

Now, computing the partial sum

$$\sum_{n=1}^{79} -(H_{2n} - H_n)\frac{9n^2 + 11n + 4}{3(n+1)(2n+1)(3n+1)(3n+2)}$$

exactly and the limes

$$\sum_{n=80}^{\infty} -(H_{2n} - H_n)\frac{9n^2 + 11n + 4}{3(n+1)(2n+1)(3n+1)(3n+2)}$$

after substituting for $H_{2n} - H_n$ the lower and upper bounds given by (3), Equations (1) and (2) yield

$$0.1859 < \lim_{n\to\infty} E(n) < 0.1860.$$

Thus, we get for the lower bound

$$\begin{aligned}
\lim_{n\to\infty} (E(n) + E(2n)) &= 2 \cdot \lim_{n\to\infty} E(n) \\
&> 2 \cdot 0.1859 \\
&= 0.3718
\end{aligned}$$

and for the upper bound

$$\begin{aligned}
\lim_{n\to\infty} (E(n) + E(2n, 2n, 2n)) &= \lim_{n\to\infty} E(n) + \lim_{n\to\infty} E(2n, 2n, 2n) \\
&< 0.1860 + \frac{\pi^2}{6} \\
&< 1.8310
\end{aligned}$$

□

5. CONCLUSION

In this paper, we have presented computational results for the random hypergraph assignment problem and proven that the expected value of a minimum cost hyperassignment which uses exactly half the possible maximum number of proper hyperedges if the vertex number tends to infinity lies between 0.3718 and 1.8310 when hyperedge costs are exponentially i. i. d. with mean 1. The method presented in this paper can maybe be be extended to provide better bounds and consider also arbitrary or other fixed numbers of proper hyperedges in the hyperassignment.

6. ACKNOWLEDGMENTS

This work was supported by the DFG Research Center MATHEON "Mathematics for key technologies".

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The Roman Domination Problem on Grid Graphs

[Extended Abstract]

Vincenzo Curro'
Department of Mathematics and Computer Science
University of Catania, Italy
curro@dmi.unict.it

Vincenzo Cutello
Department of Mathematics and Computer Science
University of Catania, Italy
cutello@dmi.unict.it

Salvatore Mario Nolassi
Department of Mathematics and Computer Science
University of Catania, Italy
nolassi@dmi.unict.it

ABSTRACT

The *Roman Domination Problem* is a combinatorial optimization problem defined over undirected graphs, whose decisional version has been proven to be $\mathcal{NP}$-complete.

Given an undirected graph $G = (V, E)$, a *Roman Dominating Function* is a function $f\colon V \to \{0, 1, 2\}$, satisfying the condition that every vertex $u\colon f(u) = 0$ is adjacent to at least one vertex $v\colon f(v) = 2$. The weight of a Roman Dominating Function is the sum of all the label $f(u)\colon u \in E$, and the minimum weight is called the *Roman Domination Number*. The Roman Domination Problem is to find such number.

In this paper we study the problem when restricted to the class of grid graphs. We derive an improved lower-bound and define and then discuss a general schema to produce good coverings for the Roman Domination Problem over grid graphs and finally present an upper-bound on the Roman Domination Number, derived from such schema, which improves the previous upper-bound and, we conjecture, is the RDN for many of the grid graphs.

Categories and Subject Descriptors

G.2.2 [**Discrete Mathematics**]: Graph Theory—*Graph Coloring, Graph Algorithms*

General Terms

Graph Theory

Keywords

Roman Domination Problem, Roman Domination Number, Grid Graphs

1. INTRODUCTION

The *Roman Domination Problem* (RDP) is a combinatorial problem, introduced fairly recently by Stewart in [19]. The RDP is a variation of the *Domination Problem* (DP), that has been well studied, see [11] and [12]. In this article, when we refer to a graph, we implicitly mean an undirected graph.

In [5] the authors studied the Roman Domination Problem as a variation of the Domination Problem on graphs, and formalized for the first time the RDP as we know it.

Because both DP, as showed in [11], and RDP, as showed in [7], are $\mathcal{NP}$-complete,it is interesting to study the properties of γ, γ_R for specific classes of graphs. (See [1], [4], [10], [5], [9], [13], [18], [16]).

Like many domination problems on graphs, RDP has several applications, either in military strategy, see [2], or for server placements over networks, see [15].

Formally, given a graph $G = (V, E)$, a *Roman Dominating Function* (RDF) is a labeling function $f\colon V \to \{0, 1, 2\}$, satisfying the following:

$$\forall\, u \in V : f(u) = 0 \quad \Rightarrow \quad \exists\, v \in V : (u, v) \in E \ \wedge\ f(v) = 2\,.$$

The function f induces a partition of V: (V_0, V_1, V_2), where $V_i = \{v \in V : f(v) = i\}$. If we define $n_i = |V_i|$ then we will have $n_0 + n_1 + n_2 = n = |V|$.

For each graph G, we define the *Roman Domination Number*, $\gamma_R(G)$, as the minimum value of a RDF: $\gamma_R(G) = \min_{f \in F}\ f(V) = \min_{f \in F}\ \sum_{u \in V} f(u)$ where F is the set of all RDF for G.

2. GRID GRAPHS

A special class of undirected graphs is given by grid graphs. We will denote a grid graph with m rows and n columns by $G_{m,n}$.

A grid graph is the graph whose vertices correspond to the points in the plane with integer coordinates (i, j), with $0 \le i \le n-1$ and $0 \le j \le m-1$, and two vertices are connected by an edge whenever the corresponding points are at distance 1.[1]

Each vertex of the grid graph is connected to (at most) 4 vertices, namely, the vertices of coordinates $(i, j-1)$, $(i, j+1)$, $(i-1, j)$, $(i+1, j)$. Obviously vertices on the grid graph corners are connected to only 2 other vertices, whereas vertices

[1]In alternative, we can define a grid graph as a *Cartesian product* of two path graphs with $n-1$ and $m-1$ edges.

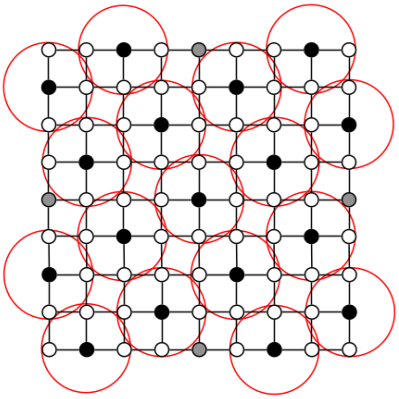


Figure 1: Covering by S_2 of $G_{9,9}$. The circles define the influence of the vertices labeled by 2.

on the borders (but not on the corners) are connected to 3 vertices.

For sake of clarity, we specify that the coordinates of the top-left corner of the grid are $(0,0)$ and the coordinates of the bottom-right corner of the grid graph $G_{m,n}$ are $(m-1,n-1)$.

In [5] was given a characterization of the RDP for grid graphs $G_{2,n}$, leading to: $\gamma_R(G_{2,n}) = n+1$.

They also left an open problem, i.e. to give a characterization of the RDP for grid graphs $G_{m,n}$, for $m,n \geq 3$.

This problem was addressed by Dreyer in [7], Cockayne *et al.* in [6] and, quite recently, Pavlic and Zerovnik in [16]. In particular, in [7] the author proposes a covering method for grid graphs of type $G_{3,n}$, which leads to:

$$\gamma_R(G_{3,n}) = \begin{cases} 6k+1 & n = 4\cdot k \\ 6k+2 & n = 4\cdot k+1 \\ 6k+4 & n = 4\cdot k+2 \\ 6k+6 & n = 4\cdot k+3 \end{cases} \quad (1)$$

and a covering method for grid graphs of type $G_{4,n}$, which leads to:

$$\gamma_R(G_{4,n}) = \begin{cases} 2n+1 & n = 1,2,3,5,6 \\ 2n & \text{otherwise} \end{cases} . \quad (2)$$

In [16] the authors showed covering methods for grid graphs of type $G_{k,n}$ with $5 \leq k \leq 8$ and $n \geq 5$.

In [6], for grid graphs of type $G_{m,n}$, with $m,n \geq 5$, they proved the following *upper-bound*:

$$\gamma_R(G_{m,n}) \leq 2 \cdot \left(\left\lceil \frac{m\cdot n}{5} \right\rceil + \left\lceil \frac{m}{5} \right\rceil + \left\lceil \frac{n}{5} \right\rceil \right) .$$

Also in [6], it was proved that for any graph $G \neq \overline{K_n}$ with $|V| = n$, the following lower-bound holds:

$$\gamma_R(G) \geq \left\lceil \frac{2\cdot n}{\Delta(G)+1} \right\rceil .$$

If we compute this lower bound for a grid graph $G_{m,n}$, with $m,n \geq 3$ we will have $|V| = m\cdot n$ and $\Delta(G_{m,n}) = 4$, i.e.:

$$\gamma_R(G_{m,n}) \geq \left\lceil \frac{2\cdot(m\cdot n)}{4+1} \right\rceil = \left\lceil \frac{2\cdot(m\cdot n)}{5} \right\rceil .$$

$i \mod 5$	$j \mod 5$
0	2
1	0
2	3
3	1
4	4

Table 2: Rules for placing labels 2 on the grid graph

3. IMPROVING THE UPPER-BOUND FOR GRID GRAPHS

We introduce now our covering schema S_2.The schema work as follows:

1. choose the vertices of the grid graph where to place the label 2, see Table 2;
2. place the label 0 on all the vertices connected to at least a vertex labeled by 2;
3. place the label 1 on the remaining vertices.

For example, if we consider the grid graph $G_{9,9}$ we would have the covering shown in Figure 1.

Such covering guarantees that none of the internal vertices of the grid will be labeled by 1, in fact by construction, the following theorem clearly holds.

THEOREM 1. *Let $G_{m,n}$ be a grid graph. If a RDF of $G_{m,n}$ is obtained by using the schema S_2, then every internal vertex is either labeled by 2 or it is connected to one and only one vertex labeled by 2 and thus labeled by 0.*

Given any grid graph $G_{m,n}$ and its transpose $G_{n,m}$, they are the same graph, so it follows $\gamma_R(G_{m,n}) = \gamma_R(G_{n,m})$.

In what follows, given a grid graph $G_{m,n}$, we will denote by $\gamma_2(G_{m,n})$ the Roman Domination value obtained by schema S_2.

For sake of clarity, we define $\gamma_2^*(G_{m,n})$ as

$$\gamma_2^*(G_{m,n}) = \min\{\gamma_2(G_{m,n}), \gamma_2(G_{n,m})\} =$$

$$= \begin{cases} \left\lfloor \frac{2\cdot(m\cdot n+m+n)}{5} \right\rfloor - 1 & \text{if} \quad m,n \mod 5 = 4 \\ \left\lfloor \frac{2\cdot(m\cdot n+m+n)}{5} \right\rfloor & \text{otherwise.} \end{cases}$$

Grid Graph	RDN γ_R	S_2 γ_2	S_2 γ_2^*	Grid Theorem	Old upper-bound
5x5	**14**	**14**	**14**	**14**	14
5x6	**16**	**16**	**16**	**16**	18
5x7	**18**	**18**	**18**	**18**	20
5x8	**21**	**21**	**21**	**21**	22
5x9	**23**	**23**	**23**	**23**	24
6x5	**16**	**16**	**16**	**16**	18
6x6	**19**	**19**	**19**	**19**	24
6x7	**22**	**22**	**22**	**22**	26
6x8	**24**	25	**24**	**24**	28
6x9	**27**	**27**	**27**	**27**	30
7x5	**18**	19	**18**	**18**	20
7x6	**22**	**22**	**22**	**22**	26
7x7	**24**	25	25	25	28
7x8	**28**	**28**	**28**	**28**	32
7x9	**31**	**31**	**31**	**31**	34
8x5	**21**	**21**	**21**	**21**	22
8x6	**24**	**24**	**24**	**24**	28
8x7	**28**	**28**	**28**	**28**	32
8x8	**32**	**32**	**32**	**32**	34
8x9	**35**	**35**	**35**	**35**	38
9x5	**23**	**23**	**23**	**23**	24
9x6	**27**	**27**	**27**	**27**	30
9x7	**31**	**31**	**31**	**31**	34
9x8	**35**	**35**	**35**	**35**	38
9x9	n.d.	**38**	**38**	**38**	42

Table 1: A comparison between the exact value of γ_R, given by the formulae found in [16], Schema S_2, the Grid Theorem and the upper-bound found in [6].

We will now state our main theorem, which, as said before, improves the upper-bound given in [6].

THEOREM 2 (GRID THEOREM). *Let $G_{m,n}$ be a grid graph, with $m, n \geq 5$. Then, by using Schema S_2, we have*[2]*:*

$$\gamma_R(G_{m,n}) \leq \gamma_2^*(G_{m,n}) \tag{3}$$

The Grid Theorem gives a sharper upper-bound over the Grid Graphs. Indeed, we clearly have:

$$\gamma_2^*(G_{m,n}) \leq \left\lfloor \frac{2 \cdot (m \cdot n + m + n)}{5} \right\rfloor \leq$$

$$\leq 2 \cdot \left(\left\lceil \frac{m \cdot n}{5} \right\rceil + \left\lceil \frac{m}{5} \right\rceil + \left\lceil \frac{n}{5} \right\rceil \right) .$$

The equalities hold only when $m, n \mod 5 = 0$.

4. IMPROVEMENT OF THE LOWER-BOUND ON GRID GRAPHS

In order to improve the lower-bound, we introduce now the idea of *cost*, i.e. for each vertex in a given graph we associate a new value that represents how much we spend to protect that vertex given a RDF.

We suppose that the covering is minimal, i.e. every vertex labeled by 1 has no neighbor labeled by 2.

[2]For a proof see the full article.

If a vertex v is labeled by 1, then its cost is 1, i.e. $\chi(v) = 1$.

If a vertex v is labeled by 2, then the cost is shared equally among the vertex itself and its neighbors. So, the shared cost σ is defined as:

$$\sigma(v, w) = \frac{2}{(|\operatorname{Adj}(v)| + 1)} \qquad \forall w \in \operatorname{Adj}(v) \cup \{v\} .$$

If a vertex v is labeled by 0, then: $\sigma(v, w) = 0 \qquad \forall w \in \operatorname{Adj}(v) \cup \{v\}$.

If a vertex v is labeled by 0 or 2, then its cost is the sum of all the shares from all the vertices in its neighborhood, including itself, i.e.:

$$\chi(v) = \sum_{w \in \operatorname{Adj}(v) \cup \{v\}} \sigma(w, v) .$$

For example, if we consider a K_n, then a vertex is labeled by 2 and the others by 0, but each vertex has a cost of $2/n$.

Clearly, we will have that the sum of all the costs is equivalent to the sum of the value of the chosen RDF, i.e.:

$$\sum_{v \in V} \chi(v) = \sum_{v \in V} f_{RD}(v) .$$

In case of grid graphs, we divide the vertices in two sets: A is the set of the internal vertices and B is the set of vertices on the borders.

The lower-bound for a grid graph is[3]:

$$\gamma_R(G_{m,n}) \geq \frac{|A|\cdot 2}{5} + \frac{|B|\cdot 2}{4} =$$

$$= \frac{(m-2)\cdot(n-2)\cdot 2}{5} + \frac{(2m+2n-4)\cdot 2}{4} =$$

$$= \frac{((2\cdot m\cdot n + 8 - 4m - 4n) + (5m+5n-10))}{5} =$$

$$= \frac{(2\cdot m\cdot n + m + n - 2)}{5} =$$

$$= \left\lceil \frac{(2\cdot m\cdot n + m + n - 2)}{5} \right\rceil > \left\lceil \frac{2\cdot(m\cdot n)}{5} \right\rceil .$$

As we proved earlier (see The Grid Theorem):

$$\gamma_R(G_{m,n}) \leq \left\lfloor \frac{2\cdot(m\cdot n + m + n)}{5} \right\rfloor .$$

Therefore,

$$\left\lceil \frac{(2\cdot m\cdot n + m + n - 2)}{5} \right\rceil \leq \gamma_R(G_{m,n}) \leq$$

$$\left\lfloor \frac{2\cdot(m\cdot n + m + n)}{5} \right\rfloor .$$

The gap is $(m+n+2)/5 = \Theta(m+n)$, which is sub-linear, given the number of vertices, $m\cdot n$, of a grid graph.

5. CONCLUSIONS AND OPEN PROBLEMS

In this paper, we have presented a method for producing coverings for RDP over grid graphs. In particular, we proved that these coverings have a sharper upper-bound on the Roman Domination Number over grid graphs, with respect the previous known upper-bound, see [6]. Moreover, we have proven that the RDP has a higher lower-bound and that the difference between lower and upper bound is $(m+n+2)/5 = \Theta(m+n)$, which is sub-linear, given the number of vertices, $m\cdot n$, of a grid graph.

As the covering methodologies we propose enjoy the property of non redundancy, i.e. each vertex labeled by 0 is covered by exactly one vertex labeled by 2 and given the regular structure of the grid graphs, we conjecture that, given a grid graph $G_{m,n}$, with $m,n \geq 5$, our upper-bound is very close to the exact value for the RDN of that grid graph. In fact, we conjecture that (see Table 1):

$$\gamma_2^*(G_{m,n}) - 1 \leq \gamma_R(G_{m,n}) \leq \gamma_2^*(G_{m,n}) .$$

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Relaxations in Practical Clustering and Blockmodeling

[Extended Abstract]

Stefan Wiesberg
Institut für Informatik
Im Neuenheimer Feld 368
Universität Heidelberg, Germany
stefan.wiesberg@informatik.uni-heidelberg.de

Gerhard Reinelt
Institut für Informatik
Im Neuenheimer Feld 368
Universität Heidelberg, Germany
gerhard.reinelt@informatik.uni-heidelberg.de

ABSTRACT

Network analysts try to explain the structure of complex networks by the partitioning of their nodes into groups. These groups are either required to be dense (clustering) or to contain vertices of equivalent positions (blockmodeling). However, there is a variety of definitions and quality measures to achieve the groupings. In surveys, only few mathematical connections between the various definitions are mentioned.

In this paper, we show that most of the definitions practically used can be seen as Lagrangean-type relaxations of four basic graph theoretical definitions. Quality measures like *Newman's modularity* can be seen as Lagrangean functions of these relaxations. The theory holds for both clustering and blockmodeling. It can be used as the basis of a methodological analysis of different practical approaches.

Keywords

network analysis, clustering, blockmodeling

1. INTRODUCTION

To group the vertices of a complex network's graph $G = (V, E)$ is one established way to obtain information about its structure. *Clustering* is the best-known example of this kind. Here, every vertex group is required to induce a dense sub graph in G. Other examples are *structural* and *regular equivalence*. Here, vertices with equivalent structural positions are grouped; a notion to be defined below. In the latter cases, not only the groups themselves, but also the relations between them are of interest.

Formally, a vertex grouping is defined as a disjoint partition $\mathbf{V} = \{V_1, \dots, V_c\}$ of the vertex set V. The partition is often expressed in terms of a coloring. This is possible since every vertex coloring $\phi : V \to [c]$, where $[c] = \{1, 2, \dots, c\}$, naturally defines a partition into the color classes. W.l.o.g. we assume that ϕ is surjective, i.e., all c colors are used.

2. DEFINITIONS TO BE RELAXED

We will now discuss several ways to define the vertex groups in ways that turned out to be meaningful in network analysis. These ways are *clique coloring (CC), clique component coloring (CCC), structural coloring (SC)* and *regular coloring (RC)*. In the next sections we will see that these strict definitions are usually relaxed for practical computations. A vertex coloring ϕ with exactly k colors is called a *k-clique coloring* if every vertex $u \in V$ is adjacent to all other vertices of the same color $\phi(u)$. We call the coloring a *k-clique component coloring* if every vertex $u \in V$ is adjacent to all other vertices of the same color $\phi(u)$ and to no vertex of any other color. The latter colorings are used for clustering measures in which not only the density of the clusters, but also the sparsity of inter-cluster relations are taken into account. Another well-studied way is the grouping of vertices which have the very same neighbors. The corresponding mathematical definition of *k-structural colorings* is introduced by Lorrain and White [7]. Here, the same color of two vertices $u, v \in V$ implies that u and v have the same neighbors in G: $N(u) \setminus \{v\} = N(v) \setminus \{u\}$, where $N(u)$ denotes the set of vertices in V which are adjacent to u. The number k again represents the number of used colors. A fourth common way of grouping is based on *k-regular colorings*. A coloring $\phi : V \to [k]$ is *k-regular*, if for every two vertices $u, v \in V$ with $\phi(u) = \phi(v)$ holds:

$$\{\phi(w) \mid w \in V, uw \in E\} = \{\phi(w) \mid w \in V, vw \in E\}.$$

That is, if u and v have the same color, then their neighboring color sets are identical.

There is a well-known characterization of the four coloring types. It describes certain sub graphs of G. Given a coloring ϕ, there is one such sub graph $G_{\phi,c,d}$ for every pair (c, d) of colors. It is obtained from G by deleting all vertices but the ones colored with c or d and deleting all edges but those connecting an c-colored with a d-colored vertex. $G_{\phi,c,d}$ is hence bipartite for $c \neq d$. Note that all of these sub graphs are edge disjoint.

THEOREM 1. *Given a graph G, a k-coloring $\phi : V \to [k]$ of its vertex set is...*

(i) a k-clique coloring, if for all $c \in [k]$, the graph $G_{\phi,c,c}$ is complete.

(ii) a k-clique component coloring, if for all $c, d \in [k]$, the graph $G_{\phi,c,d}$ is complete if $c = d$ and empty if $c \neq d$.

(iii) a k-structural coloring, if for all $c, d \in [k]$, the graph $G_{\phi,c,d}$ is either empty or a complete (bipartite for $c \neq d$) graph.

(iv) a k-regular coloring, if for all $c, d \in [k]$, the graph $G_{\phi,c,d}$ is either empty or contains no isolated vertices.

3. LAGRANGEAN TYPE RELAXATIONS

We will now show that in practical network analysis, relaxations of the four definitions above are usually used. We denote by $CP(k, G)$ the set of all k-clique colorings of the vertices of G. Analogously, we define $CPP(k, G)$, $SE(k, G)$ and $RE(k, G)$, or simply write $X(G)$ in a statement which holds for any fixed type and any fixed number k of colors. Practitioners, often implicitly, enlarge the set of feasible colorings $X(G)$ to a set $X_L(G) \supseteq X(G)$ and assign a penalty value $p(\phi) \geq 0$ to each member ϕ of the enlarged set $X_L(G)$. Afterwards, they solve the optimization problem of finding a coloring ϕ^* in $X_L(G)$ with the minimum penalty value $p(\phi^*)$. We now show that this is usually done in a Langrangean way. That is, the set $X(G)$ of feasible colorings is enlarged by dropping some of the requirements in the definition of X. Furthermore, the penalty function p is not arbitrary, but measures the degree of violation against the *dropped* requirements. The optimization problem to be solved is thus:

(MIN-P) Given the set $X_L(G)$ and the penalty function $p : X_L(G) \to \mathbb{R}_0^+$, find a $\phi^* \in X_L(G)$ which minimizes p.

That is, among the colorings satisfying the non-dropped requirements, find the one which violates the dropped requirements to the least possible extent. As a convention, a penalty value of 0 is assigned to the colorings in $X(G)$, as they do not violate any dropped requirements (*compatibility requirement*, see Doreian et. al. [5]). Hence, a coloring satisfying the original definition X is always an optimum solution to (MIN-P). We will now classify literature by the type of relaxation used. As we are considering colorings of graphs, two types of relaxations are suggesting: The relaxation of the coloring definition and the relaxation of the graph structure. Indeed, these possibilities are widely used. In Section 3.2, we will look at the cases where the general definition of coloring is relaxed. E.g., a vertex might be allowed be assigned several colors here. Section 3.3 subsequently addresses the case where the structure of the graph G is relaxed. We start, however, with a third possibility. There, the definition specific properties of CC, CCC, SC, and RC are being relaxed.

3.1 Problem Specific Relaxations

For problem specific relaxations, two forms of p are most commonly used: p is constant or decomposable over the set of all vertex pairs. In the first case, say $p \equiv 0$, some requirements are simply dropped, but not penalized.

Example (Sociometric Cliques.) Alba [1] finds the graph theoretical definition of *clique* to be not perfectly appropriate to describe friendship (or sociometric) cliques in social networks. He thus relaxes its definition to so-called n-cliques, where the distance of two members is not at most 1, but at most n. That is, the requirements "The distance is at most i" are dropped for $i = 1, \ldots, n-1$. If no penalties are introduced, the problem (MIN-P) merely consists in the search for *any* partition into n-cliques.

A second common type of problem specific relaxations is based on *vertex similarities*. In this special case of (MIN-P), the penalty function p can be decomposed over all vertex pairs, i.e., $p(\phi) = \sum_{u,v \in V} p_{uv}\delta(\phi(u), \phi(v))$. Here, $p_{uv} \geq 0$ are real numbers and δ denotes the Kronecker function. It is 1 if $\phi(u) = \phi(v)$ and 0 otherwise. In literature, the numbers p_{uv} are often called *(dis)similarity values*. The relaxation technique of using such a decomposable function is called *indirect blockmodeling approach* by Doreian et al. [5].

Example (Structural Equivalence.) Several functions p of the above form have been proposed for SE. This propositions were made indirectly by a specification of the values p_{uv}. They quantify how much a coloring violates this dropped requirement. That is, to quantify how similar two vertices are with respect to common neighbors. See Leicht, Holme, and Newman [6] for an overview on these functions.

3.2 Coloring Relaxations

Beside the definition specific relaxations above there is the possibility to relax the definition of "coloring" itself. If we use the binary variables x_{vc} to express whether vertex v is colored with c ($x_{vc} = 1$) or not ($x_{vc} = 0$), the requirement "to be a k-coloring" can be decomposed into the following sub requirements:

$$\sum_{c=1}^{k} x_{vc} = 1 \quad \text{for all } v \in V, \tag{1}$$

$$\sum_{v \in V} x_{vc} \geq 1 \quad \text{for all } c \in [k], \tag{2}$$

$$0 \leq x_{vc} \leq 1 \quad \text{for all } v \in V, c \in [k], \tag{3}$$

$$x_{vc} \in \mathbb{Z} \quad \text{for all } v \in V, c \in [k]. \tag{4}$$

Example (Fuzzy Colorings.) In some applications, it is meaningful for a vertex to get several colors at the same time. E.g., a person might be a member of several clubs. In this case, requirement (1) is dropped. Alternatively, a vertex might be allowed to consist of color fractions that sum up to 1, such as 50% red, 30% green and 20% blue. In this case, requirement (4) is dropped. One speaks of *fuzzy colorings* or *partitionings* in both of these cases of relaxation. The penalty function p is usually constant with respect to these requirements.

Example (Number of Colors.) For many applications, a good choice for the number of colors is not a priori known and hence not fixed to a certain value k. That is, the requirement that k colors must be used is dropped. As small numbers are usually more suitable for interpretation, the penalty function p might be defined to assign each coloring ϕ the number of colors used by ϕ. The lower the number of colors, the less the amount of penalty. As an example, the algorithm CATREGE [3] solves (MIN-P) for such a p and X=RE. I.e., given a graph, it finds a k-regular coloring with the smallest possible k.

3.3 Graph Relaxations

Assume a practitioner is interested in 4-regular colorings on a given graph $G = (V, E)$. However, such a coloring does not

exist on G. It is then reasonable to consider a 4-coloring ϕ to be a good solution, if it is not regular on G, but turns regular if G is changed by a very small amount. Following this idea, the best 4-coloring is the one that requires the lowest amount of changes in G in order to become regular. Possible changes are usually the deletion and addition of edges. That is, requirements of the forms "$uv \in E$" and "$uv \notin E$" are dropped. If they are penalized by the function p, then the coloring ϕ^* which requires the lowest amount of edge changes in G will be the optimal solution to (MIN-P). In order to define a suitable penalty function p, we first need to define a function d to measure the amount of edge changes. More precisely, d measures the distance of two graphs $G = (V, E)$ and $H = (V, F)$ on the same vertex set V. A simple but common exemplary form of such a d is given by

$$d(G, H) = \sum_{u,v \in V, u \neq v} |A(G)_{u,v} - A(H)_{u,v}|, \qquad (5)$$

where A denotes the adjacency matrix of the graph. The function counts the number of different entries in the adjacency matrices of G and H. More complex distance functions are discussed below. d measures the distance of G to a single graph H. We can also measure its distance to a set of graphs $\mathbf{H}$, by defining the distance $d(G, \mathbf{H})$ as the distance of G to its closest element in $\mathbf{H}$. That is,

$$d(G, \mathbf{H}) := \min_{H \in \mathbf{H}} d(G, H).$$

To measure how much G has to be changed, it is compared to sets of ideal graphs $\mathcal{H}(\phi)$, on which ϕ perfectly satisfies the requirements. In our example, $\mathcal{H}(\phi)$ is defined such that ϕ is 4-regular on all $H \in \mathcal{H}(\phi)$. The penalty function for (MIN-P) is hence $p(\phi) = d(G, \mathcal{H}(\phi))$.

We now give more details on this procedure. First, we will see how ideal graphs $\mathcal{H}(\phi)$ can be defined. Then, we give an overview on the distance functions $d(G, H)$ which are practically used. Afterwards, a common variant of this procedure is discussed, which does not relax G, but several sub graphs of G simultaneously. We close by some examples on how graph relaxation is used in literature.

Ideal, Worst and Average Graphs

Given an ideal coloring definition X (for example CC, CCC, SC, RC), a graph $G = (V, E)$ and a coloring ϕ of its vertices, the set $\mathcal{H}(\phi)$ of ideal graphs can be naturally defined. It is the set of all graphs H with the same vertex set as G, such that ϕ is an X-coloring on H. Theorem 1 gives a characterization of these graphs. In the case of clustering (X = CC), the ideal graphs are those in which vertices of the same color induce cliques. Note that for every $\phi : V \to C$, the set $\mathcal{H}(\phi)$ is non-empty.

Alternatively, one can define $\mathcal{H}(\phi)$ to be the set of *worst* graphs instead of ideal ones. Worst graphs can be easily defined for CC, CCC, and SE. This is because their sub graph characterization in Proposition 1 use empty and complete graphs only. As "being empty" and "being complete" are opposite extremes, one can define worst graphs by interchanging the words "empty" and "complete" in the proposition. E. g., in a worst graph for clustering (CC) no cluster contains any edges. If worst graphs are used, the distance of the closest graph to G needs to be maximized instead of minimized.

A third alternative has been used for CC and SE: G is compared to average graphs. For clustering, the sub graphs are hence neither empty nor complete, but have an average density. The distance of G to the average graphs $\mathcal{H}(\phi)$ can then be positive or negative, depending on whether G is worse (sparser) or better (denser) than average. The same holds hence for the penalty function. It is usually used as a reward function $\overline{p}$: The farther G is from average in the positive direction, the larger is $\overline{p}$, the better is ϕ.

Overview on Distance Functions

With (5), we already stated the most simple distance function to measure the distance between two graphs on the same vertex set. It counts the number of edges to be added or deleted (changed) in G to obtain the ideal graph H. The adjacency matrix of H is possibly weighted, especially when G is compared to an average graph. Practically, these functions are usually weighted. Clearly, the amount of change that is introduced by the change of an adjacency matrix entry is often not the same for every entry. There are two common reasons. Firstly, the amount of change can depend on the weight of the edge. That is, the deletion of a heavier weighted edge might be considered a greater change. Secondly, a variation in the amount of change can also evolve from a priori statistical computations. Adding an edge which is unlikely to exist can be considered more expensive than adding a likely edge. Hence, edge depended weights $c_{uv} \geq 0$ are commonly used in distance functions.

Another kind of weight is based on the following observation. Changing edges between yellow and red vertices can be modeled to be more expensive than changes between yellow and blue ones. To this end, scaling factors $w_{cd} \geq 0$ are introduced for all pairs of colors. The resulting weighted distance function can be stated as

$$d(G, H) = \sum_{u,v \in V, u \neq v} w_{\phi(u)\phi(v)} \cdot c_{uv} \cdot |A(G)_{u,v} - A(H)_{u,v}|. \quad (6)$$

The absolute value function is a problem for the comparison to average graphs. Here, we want to distinguish whether G is worse or better than average. Hence, the following function is more suitable in this case.

$$d(G, H) = \sum_{u,v \in V, u \neq v} w_{\phi(u)\phi(v)} \cdot c_{uv} \cdot (A(G)_{u,v} - A(H)_{u,v}). \quad (7)$$

Beside these linear functions, several non-polynomial functions have been proposed. Being derived from general statistical matrix correlation measures, they can be used to compare the adjacency matrices of G and H. See Wasserman and Faust [9] or Arabie et al. [2] for an overview.

Relaxing Sub Graphs Separately

We have seen in Theorem 1 that the coloring conditions can be equivalently formulated as requirements for the sub graphs $G_{\phi,c,d}$ of G. In the widely used *direct blockmodeling approach*, these sub graphs are relaxed separately. That is, there is a separate penalty value for each sub graph. However, the same distance function d us used for each sub graph. Whether the separate relaxations of the sub graphs is equivalent to the relaxation of G itself depends on the choice of d. In direct blockmodeling, we have single penalty values $p_{cd}(\phi) = d(G_{\phi,c,d}, \mathbf{H}_{\phi,c,d})$ for the sub graphs. They need to be combined to a total penalty value $p(\phi)$. In

most cases, the p_{cd} are simply summed up:

$$p(\phi) = \sum_{c,d \in C} p_{cd}(\phi). \quad (8)$$

For clustering (CC), the sum runs clearly only over those c, d with $c = d$. If scaling is used, the factor is usually $1/m_{cd}$, where m_{cd} is the number of possible edges in the sub graph $G_{\phi,c,d}$. More precisely, $m_{cd} = |c| \cdot |d|$ if $c \neq d$ and $m_{cc} = |c| \cdot (|c| - 1)$.

$$p(\phi) = \sum_{c,d \in C} \frac{1}{m_{cd}} \cdot p_{cd}(\phi). \quad (9)$$

In some statistically based approaches, the squares of the penalties are summed up instead. This mostly occurs so-called chi-squared approaches.

$$p(\phi) = \sum_{c,d \in C} (p_{cd}(\phi))^2. \quad (10)$$

Besides the above scaling factor, a second one can be used here. The distance of $G_{\phi,c,d}$ to $H_{\phi,c,d}$ can be seen in relation to the maximum distance $d^{\max}_{\phi,c,d}$ of any graph, on the same vertex set, to $H_{\phi,c,d}$.

$$p(\phi) = \sum_{c,d \in C} m_{cd} \cdot \left(\frac{p_{cd}(\phi)}{d^{\max}_{\phi,c,d}}\right)^2. \quad (11)$$

Examples

We now give some examples on how this kind of relaxation is used in literature, either for coloring type CC, CCC, SC, or RC. For each example, we need to specify the following modeling choices:

- Whether ideal, worst, or average graphs are used and how average is defined.
- Which distance function d is used.
- Whether G or its sub graphs $G_{\phi,c,d}$ are relaxed and how $p(\phi)$ is combined by the $p_{cd}(\phi)$.

Example (Maximal Cluster Density.) A basic measure for the quality of a clustering (X=CC) on $G = (V, E)$ is the sum over all *intra-cluster densities* $\delta_{int}(V_i)$. They give the proportion of actual edges to theoretically possible edges within the i-th cluster:

$$\delta_{int}(V_i) = \frac{\#\text{ internal edges of } V_i}{|V_i|(|V_i| - 1)/2}.$$

The search for a coloring ϕ^* with maximum total intra-cluster density can be expressed as (MIN-P). To see this, compare G to the standard ideal graphs $H(\phi)$ with the most basic distance function (5). Apply it separately on each sub graph $G_{\phi,c,c}$ and combine the penalty values linearly by formula (9).

Example (Maximal Structural Density.) Wasserman and Faust explain a simple measure for structural colorings in their survey [9]. It is a generalization of the preceding example from clique to structural colorings. For each pair c, d of colors, they sum up the values $|I_{cd} - \Delta_{cd}|$. Here, I denotes the image matrix and Δ_{cd} denotes the density. The density is defined as the number of edges from c-colored to d-colored vertices, divided by the maximum possible number m_{cd} of such edges. They hence compare the sub graphs $G_{\phi,c,d}$ to ideal graphs with the most basic distance function (5). Again, the separate penalties are combined linearly by formula (9).

Example (Newman-Girvan-Modularity.) Newman and Girvan [8] present a well-known relaxation for clustering. They choose $H(\phi)$ to contain average graphs. More precisely, $H(\phi)$ consists of exactly one graph $H = (V, F)$. The edge weight of $uv \in F$ is $deg(u)deg(v)/2|E|$. This is precisely the probability of the edge to exist in a random graph with the same degree distribution as G. For this reason, H can be interpreted as the average graph w.r.t. to the degree distribution of G. The distance function is the unweighted version of (7). It is applied separately to each $G_{\phi,c,c}$. These values are summed-up by the again unweighted formula (8) to obtain the total penalty $p(\phi)$. Note that $p(\phi)/2|E|$ is called the *modularity* of ϕ. The factor $1/2|E|$ is however constant and can thus be ignored in the solution of (MIN-P). Other so-called *Newman-like modularities* can be modeled analogously.

Example (Berkowitz-Carrington-Heil Index.) The index [4] is designed for structural colorings (X=SC). It compares G to an average graph H. The user is asked to specify an average density α from the interval between 0 and 1. H is then the complete graph with edge weights all α, letting its density equal α. The distance function d is (5), hence the most simple one. It is applied on sub graphs. Since the index is a chi-squared approach, the function $p(\phi)$ is composed as in (11).

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Estimation of cervix cancer spatial distribution for brachytherapy applicator analysis

Peter Rogelj
University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies
Glagoljaška 8, 6000 Koper, Slovenia
peter.rogelj@upr.si

ABSTRACT

Standard applicators for cervix cancer brachytherapy (BT) do not always enable a sufficient radiation dose coverage of the target structure (HR-CTV). The aim of this study was to enable statistical analysis of applicator dose coverage by computing a distribution of the BT target from a cohort of cervix cancer patients. The method presented in this paper requires data of several patients that includes medical images of arbitrary resolution and modality supplemented with delineations of HR-CTV structure and reconstructed applicator structure. As a result an object in a form of a 3D image is obtained providing the statistical distribution with respect to applicator soordinate system. In our implementation the result was saved in DICOM format to enable further analysis using existent BT planning systems leading to BT applicator improvements.

1. INTRODUCTION

Applicators for cervix cancer brachytherapy (BT) enable cancer treatment that in comparison with external beam radiotherapy (EBRT) provides better radiation coverage of the high risk clinical target volume (HR-CTV) and better avoidance of organs at risk [1]. During the last decade remarkable progress has been made in radiotherapy, including cervix cancer BT [2]. Standard BT applicators for cervix cancer, as shown in Fig. 1, however still do not always enable a sufficient radiation dose coverage of the target, especially in cases of locally advanced cervical cancer. Improvements are searched in the direction of incorporating additional application needles. A development of new applicators that would enable better target dose coverage requires a knowledge of cervix cancer spatial distribution. In this work we aimed to develop an application to obtain this information statistically using available data of past and present cervix cancer patients. The information required from each patient includes BT planning medical image, delineated HR-CTV structure and reconstructed BT applicator structure. HR-CTV structure is in each 3D image delineated on each image slice, wherever the structure is present and, thus, available as a set of closed planar contours. BT applicators are reconstructed such that an applicator model is positioned in the 3D image inside the BT planning system. The applicator models consist of a ring, applicator tandem and needles, which are reconstructed independently. The actual position of the applicator is evident from the position of the applicator ring. Because the applicator must be positioned directly to the cervix and because the purpose of spatial cervix cancer distribution is in applicator improvements, the spatial distribution must be defined in the applicator coordinate system.

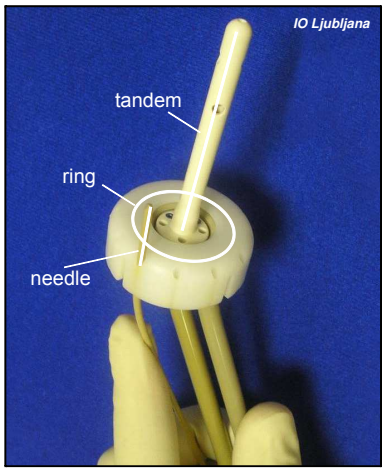


Figure 1: An image of a standard BT cervix cancer applicator with indicated parts: tandem, ring and optional needles.

In the following sections our approach to estimate the spatial cervix cancer distribution is described first, then some results are presented and, finaly, the paper is concluded with some discussion.

2. METHODS

Our approach to estimate spatial distribution of cervix cancer was image processing based. It consisted of the following processing steps that are described below: data input, applicator coordinate system definition, structure processing, data integration and export.

2.1 Data input

The input data for the analysis consisted of patient medical data sets and an analysis configuration. Patient medical data sets comprised all the required information of each patient, i.e., a 3D medical image, delineated HR-CTV structure and a reconstructed applicator stucture, all of them provided in the DICOM file format. Input of all medical data was performed using the GDCM library (version 1.3) [3]. Medical images were used only to obtain the image configuration, i.e., transformation of image coordinate system according to the patient coordinate system and image slice positions, which were needed to correctly interpret the structures. Structures were provided in a form of struc-

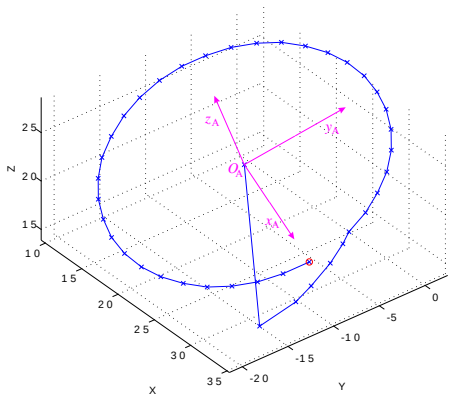


Figure 2: Applicator ring structure is defined with 41 points in the 3D patient coordinate system. The corresponding applicator coordinate system is defined with origin in the ring center, xy plane in the ring plane with x axis pointing towards the contour starting point (labeled with a circle) and z axis in the direction of the tandem.

ture sets, providing all the structure data required for BT treatment. The target structure (HR-CTV) and the applicator ring structure were identified from all the structures according to their names, which were known in advance for each individual data set; the naming was not standardized. The target structures were provided as sets of closed planar contours. The applicator ring structure was provided as a single open nonplanar contour. All contours were defined according to the patient coordinate system. All the required information about datasets, i.e., file locations and structure names, as well as information of the extent and resolution of resulting statistical distribution were provided in the analysis configuration, in a XML file.

2.2 Applicator coordinate system definition

Because the spatial distribution of cervix cancer needed to be defined according to the applicator perspective, we needed to define an applicator coordinate system. The applicator reconstruction [4, 5] is performed on radiotherapy planing systems by importing predefined geometry structures. The applicator tandem and ring were reconstructed individually. In our case only the ring structure was used to define applicator coordinate system. Three types of rings were used in the data with the only difference of ring diameter. However, the applicator ring structure was in the library in all three cases defined with a contour consisting of 41 points with the same point ordering and meaning. For the illustration see Fig. 2. The applicator coordinate system was defined such that its origin was in the ring center (the last point of the contour), xy plane in the ring plane, x axis in the direction towards ring contour starting point and z axis in the direction of the tandem.

The transformation that defines the applicator coordinate system was for each applicator computed from its ring contour coordinates provided in the patient coordinate system. Actually, only three contour points were needed to compute the applicator coordinate system transformation $\mathbf{T}_A$. We used points $A(0)$, $A(28)$ and $A(40)$, where A stands for the applicator contour and the parameter is the point index (starting with zero). The transformation was defined using the following procedure:

$$O_A = C(40) \quad (1)$$
$$V_1 = C(0) - O_A \quad (2)$$
$$V_2 = C(28) - O_A \quad (3)$$
$$V_z = \|V_1 \times V_2\| \quad (4)$$
$$V_y = \|V_z \times V_1\| \quad (5)$$
$$V_x = \|V_y \times V_z\| \quad (6)$$
$$\mathbf{T}_A = \begin{bmatrix} V_x(x) & V_y(x) & V_z(x) & O_A(x) \\ V_x(y) & V_y(y) & V_z(y) & O_A(y) \\ V_x(z) & V_y(z) & V_z(z) & O_A(z) \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (7)$$

where, V and O are three dimensional vectors with components x, y, and z, such that O_A represents applicator coordinate system origin while V_x, V_y, and V_z are applicator coordinate system axes. Vector (cross) products assured coordinate axis perpendicularity, defining a Cartesian coordinate system. The obtained transformation matrix $\mathbf{T}_A$ was later used for transformation of BT target structures to the applicator coordinate system in which the cervix cancer distribution was searched.

2.3 Structure processing

For each image the corresponding BT target structure had to be presented in a coordinate system of the applicator. However, the structures were provided as contours delineated on individual image slices with point coordinates given in a patient coordinate system. Because of the vector format of the structures, they are difficult to be statistically processed directly. Our solution was to transform each structure into a 3D binary image, such that regions inside the structure had value 1, while others were labeled with 0. The approach is illustrated in Fig. 3. The binary image covered the same region as the original medical image, except that, typically, it had higher resolution in x and y image direction, according to requested resolution of resulting cervix cancer distribution image. The resolution in z image direction was the same as in the original medical image to preserve location of slices on which contours were drawn.

Slice resolution of the binary image (in x and y image directions) was defined as the smallest multiple of original image resolution that exceed or equals the desired resulting distribution image resolution. The process of converting a structure into a binary image started with initialization of empty binary image. Then the image transformation $\mathbf{T}_I$, which was read from the original medical image from DICOM tags *Image Position Patient* (0020,0032) and *Image Orientation Patient* (0020,0037), was used to convert the structures into the image coordinate system. Here, each contour C was mapped from patient coordinate system into image coordinate system:

$$C' = \mathbf{T}_I^{-1} C. \quad (8)$$

The obtained transformed structure was then drawn to the binary image, contour by contour. For each converted contour all its points had the same z coordinate that corresponded to position of one of the image slices, due to their closed planar nature. The drawing was performed such that each slice voxel was checked whether the point is inside or outside the polygon defined by the contour points. If inside,

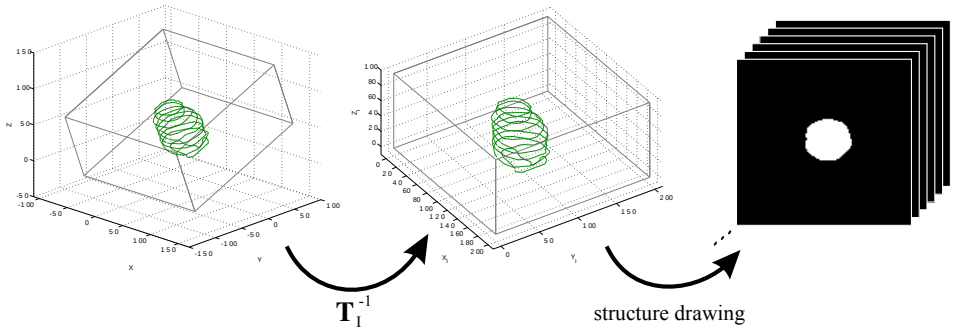


Figure 3: Illustration of structure processing: first, contours provided in the patient coordinate system (left) are transformed to the image coordinate system (center). Then, contours are drawn on image slices in 2D, which resulted in a 3D binary image of the structure (right).

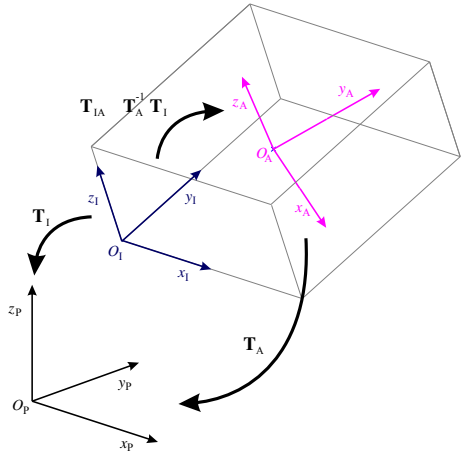


Figure 4: Illustration of patient (P), image (I) and applicator (A) coordinate systems and their transformations: $\mathbf{T}_{IA} = \mathbf{T}_A^{-1}\mathbf{T}_I$.

the value of the voxel was negated, else the value was preserved. The result was a binary image of the structure that correctly considered arbitrary complex structure shapes, including eventual holes inside structures. Such prepared image data were suitable for data integration comprising transformation into the application coordinate system.

2.4 Data integration and export

To integrate the structure binary images for all the patients, they all had to be transformed into the same coordinate system. For the applicator analysis this is evidently the applicator coordinate system (A). The coordinate systems and their transformations were defined for each patient and are illustrated in Fig. 4. The image data, defined in image coordinate system (I) can be transformed to the applicator coordinate system (A) through the patient coordinate system (P) using transformation $\mathbf{T}_{IA}$:

$$\mathbf{T}_{IA} = \mathbf{T}_A^{-1}\mathbf{T}_I. \tag{9}$$

Note that binary target structure images were not only defined in different coordinate systems than the resulting distribution image, they also had different resolution and size. All the differences were covered using linear interpolation of structure images during transformation. The interpolation was performed in reverse direction such that intensity corresponding to each voxel in distribution image was interpolated from voxel intensities in the binary structure image Note, that linear interpolation transformed a binary image into an image with real voxel values in interval $[0, 1]$.
The result, i.e., the spatial distribution image D, is obtained from transformed structure images by averaging,

$$D = \frac{1}{n}\sum_{i=1}^{n} interp(\mathbf{T}_{IA,i}^{-1} S_i), \tag{10}$$

where S_i represents structure data of i-th patient in binary image representation and *interp* indicates the linear interpolation.
The resulting image was exported into the DICOM image format using the GDCM Library [3]. As such it was imported into BT planning system (Brachyvision©) for further analysis.

3. RESULTS

264 consecutive cervix cancer patients were included in the analysis. Due to relatively large number of patients, the obtained estimate of spatial cervix cancer distribution was named a virtual patient (VP). Imported to the BT planning system isosurfaces that connect voxels with the same values were created and labeled as percentage of encompassed voxels. VPn was defined as VP subvolume, encompassed by the n% isosurface, see the illustration in Fig. 5.
The obtained VP data was used for analysis and development of BT applicators for cervix cancer [6]. Let us summarize results obtained from analysis of three different applicator types. For each type a treatment plan for a VP was prepared and evaluated for individual VP subvolumes. The following results were obtained:

- type A: tandem and ring (T&R) applicator, standard loading, enabled an adequate treatment of VP60 subvolume,
- type B: type A + interstitial needles, parallel to tandem, extends adequate treatment to VP95 and
- type C: type B + oblique needles, inserted at points, angles and depths, enabling balance between insertion complexity and VP coverage, extends adequate treatment to VP99 subvolume.

For an illustration of the BT applicator types and their target coverage see Fig. 6. VP and limitations established for existent applicator types enable further applicator develop-

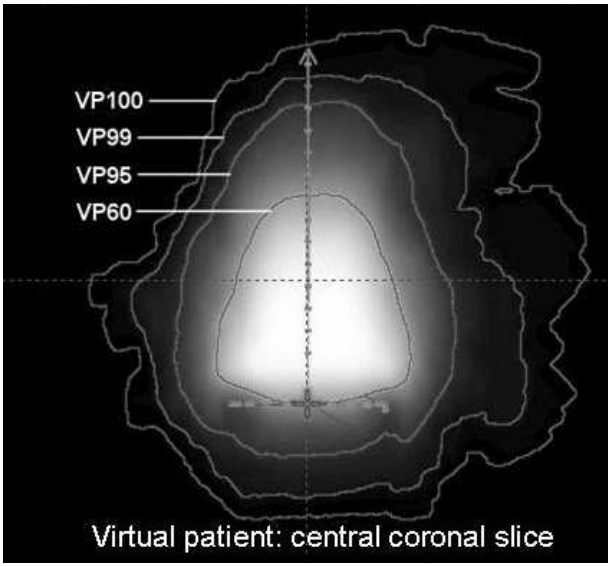


Figure 5: Illustration of the cervix cancer spatial distribution representing a virtual patient, the central coronal slice.

ment.

4. DISCUSSION AND CONCLUSION

Cancer spatial distributions must be considered whenever cancer treatment tools and procedures are being developed. Unfortunately, statistical analysis of spatial distributions related to specific organs is in general tedious due to difficulties defining the reference coordinates system originating in complex organ/structure shapes and their high variability. In the specific case of cervix cancer the organ geometry enables unambiguous coordinate system definition that agrees with the applicator ring structure and, thus, cancer distribution estimation as proposed in this paper. Analysis of other cancer types would require definition of standard organ geometry that could serve as a reference/atlas for registering actual patient data [7]. Similarly, image registration has already been used for analyzing interfraction variation of high dose regions of OARs [8], and could be extended to inter-subject analysis of cancer distributions.

In addition to target tumor regions, organs at risk (OARs) that should be avoided by radiation could also be considered and obtained using the same approach that is proposed in this paper. However, statistical distribution of OAR regions could overlap with the statistical distribution of the target region, which means that in such analysis not only distributions but also variations should be analyzed. In this manner our approach could be extended to take into account all the structures/organs simultaneously by performing principal component analysis to describe their variations.

To conclude, it may be widely accepted that reducing dose at organs of risk is difficult without reducing dose at large tumors [9], we believe that applicator improvements based on statistical distribution estimations could provide better alternatives.

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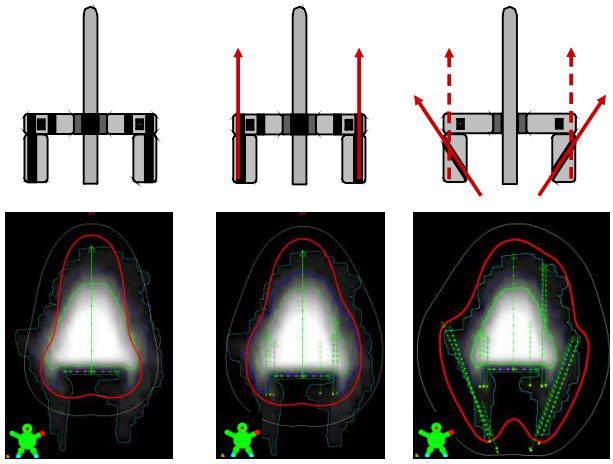


Figure 6: Illustration of the compared cervix cancer BT applicators (top) and their coverage of the virtual patient (bottom).

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Recognition of Repeating Segment from an Audio Using Vector Quantization and K-means algorithm

Shruti Sehgal[1]
[1]Student of Electronics and Communication Engineering
Amity School of Engineering & Technology
Noida (U.P)-201303, India
shrutiaquarius90@gmail.com

Garima Vyas[2]
[2]Asst. Prof. of Electronics and Communication Engineering
Amity School of Engineering & Technology
Noida (U.P)-201303, India
gvyas@amity.edu

***Abstract*— In this paper, we proposed a structure to detect repeating segments in the audio that can be used for the efficient selection of the liking or disliking for any unheard song. In this work, features are extracted by using Mel frequency cepstral coefficients (MFCC) and then matching process is carried out by using Vector Quantization (VQ) method. The proposed systems evaluated carry the database for the query segment and the recorded speech segments. From the evaluation results, it is observed that about 98% of the accuracy is computed on histogram that corresponds to the peaks at which matches were found and can be used to detect a set of repeating segments.**

***Keywords*— Repeating segment, MFCC, Vector Quantization**

I. INTRODUCTION

In recent years, we have seen that music stores have installed music listening stations to ease customers from their busy schedule to first listen the whole song from start to end and then decide whether they like it or not, whether they want to purchase CD of that song or not. For this only reason, they used to give them a section of listening or chorus so as to quickly determine whether a selection is the music one has been looking for. These criteria used to help the customers by saving their time as well as giving them the required song.

In this paper, we have used the pattern matching approach over "clustering approach" as it gives more accurate results. The goal of our project is to detect the repeating segments in the song by pattern matching method for that firstly we extract features from audio using Mel frequency cepstral coefficients (MFCC) and then match the frames or segments using Vector quantization method.

Here, the automatic detection of the repeating segments often referred to as chorus segments any of the above method can be used. These repeating segments can be thought of as audio thumbnails helps for instant identification and recognition of the songs. For pattern matching, the computation of distance matrix or similarity matrix for the whole song is not required as it is very expensive.

We can adopt two methods for achieving our objective, they are:-

- One of the method is to take a song, segment it into different sections and then do matching by comparing each segment with each other.
- Another method is to identify repetitive sections of the song by matching different sections of the song with any one of the segment as query segment.

II. A PROPOSED STRUCTURE

We have proposed a structure layout in which we have done feature extraction by using Mel frequency cepstral coefficients (MFCC) and feature matching by using Vector Quantization. For the input audio, we have taken different segments of the same size as shown in the fig 1given below. We can also generate the database by recording the same speech segment a number of times.

Here, in this paper we have extracted the MFCC features from query segment and then we extract the MFCC features from another repeating segments of the same size that are segmented into equal parts. The length of the segment should be at least 15msec.

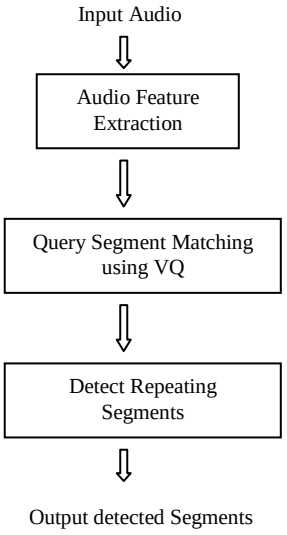


Fig 1 A proposed system for repeating segments detection

A. *Feature Extraction*

Feature extraction is the process that extracts a small amount of data from the voice signal that can later be used to represent each speaker. We used MFCC algorithm in this paper for extraction of the features as this is one of the most important feature and shows high accuracy results for the audio signals. We implement the following steps as shown in fig 2 on each segment and store the coefficients in one feature vector say x, y or z.

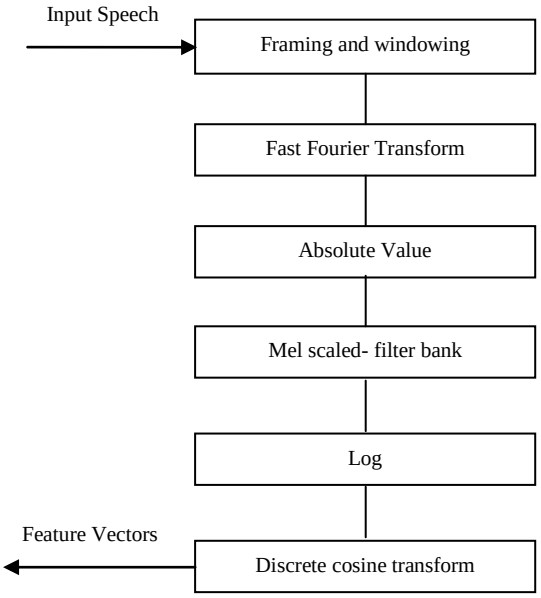


Fig. 2 Flow chart for MFCC extraction

Firstly, we divide the speech into different frames and then apply any window. In this step the continuous speech signal is blocked into frames of N samples, with adjacent frames being separated by M ($M < N$). The first frame consists of the first N samples. The second frame begins M samples after the first frame, and overlaps it by N - M samples and so on. This process continues until all the speech is accounted for within one or more frames. Typical values for N and M are N = 256 (which is equivalent to ~ 30 msec windowing and facilitate the fast radix-2 FFT) and M = 100.

Here, the next step in the processing is to window each individual frame so as to minimize the signal discontinuities at the beginning and end of each frame.

The concept here is to minimize the spectral distortion by using the window to taper the signal to zero at the beginning and end of each frame. If we define the window as $w(n), 0 \le n \le N-1$, where N is the number of samples in each frame, then the result of windowing is the signal

$$y_l(n) = x_l(n)w(n), \quad 0 \le n \le N-1$$

We used hamming window through which we can edit some of the information from the start and end of each frame.

For accurate results we have done pre-emphasis before windowing. Then, we applied fast Fourier transform to convert the signal from time domain to frequency domain.

The hamming window is defined as:

$$W_H(n) = 0.54 - 0.46\cos\left(\frac{2n\pi}{N-1}\right)$$

The next processing step is the Fast Fourier Transform, which converts each frame of N samples from the time domain into the frequency domain.

The FFT is a fast algorithm to implement the Discrete Fourier Transform (DFT), which is defined on the set of N samples $\{x_n\}$, as follow:

$$X_k = \sum_{n=0}^{N-1} x_n e^{-j2\pi kn/N}, \qquad k = 0,1,2,\ldots,N-1$$

where X_k's are complex numbers and we only consider their absolute values (frequency magnitudes). The resulting sequence $\{X_k\}$ is interpreted as follow: positive frequencies $0 \le f < F_s/2$ correspond to values $0 \le n \le N/2-1$, while negative frequencies $-F_s/2 < f < 0$ correspond to $N/2+1 \le n \le N-1$ .Here, F_s denote the sampling frequency. The result after this step is often referred to as spectrum or periodogram.

The mel-frequency scale is linear frequency spacing below 1000 Hz and a logarithmic spacing above 1000 Hz.

This mel scale is used in MFCC to emphasize on low frequency components. As the mel cepstrum are the real numbers we convert it to time domain signals using Discrete Cosine Transform (DCT). We used the following formula to compute the mels for a given frequency f in Hz:

mel(f)= 2595*log10(1+f/700)

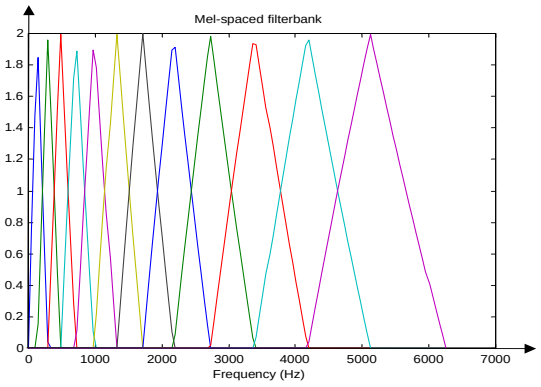


Fig. 3 An example of mel-spaced filter bank

As MFCC parameters had too much components to be processed, DCT helps to get a lower dimensional feature. In

the last block of fig 2 we have seen that the log mel spectrum has to be converted back to time. The result is called as the mel frequency cepstrum coefficients (MFCCs) that consists of two main components- DCT and Log as shown in fig 4.

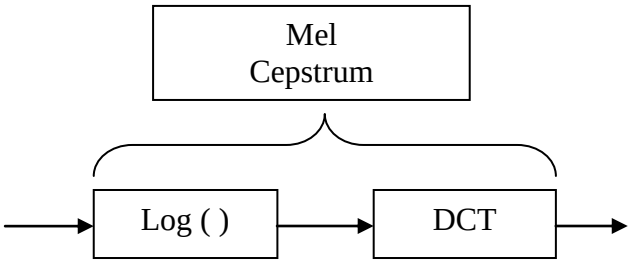


Fig. 4 Mel Cepstrum Coefficients

The MFCCs can be calculated by using the following formula:

$$\widetilde{C_n} = \sum_{k-1}^{K} (\log \widetilde{S_k}) \left[n \left(k - \frac{1}{2} \right) \frac{\pi}{K} \right]$$

where n=1,2…….K

B. Feature Matching

Feature matching involves the actual procedure to identify the unknown speaker by comparing extracted features from his/her voice input with the ones from a set of known speakers.

Vector Quantization is an easy quantization technique used to compress the large data into small information has a high accuracy and is effective. Using this method, we have done mapping of the different feature vectors that carry the information of the each repeating segment that we have extracted using MFCC. We have generated the codebook by k means algorithm as shown in the fig 5 given below.

Firstly, N codebooks are created for all N repeating segments in a well defined manner and stored in a database. And secondly, a group of vectors are created and then computed to N codebooks in the database. We can perform this technique by using K-means clustering algorithm that is slower and more accurate algorithm. In this, we arbitrarily choose M vectors and then nearest neighbour vectors are searched. The centroid is updated and we repeat this procedure until the error is minimum.

Another method is the binary split with K-means clustering algorithm that is faster and accurate than K-means algorithm. We used to split the large data into small bits using VQ like if there are 24 bits used for data representation, VQ helps to perform using only 4 bits.

Firstly, we find the centroid C from all the data. Then we split the data into two- C1, C2. Regroup the data into two classes according to the two new centroids C1, C2. Next step is to update the 2 centroids according to the two splitted groups and from each group find a new centroid. Similarly, split the centroids again to become 4 centroids, regroup and update the 4 new centroids. This is how the binary split codebook is generated.

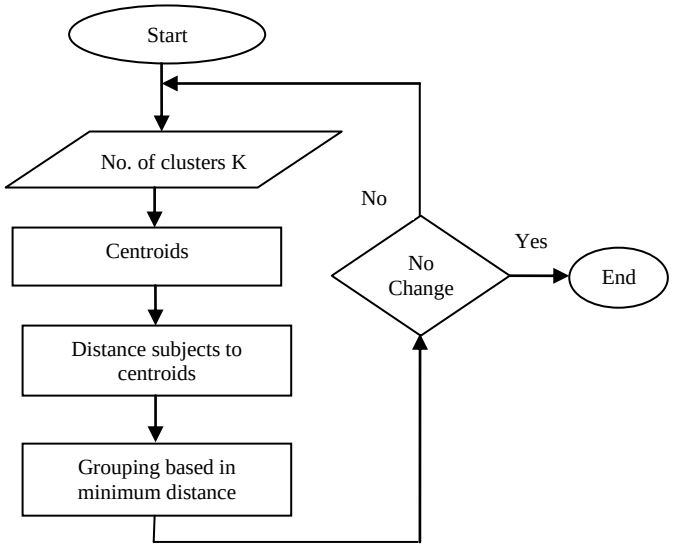


Fig. 5 Flow chart for the K means algorithm used for matching

Split function: new_centroid= old_centriod(1+/-e), for 0.01≤e ≤ 0.05VQ is used to represent the centroids of the distribution by taking a large set of feature vectors and creating a smaller set of vectors. A total number of 10 centroids were used. It was the model system used to measure the best matching repeating segments between the query segment and other segments of the same size for each of the 5 songs in the database.

III. RESULTS & DISCUSSIONS

We have considered different Hindi songs and examined the repeating segment in the song and taking one as the query segment we used to do matching for calculating the accuracy for different songs. The results are summarized in table I.

TABLE I

SIMULATION RESULTS FOR HINDI SONGS

S. No.	List of songs	Duration of song	Query segment	Length of query segment	Number of repeating segments	Accuracy (%)
1	Song1	2min	"Karta hain Dil"	15msec	2	98
2	Song2	3min	"Laage"	12msec	7	96
3	Song3	4min	"Saadi"	13msec	6	95
4	Song4	5min	"O piya"	14msec	5	98
5	Song5	6min	"yarrian"	12msec	4	97

Here in this paper, we have detected the repeating segments using MFCC as feature extraction and matching procedure is carried out using VQ by K-means algorithm. From the table I it is seen that accuracy, number of repeating segments for different query segments have been calculated by performing an experiment.

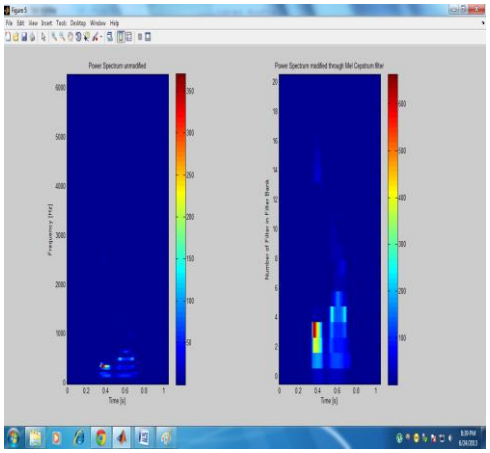


Fig. 6 Power Spectrum Modified through Mel Cepstrum Filter for song 1

The similarity matrixes that give expensive results are compared with the VQ method for detecting the repeating segments as shown in fig 7.

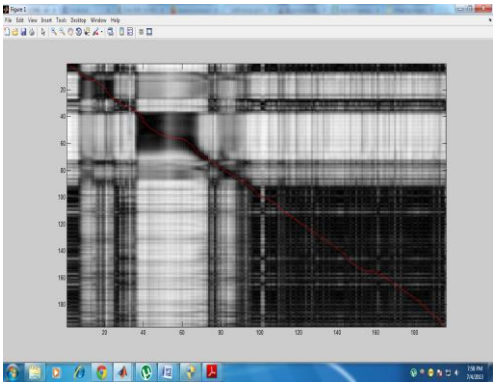


Fig. 7 Similarity matrix computation for song 1

In fig 8, we have plotted the histogram for detecting the best match as well as the peaks represents the repeating segments for the song 1 taken in the experiment. Similarly, we perform the same procedure for rest of the songs.

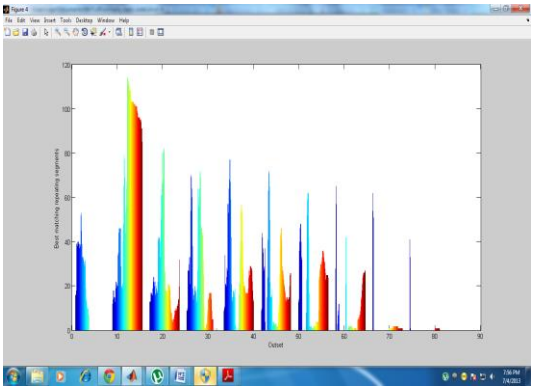


Fig. 8 Repeating segment detection Histogram for song 1

IV. FUTURE PLANS

Our future work is to detect the repeating segment using different methods for song in various languages like English, Spanish, Punjabi and for categories like jazz, classic and many more.

V. CONCLUSION

We proposed a structure that gives 98% accurate results for the detection of repeating segments as shown in fig 8. In this procedure we first extract features from the different repeating sections. We considered first segment of the song as query segment, extract MFCC features from it and then, we extract MFCC features for other recorded segments. Then, we match query segment with the other segments one-by-one and compute histogram of the repeating matching segments.

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A Faster Algorithm for Calculating the Sample Entropy

A faster algorithm for calculating the sample entropy of physiological signals

Gašper Fele-Žorž
Faculty of Computer and Information Science
Tržaška cesta 25
Ljubljana, Slovenia
polz@fri.uni-lj.si

ABSTRACT

In this paper, we present an overview of different methods for calculating a measure of signal complexity called sample entropy. We then present a way to improve the most widely used algorithm by using a skip-list.

Categories and Subject Descriptors

I.5.4 [**Applications**]: Signal processing

Keywords

sample entropy, skip list

1. INTRODUCTION

In nature, many processes are quite unpredictable. The level of unpredictability can sometimes tell us a lot about the system under observation. Research has shown, for example, that the heart-beats of people with some heart problems tend to be more regular than the heart-beats of healthy individuals.

Unfortunately, the most widely used method currently for calculating the sample entropy of signals is too slow to allow anything but offline processing of signals.

2. METHODS

Sample entropy is a measure of predictability of a time series. Apart from the time series itself, it also depends on two parameters, template length m and tolerance r. The less predictable time series, the higher it's sample entropy will be.

Suppose we have a finite time series $y(0, \ldots, N-1)$ of length N. Given a constant $m; m << N$, $y(t)$ can be divided into $N-m+1$ pattern templates $x_t(0, \ldots m-1)$ of length m so that $x_t(i) = y(t+i)$ for each $i = 0 \ldots m-1$ and for each $t = 0 \ldots N-m$.

Given a positive tolerance r, we can consider x_{t2} to match x_{t1} if $|x_{t1}(i) - x_{t2}(i)| \leq r$ for each $i = 0 \ldots m-1$.

The predictability of a time series can then be estimated by counting the number of matching templates for each template within a time series. An example time series with

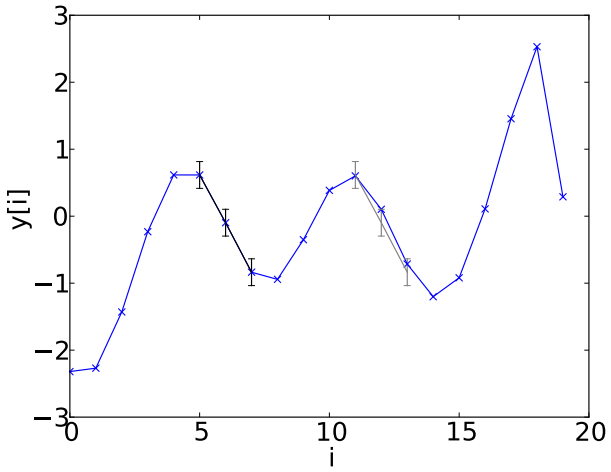


Figure 1: A time series with a template of length 3 at $i = 5$ and it's match within $r = 0.2$

a template m=3 samples long and it's matching template within $r = 0.2$ are shown in Figure 1.

Sample entropy depends on the probability that if for some template, a matching template of length m within a margin of r is found within a time series, then a matching template of length $m+1$ within a margin of r is also found. If no matching templates are found in the whole signal, sample entropy depends only on the length of the time series N and the template length $m+1$. The templates of length m at the end of a time series $(y(N-m) \ldots y(N-1))$ are a special case since there can be no matching templates of length $m+1$ corresponding to these matches.

More precisely, if A_m is the number of matches for all templates of length m within a time series $y(t)$ and B_m is the number of matches for all templates of length m except the ones at the end of the time series $y(t)$, sample entropy is

```
sampEn(y, r, M):
    N=len(y);
    lastruns=zeros(N);
    runs=zeros(N);
    A=zeros(M);
    B=zeros(M);
    e=zeros(M);
    for i in 0...N-1:
        y1=y[i];
        for j in i+1...N-1:
            if |y[j]-y1| < r:
                runs[j]=lastruns[j-1]+1
                for m in 0...min(M, run[j])):
                    A[m]+=1
                    if j<N-1:
                        B[m] += 1
            else:
                run[j]=0;
        (runs, lastruns) = (lastruns, runs)
    B = concatenate([N*(N-1)/2], B[:-1])
    p=A/B;
    return -log(p)
```

Figure 2: The most widely used algorithm for calculating the sample entropy of a signal

defined [3] as:

$$sampEn_{m,r}(y) = \begin{cases} -log(\frac{A_m}{B_{(m-1)}}) & : A_m \neq 0 \wedge B_{m-1} \neq 0 \\ -log(\frac{(N-m)}{(N-m-1)}) & : A_m = 0 \vee B_{m-1} = 0 \end{cases} \quad (1)$$

For $m = 0$, B_m is set to $\frac{N \cdot (N-1)}{2}$.

2.1 Calculating the sample entropy in $O(N^2)$ time

The obvious naïve algorithm for calculating sample entropy is to count the number of matches for each template of length m. Assuming that m is much smaller than N, the time complexity of this algorithm is

$$O\left(\frac{N^2}{2} \cdot (1 - (1 - p_r)^m)\right)$$

where p_r represents the probability of two samples, $y(i)$ and $y(j)$, being within r of each other. For typical physiological time series, r will be chosen so that p_r is usually small.

The algorithm above can typically be improved by a factor of close to $\frac{1-(1-p_r)^m}{p_r}$ by storing the runs of matches in an array of length N. The improved algorithm also calculates the sample entropy for every $m \leq M$ at no extra cost:

The time complexity of this algorithm is $O(N \cdot \frac{N}{2} \cdot (1 + p_r \cdot m))$

An example calculation of sample entropy is shown in Figure 3. The time series used, y, is the same as in Figure 1. The table runs is shown for each iteration through y. This seems to be the standard algorithm most researchers use. An implementation in C is available on Physionet [1].

2.2 Calculating the sample entropy using K-D trees

Recently, an improved method has been presented for calculating sample entropy by [2]. The method works by using each template of length m starting at index i within a signal y as a point p_i in m-dimensional space. $N - m$ points are constructed from a signal of length N. All points are inserted into a K-D tree of dimension $d = m$. The number of matches within r for each point are then counted.

Since range counting in K-D trees can be done in $O(N^{1-(1/d)})$ time and a K-D tree can be constructed in $O(NlogN)$ time, this algorithm is noticeably faster than the most commonly used algorithm.

This algorithm has been improved further by [4]. Instead of inserting all points into a single K-D tree and then performing queries against the whole tree, the number of points in the tree during each query can be drastically reduced by first removing all points from the tree and sorting the points by the first dimension $p(0)$.

The sorted points are then inserted back into the tree one by one until $p_i(0) > min(p(0)) + 2r$. Matches are then counted for each point in order of $p(0)$. When $p_i(0)$ reaches $min(p(0)) + r$, the points with the lowest $p(0)$ are removed from the K-D tree and all the points with $p(0) < p_i(0) + r$ are inserted.

This way, the K-D tree is kept small so the counting of matches can be done faster.

Due to the curse of dimensionality, these methods should perform poorly for large values of m. Since m is usually low, this is unlikely to present a problem.

2.3 Calculating the sample entropy using a skip-list

As depicted in Figure 3, typically, a small number of samples in y are within r of each other. The standard algorithm for calculating the sample entropy can be improved by skipping over those parts of y where the begginings of patterns do not match.

```
sampEn(y, r, M):
    N = len(y)
    lastrun = zeros(N) with history of length M;
    run = zeros(N) with history of length M;
    A = zeros(M)
    B = zeros(M)
    L = OrderedStructure
    for i in 0...N-1:
        L[y[i]] = i
    for i in 0...N-1:
        y1 = y[i];
        runs.history.remove_oldest()
        for j in run.history:
            runs[j] = 0
        sums = zeros(M)
        for j in L[y1 - r]...L[y1 + r]:
            runs[j] = lastruns[j-1]+1
            runs.history.newest.add(j)
            sums[min(M, runs[j])] += 1
        m_sum = 0
```

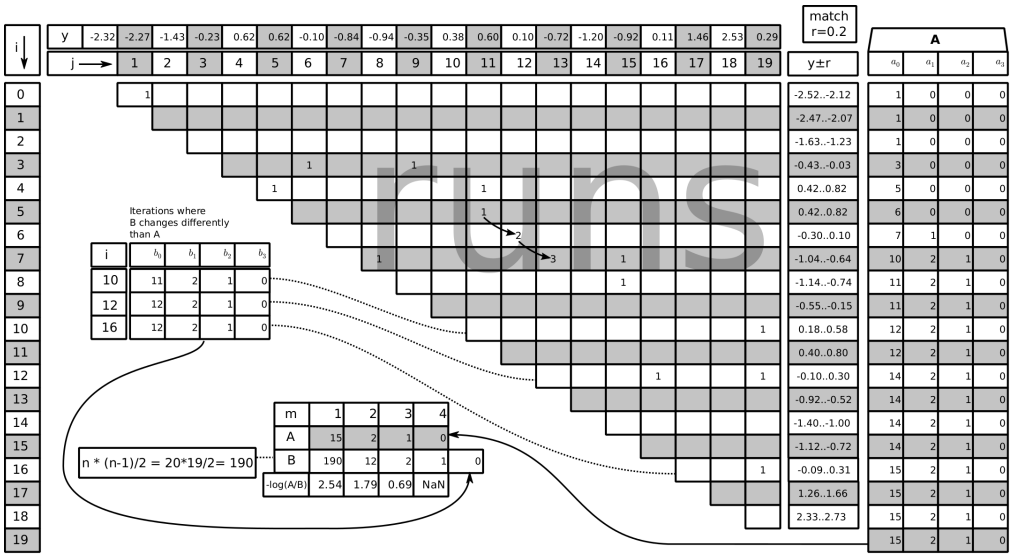


Figure 3: An example of sample entropy calculation.

```
    for m in M...0 step -1:
        m_sum += sums[0]
        A[m] += m_sum
        if j<N-1:
            B[m] += m_sum
    (runs, lastruns) = (lastruns, runs)
B = concatenate([N*(N-1)/2], B[:-1])
p=A/B;
return -log(p)
```

The time complexity thus becomes $O(N \cdot A_{L0} + N \cdot (A_{L1} + p_r \cdot (N/2 \cdot A_{L2} + m)))$ where A_{L0} denotes the time to add an element to L, A_{L1} denotes the time to access the first sample $y(j)$ which is greater than $y(i) - r$ and A_{L2} denotes the time to access each subsequent sample. The expected number of matches for each $y(i)$ is $p_r * N/2$.

For the algorithm to offer an improvement, the data structure L would have to offer certain performance guarantees. The value of the sample would serve as the key and it's position in the original time-series would serve as the value. In this data structure, the following operations would have to be fast ($O(\log(N))$ or better):

1. the storage of multiple instances with the same key (A_{L0}),
2. the retreival of the first instance whose key is above a certain limit (A_{L1}),
3. given an instance, the retreival of the next-higher instance (A_{L2}).

Preferably, the structure would also be simple to implement.

We decided to use a modified skip list. Normally, each node in a skip list contains a single value. Unfortunately, on modern computers, pointer lookups are relatively costly, especially when they lead to pages which are not yet in the processor's cache.

We therefore decided to implement a "fat skip list". A fat skip list is a skip list whose nodes contain sorted tables of elements. The size of each node is chosen according to the expected target microprocessor architecture during compile time. Our implementation is written in C.

When using a skip list, the time complexity of adding an element to L, A_{L0}, is $O(\log(N))$ and the expected time complexity of searching for the first matching element, A_{L1}, is $O(\log(N))$ in both cases with very high probability. The time complexity of finding the next match, A_{L2}, is $O(1)$.

Our algorithm would perform poorly if the value of r were high (i.e., p_r would be high), which would mean that for each starting sample in each pattern, there would be many matches within the time series. For finite, semi-random time, series and a small enough p_r, we can assume that the number of matching samples for each sample $y(i)$, $p_r \cdot N/2$ will be small. For a small enough r, this could be considered as a constant, C_{p_r}.

With these assumptions, the time complexity of our algorithm becomes $O(N \cdot \log(N) + N \cdot (\log(N) + C_{p_r} + m))$.

Unfortunately, if the signal is normalized prior to calculating sample entropy. The number of matching samples in this case can no longer be considered as small and the time complexity of our algorithm becomes $O(N \cdot \log(N) + N \cdot (\log(N) + N \cdot p_r + m))$. We expect our implementation to be slower than the algorithms using K-D trees and range counting.

3. RESULTS

We tested our algorithm on sections of two time series with various parameter settings. The first was the test data provided with the sampEn program. The second was pink noise.

We used pink noise as an approximation of a physiological signal [5]. We noted the running times of our algorithm and of the more widely used implementation with respect to the length of the signal subsection. Both our algorithm and the most widely used implementation were compiled using gcc 4.8.1 with the -O3 flag and run on a desktop computer running Ubuntu with Linux version 3.2 on an Intel(R) Core(TM) i5-3570K CPU @ 3.40GHz with 8G RAM.

3.1 Worst case

In the worst case, we normalized the signal and set the r parameter to 1.0 so that every pattern matched on each sample in the time series. To make the most widely used algorithm perform better, we set m to 2. Even in this case, our algorithm was faster than the most widely used implementation.

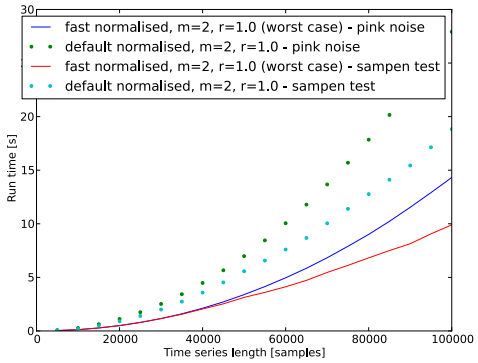


Figure 4: Time needed to calculate the sample entropy of the used signals (worst case). The most widely used implementation is marked as "default".

3.2 Best case

In the best case, the signal was not normalized, r was set to 0.02 and m to 100. In this case, the most widely used algorithm performed relatively poorly.

3.3 Typical case

Typically, sample entropy is calculated for physiological time series. The signals were normalized, m was set to 5 and r was set to 0.2 - the default settings for the most widely used implementation. The improvement in runtime when compared to the more widely used method was noticeable, especially for longer time series lengths at a low value of r.

4. DISCUSSION

The main idea behind the improvement of the algorithm used to calculate the sample entropy of a time series was to only count those pattern matches where the first samples of the patterns are within r of each other, skipping over the rest. To do this efficiently, we only needed to use a data structure which enabled us to search for an element greater than some specified value faster than in $O(N)$ time.

The first implementation of our algorithm used simple skip lists. The penalty incurred by the constant dereferencing of

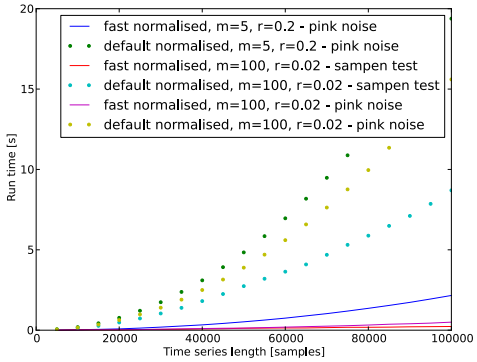


Figure 5: Time needed to calculate the sample entropy of a signal (best, typical cases). The most widely used implementation is marked as "default"

pointers turned out to be so great that our implementation of the algorithm was slower than the more popular sampEn on all but the longest time series. Using fat leaves, in the worst case, the current implementation is faster than the most widely used algorithm.

4.1 Further work

The algorithm presented in this article can easily be adapted for the calculation of sample entropy of consecutive subsections of a time series, using a sliding window.

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