Intelligent systems applications

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In this paper we present and discuss the state of intelligent system applications, with special emphasis on Slovenia. We take the viewpoint that intelligent systems facilitate a new qualitative step towards the information society. Thus, they provide an important opportunity for any country to intensify its information, economic and social development. We present some intelligent system applications developed or being developed in our group: (1) EMA, an employment agent, (2) GIVE, a semantic web speaking system, and (3) DEXi, a decision modeling system. Based on past experience, we highlight the principal problems that occur in the development and exploitation of intelligent systems, and suggest improvements for the future.

1 Introduction

Information society is transforming the way we live. One of the key opportunities in this context is provided by intelligent systems (Goonatilake, Treleaven 1996; Gams 1998; Hopgood 2001). Intelligent systems simulate intelligence so that a typical user seemingly perceives it as a truly intelligent system. In reality, these systems have more or less preprogrammed patterns of human behavior. Due to limited application areas, most of cliché replies can be preprogrammed in advance. From the viewpoint of computer systems, they therefore somehow manage to fake simple intelligence, and from the practical viewpoint it does not really matter whether the user deals with true or simulated intelligence.

Intelligent systems are aimed at extending the applicability of computers and providing a technological basis for new and improved information services. Intelligent systems have found a variety of valuable applications in the areas such as:

- Manufacturing and design
- Business operations
- Finance
- Diagnostics and troubleshooting
- Claims processing and auditing
- Telephony
- Software industry
- Military and Space industry

Generally speaking, intelligent systems are useful because they provide more useful functions (Buchanan et al. 1999; Hedberg 1998). Computers are much cheaper and faster than humans, yet much dumber. In fact, computers can still be regarded only as very fast computing machines without any trace of true intelligence (Gams 2001b).

Classical computer systems can function 24 hours per day, all days per year, with overall small expenses compared to humans. The speed of communication and calculation enable a single computer to communicate with hundreds of human users at the same time. Advances in engineering intelligence combined with advanced hardware enable intelligent computer systems to compete with humans in more and more tasks.

Another important factor is the growth of the information society. A growing number of functions are supported by computers (Hamilton 1999). Humans are getting overloaded due to information overload. Huge amounts of data are processed by computers several orders of magnitude faster than by humans (Lewis 1999; Schwartz, Treece 1992).

Another very important property of information society is the growing space of all possibilities. Namely, technical possibilities in recent years grow much faster than they are – or can be – exploited. In reality this means that we are dealing with huge space of generally available intelligent information technology capabilities. This is quite different compared to other technologies, such as space flights. The production of a new space shuttle is so expensive that it is hardly economic. It is cheaper to exploit the current form for years before introducing a new one. Unlike this, intelligent systems in the information age enable more new applications than we humans actually manage to implement (Figure 1). In other words – while space flights are restricted only to the richest and strongest countries in the world,

practically every qualified information technology (IT) group can in principle develop world-class computer programs. This is slightly similar to the times when everybody could grab new land. All that was needed was a good horse, a good idea and determination. In analogy, IT horses are cheap and freely available.

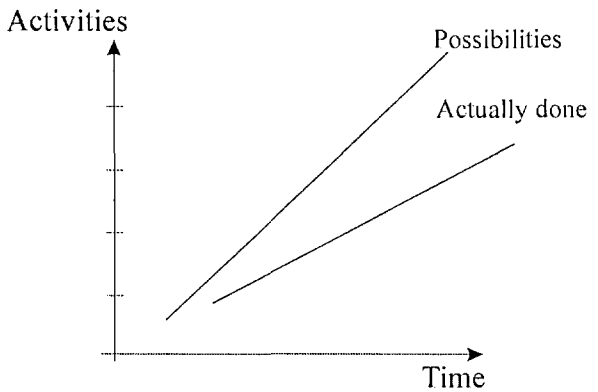

Figure 1: The information society enables more applications than we humans manage to implement. The gap is widening.

The information society also introduces major changes in the scientific community. Knowledge is not only stored in books or remote encyclopedia – it has become easily available throughout the Internet. IT has significantly changed the way we create and use knowledge.

Generally, we accept the assumption that scientific disciplines produce new ideas spurring further progress in the whole society. Intelligent systems are no different, with additional observation that these systems have a huge area of potential applications. Any system that has improved properties in the sense of intelligence is more capable and potentially more acceptable to the users.

In this light we analyze the relation between science, development and applications. Unfortunately, scientific and development communities still seem two worlds apart. When analyzing these differences and problems regarding applications we try to identify generic problems that are probably present in many countries. On the basis of these analyses, improved relations between intelligent systems and artificial intelligence (AI) research versus applications can be proposed.

In reality, the gap especially between AI research and applications is wide indeed. Many if not majority of AI researchers and professors have not cooperated in any real-life application and many if not majority of AI development engineers have not done any formal research at all. Therefore, the question at hand is why and how these strained relations occurred and which are the reasons prohibiting better cooperation?

In our department, we have several 100 man-year experience in intelligent systems. We have cooperated in several tens of applications, in several thousands of scientific publications and personal communications with several hundred researchers, developers and engineers in most of European countries and USA.

By analyzing problems in Slovenia and Europe as countries we have some experience with, we shed some light not only on the problems but also on a couple of successful applications that were developed or are being developed in our Department of Intelligent Systems. The developed systems have been already used by several ten thousand users monthly, they controlled the production of several hundred thousands tons of products and overall had a considerable impact on our society.

2 Problems with cooperation

The first difference between the scientific and development community is in different motivation and evaluation. The number and quality of publications determine the quality of researchers, while developers are evaluated mainly by their commercial success.

On average, in both communities a researcher or a developer is highly above average with respect to knowledge, intellectual and technical abilities. Many of them would be successful either in scientific or in practical development tasks.

It is generally accepted that a successful application demands the fulfillment of several successful attributes, and that many of them are not well known. For example, the key factor is the interest or motivation of the management of a particular company. Many researchers would probably regard as the major factor the novelty of the idea/product, but this is just one of important factors, not the major one.

In our experience, the single major factor was indeed the desire and knowledge of the top manager. If that person was in favor of research, then sooner or later his/hers company found some cooperation with researchers. And sooner or later one of those cooperations resulted in important advanced systems.

The following reservations are often encountered in the development/engineering community:

- Academic research and practical applications are worlds apart. Academic institutions are interested in their academic puzzles often not related to real life or real-life applications. This academic knowledge is often nice for teaching simple cases in formal domains but often irrelevant for commercial applications.
- The government supports academic institutions regardless of their influence, success and relation to human society, while commercial companies must

take care of their own, are evaluated by strict real-life commercial criteria, and have no guarantee for survival. Instead of funding academic research, governments should support research departments in commercial companies.
- By supporting R&D departments at national academic institutions, governments actually subsidize dumping competition. These research groups can offer dumping prices, thus eliminating true marker capitalism and economy.
- Commercial companies should be motivated to order research projects at national institutions by tax reductions and other systematic national support.
- Commercial companies fear cooperation with academic institutions due to bad experience with famous researchers who did not deliver products and projects in promised time, and faced practically no consequences.

Academic community, on the other hand, faces other problems. There are individuals or groups that are not interested whatsoever in any cooperation with industry due to several reasons such as their purely theoretical type of research or vague perceptions that applications only distract true researchers from high-quality work. However, those researchers that are willing to cooperate and see reasonable motives in doing so for both sides, often mention the following problems:

- Cooperation with industry is not stimulated enough compared to pure research – those interested in cooperating with industry produce less scientific publications, get lower personal evaluation marks and thus lower income and slower career progress. Since the incomes are more or less fixed in governmental institutions, additional projects and applications hardly provide additional incomes.
- Commercial companies and governmental institutions often waste huge amounts of money for non-functional matters, such as employing disproportional number of employees, luxuries, or even half-legal matters while often disregarding the possibilities of cooperation with research institutions which by definition can not be all commercially successful.
- Business institutions are not systematically motivated for cooperation with research – either by tax reductions or by projects supported by the government
- Many top-level managers are not inclined to take any risk with new research; they are fully overloaded with actual production / cash-related activities.
- Governmental institutions are often stiff and inflexible. Each risk is punished while successful actions are hardly rewarded.

It is a bit surprising that a reasonable proportion of the problems with too little cooperation between research and industry is related to small interest of top-level managers, but that is clearly the case at least in Slovenia, and probably also in Europe. For example, our Intelligent Systems group from time to time offers cost-less applications to specific companies. The idea is simple: by introducing successful applications – prototype or complete – we hope to increase cooperation. But important business companies often tend to decline such free cooperation due to several reasons that can hardly be accepted as reasonable. For example, one of the arguments is often that the company's data are confidential and sensitive, so they cannot be released to outside research organizations for analyses. But such data can easily be transformed into unrecognizable strings, and there are means to strictly impose law and regulations so as to guarantee its secrecy. The Internet and email applications are often declared unsafe, thus enabling stealing and misconduct. But compared to real life, e.g., problems with business fraud, and taking into account the availability of successful counter-measures in electronic business, these problems first of all demonstrate unreasonable fears and lack of knowledge at the top.

Some of these problems were encountered also at the post-graduate courses where students proposed advanced applications of intelligent systems and were often not allowed to proceed due to the fears of local managers. Actually, there was another fear behind – that the students will supercede their bosses, who will consequently degrade on the hierarchy ladder.

3 Some real-life applications

Here we briefly describe a couple of intelligent-systems applications. They were designed in the Department of Intelligent Systems at the Jožef Stefan Institute in Slovenia. The group has from 20 to 30 members and several hundreds of man-year experience in intelligent systems.

3.1 EMA: Employment agent

The first system we describe is the EMA employment agent (Gams 2001a; Gams et al. 1998). The basic task of the system was to provide employment information (Figure 2). About seven years ago the system offered over 90% of all nationally available vacant jobs. At that time, no other country provided similar percentage of all jobs on the Internet. Of course, due to 2 million inhabitants, absolute numbers were still small compared to large countries. On the other hand, it provides further evidence that Figure 1 showing the growing area of possible applications is indeed correct – how else could we provide a better penetration of the Internet in a specific area knowing that the average income of the country is well bellow the European Union average?

One big advantage is obviously size – in a small country it is enough to provide just one global database while large countries have to take into account federal and local specifics.

When presenting EMA, we would like to emphasize two additional factors – EMA consisted of several tens of modules, including job-description ontologies, natural speech modules in English and Slovenian, and global automatic data-wrapper as a kind of universal agent employment communications. However, all these advanced functions were not of major relevance for the business. Most of the users just wanted information about free jobs.

The major problem we faced with EMA was organizational - due to inappropriate legislation, all job applicants have to receive a hard-mail reply. Since interesting jobs offered through the Internet got hundreds and even thousands of job applications, the institutions had to send as much written replies. In return, many of job applicants complained about being returned down, thus producing additional delay, and finally, institutions were unsatisfied because of the additional work. While EMA enabled substantially improved national job services, institutions were dissatisfied because of the archaic law. Therefore, since the law regulations did not follow technological IT advances, the system was not as helpful as it could and should have been.

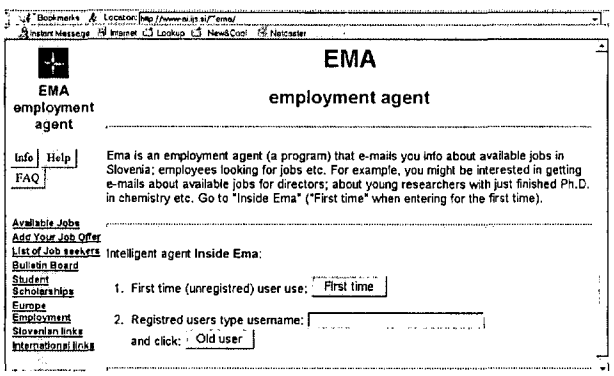

Figure 2: Intelligent agent EMA offered over 90% of all nationally available jobs seven years ago. This was a world-class result showing that Internet applications indeed enable even small countries to produce relevant systems.

There were many single stories indicating the advantages of the system. For example, a brilliant student wanted to return to Slovenia from USA and with EMA's help he found an interesting vacant job of a faculty assistant. When he applied, no competing candidate met his characteristics. But the professor already had an agreement with some local friend to hire another, reasonably decent candidate. So they decided to declare all job applications invalid and retried until the desired candidate succeeded.

It seems strange, but the result of these problems was that EMA was allowed to offer only those jobs that the employers wanted to. Consequently, any job offer was allowed to remain hidden.

In a sharp contradiction, some developed countries like USA a bit later introduced all governmental national job offers (EMA included both governmental and nongovernmental) through the Internet, but there is no way a governmental job can be hidden from the eyes of the Internet public.

The EMA experience is therefore mixed – we managed to introduce several new advanced functions, implemented a system that was used by around 10% of all our population in best months, but had to degrade the system substantially because of the lack of appropriate legislation. Better to say – the system was developed due to the encouragement of the minister of science and the director of the National Employment Service, who strongly supported the idea. But they could not modify the national laws, which later hampered the system.

Overall, the system was the most often used intelligent system in Slovenia so far, and the percentage of Internet-available jobs temporarily put it at top world level.

3.2 GIVE: Semantic-web speaking system

Another Internet-based system is GIVE – a national project that enables multimedia access and use of the Internet through telephones (Figure 3). The idea is that due to several circumstances the users need Internet functions through mobile or stationary phones – e.g., one drives a car and can only use a phone.

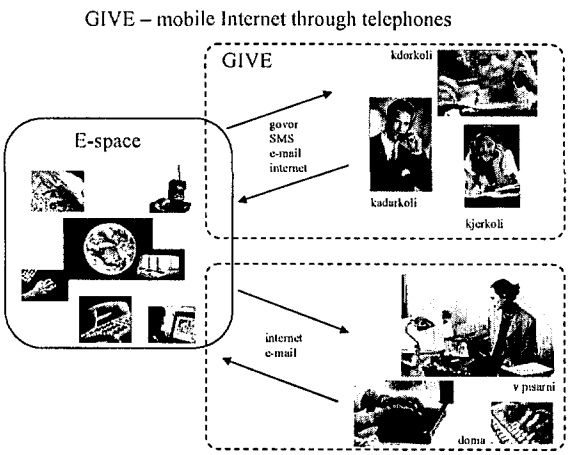

Figure 3: Project GIVE provides Internet through phones in Slovenian language.

At the first stage, there is a prerecorded human speech and dynamically generated program speech. The speech system enables voice output from any URL address by parsing HTML pages and speaking it in Slovenian. More relevant, the system enables any user to put text information through the GIVE system into GIVE's local databases. The most common access is through a specific input telephone number and the telephone

number of a particular institution or a person. In this way, for instance, anybody can get information about some governmental institution or service even though no human is present there late at night.

The GIVE project is still in progress, but several modules and functions already function fully.

3.3 DEXi: Decision modeling system

DEXi is a computer program developed in collaboration with the University of Maribor, Faculty of Organisational Sciences. The program facilitates the development of qualitative multi-attribute models (Figure 4). Such models are useful for supporting complex decision-making tasks, for instance, where there is a need to select a particular option from a set of possible ones so as to best satisfy the goals of the decision maker. A multi-attribute model is a hierarchical structure that represents the decomposition of the decision problem into subproblems, which are smaller, less complex and easier to solve than the complete problem.

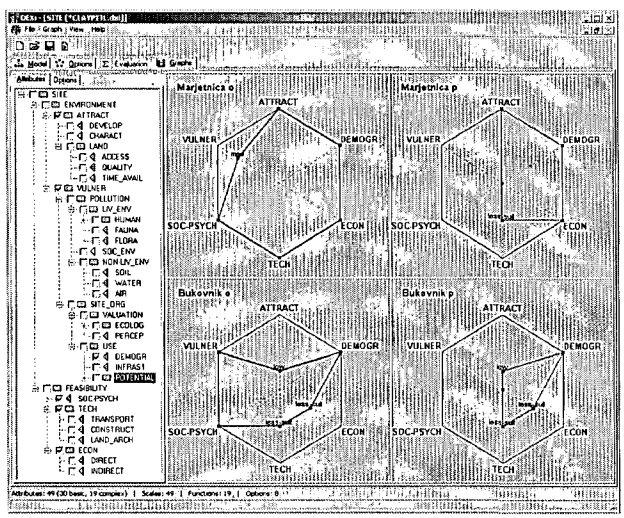

Figure 4: Decision modeling system DEXi facilitates the development of qualitative multi-attribute models (left) and their application for the evaluation and analysis of options (right). The case shown is from the area of land-use planning.

DEXi supports two basic functions: the development of models and their application for option evaluation and analysis. The models are developed by defining:

- attributes: qualitative variables that represent decision subproblems,
- tree of attributes: a hierarchical structure representing the decomposition of the decision problem (Figure 4, left),
- utility functions: rules that define the process of aggregation that takes place from the bottom to the top of the hierarchy.

In the evaluation and analysis stage, DEXi facilitates:

- description of options: defining the values of basic attributes, i.e., the leaves of the tree,
- evaluation of options: a bottom-up aggregation procedure according to utility functions,
- analysis: what-if analysis and selective explanation of options,
- graphical presentation of the evaluation results (Figure 4, right).

DEXi is not an intelligent system by itself, but contributes to the development of intelligent systems. Namely, the models developed by DEXi can provide a firm basis for intelligent decision support; the models can be either embedded into other intelligent systems, such as agents, or used in a stand-alone way to support the analysis and justification of decisions.

So far, DEXi and its predecessor DEX (Bohanec, Rajkovič 1990) have been applied in more than fifty real-life decision problems (Urbančič et al. 1998), which involved thousands of users. Recently, there were a number of applications in health-care (Bohanec et al. 2000) and industry (Bohanec, Rajkovič 1999) for decision problems related to land-use planning (Figure 4), ecology, and the evaluation of enterprises, products, projects and investments.

4 How to improve cooperation

Successful cooperation between research and application community is seen as one of the keys for successful progress in the information society. The following arguments seem particularly important:

- Researchers at faculties and institutions have great amounts of relevant and most advanced knowledge. That knowledge enables introduction of new-generation real-life systems with potentially wide influence and major market success. Researchers and professors represent the intellectual elite. Many if not even most of them are quite interested in cooperation with industry.
- Regular contacts between industry and academia are beneficial for all sides. Researchers get state-of-the-art knowledge about current level of commercial applications, and developers get some ideas about major research directions probably influencing future commercial progress.
- Regular contacts can be established on a good-will cooperation basis without major costs or funding. Conferences, public lectures and other forms of knowledge representations offer the easiest and very efficient contacts.
- Research community is diverse and heterogeneous. Therefore, directors are not good representatives of what is done at an institution. Researchers and developers should meet at department level searching for specific areas of interest.

5 Conclusion

Intelligent systems are one of the most attractive fields of IT. Due to the progress of computer raw power and advanced engineering-intelligent applications, these systems are becoming more cost-beneficial compared to humans in more and more tasks. Computer systems are much faster and cheaper than humans and with a bit of simulated intelligence they outperform humans in several bureaucratic or every-day tasks.

Information society enables great opportunities not only for the most developed countries. Small countries can quickly accept knowledge from the most developed countries and quickly reapply it in small countries for world-novel problems.

The major problem in developing intelligent systems applications is the cooperation between academic and engineering community. Improved cooperation could serve well both, but there are unreasonable obstacles indicating the need for systematic improvements.

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