Urban gamification with Augmented Reality and Geo-Referencing: An Innovative and Engaging Cultural Heritage App

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***Abstract*—Creating an application, focused on the promotion and demonstration of local cultural heritage can prove to be a task of ample difficulty. It is paramount to recognize that the aforementioned solution is designed to tackle a problem with which the target audience doesn't concern themselves habitually. Thus, the approach towards publicizing a smartphone solution for such a problem should be comprehensive, continual, inclusive and resourceful. The fact that we now live both in the age of mobile-first software development and oversaturation of application markets, only further emphasizes the importance of studying the state of the art. Furthermore, this should not only be done in the field of mobile solutions promoting cultural heritage, but also in those similar to it - be it in the way that they both strive to engage their audience with urban exploration or presentation and discovery of specific content. In addition to that, studying the advances in modern mobile technology may yield other use cases that can be used in such an application, perhaps in ways similar solutions are yet to implement.**

The authors of this article have aimed to include the overview of all above-mentioned fields herein, with the goal of making kulTura, their application for the promotion of cultural heritage in the city of Jastrebarsko and the municipality of Črnomelj, as alluring and modern as possible.

Keywords—Cultural heritage, AR, urban gamification, UX, content discovery, geo referencing

I. INTRODUCTION

The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines *Cultural heritage* as the *legacy of physical artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations*.[1] The institution does not specify in which way the artifacts of the past should be entrusted to the descendants of their creators, but to benefit from their cultural significance, the latter generation need to, above all else - comprehend their value.

It is no mystery that the current generation's lives heavily depend on the usage of mobile devices. In 2018, 52.2% of all worldwide online traffic was generated through smart phones,[2] with the 79% of internet users in the European Union using their smart phones to surf the web in 2016.[3] Furthermore, in 2017 the world's largest video streaming service – YouTube, announced that over 1 billion hours of content is being broadcasted every single day[4], with 70% of it being done on mobile platforms.[5]

These numbers alone speak volumes about the fact that the generation of today can be approached through the mobile world in an impactful way. It is here that we receive information and expect to be communicated with, with 75% of all US digital ad spend going towards native mobile advertisements.[6] Hence, mobile applications are a suitable means for our comprehension of - and consequential benefit from cultural heritage, now more than ever.

The authors of this article aim to create such an application in the following years. As part of the kulTura project funded by The European Union through the Interreg Slovenia-Croatia programme and the Slovenian Research Agency, it will seek to inform its users about the tradition and legacy of over 50 time-honored smaller towns along the Slovenian-Croatian border, starting with the cross-border pair of the Municipality of Črnomelj in Slovenia and the city of Jastrebarsko in Croatia.

However, said mobile solution is to be fashioned in such a way, that the possibility of it realizing its intent – bestowing the cultural heritage of these locations upon younger generations, will be as high as possible. Therfore, we decided to preface our work with a thorough review, resulting in this article. As the explosive growth of the mobile application market has made it a significant challenge for the users to find interesting applications in crowded App Stores[7], we concluded that a study of the state of the art is one of the methods required to accomplish this task. Furthermore, this should not only be done in the field of mobile solutions promoting cultural heritage, but also in those like it - be it in the way that they both strive to engage their audience with urban exploration or the presentation and discovery of specific content. In addition to that, studying the advances in modern mobile technology may yield other use cases that can be used in such an application, perhaps in ways similar solutions are yet to implement. The

overview of our study of these fields can be found within the following sections.

II. State of the art

When conducting the study of the newest ideas and features, as well as the highest level of general development in a specific field, it is important to adequately define it. In our case, this field does not only envelop all other solutions, oriented towards the propagation of cultural heritage, but also all of those that strive to either inform their users of points of interest in their surroundings, or educate them about a certain topic. Furthermore, any successful app features that attempt to diversify a user's – be it a tourist's, urban explorer's or local's interaction with the world around them, either through gamification or enhancing the world through the inclusion of multimedia content or AR technology, are worth considering as well.

Many of this section's subsidiaries will refer to an application aspect's effect on User experience (UX). UX refers to a person's emotions and attitudes about using a particular product, system or service. Factors influencing UX have been classified into three main categories: user's state and previous experience, system properties and the usage context.[8] While aesthetic and functional design of a service or product, respectively make it visually appealing and optimally operative, user experience design makes sure these aspects of the product work in the context of the rest of it.[9]

During the process of our study, we examined 16 applications [10] - [25] from a broad scope of categories: from those very similar to our cause, to those that only incorporate certain features of interest to us. In addition to those, we also researched several city-focused or regional applications and those that focus on pathfinding. All applications were reviewed in July of 2018 on the Android operating system running Android version 8.0.0.

The remainder of this section will describe, explain and highlight good practices of the most cutting-edge aspects found in the analyzed applications, as well as emphasize any other related conclusions about said features we made while researching them.

A. Inclusion of and redirection to third-party services

Several local or heritage focused applications can benefit a lot from third-party services. This may include, but is not limited to weather and traffic information, ticket reservations and purchases, pathfinding, etc. By integrating already polished, more focused solutions into their app, developers can dedicate more time and resources towards disruptive innovation, rather than work towards something that already exists. Some companies, like Google with its Maps Platform[26], even build their business model around third-party applications integrating their services in the form of application programming interfaces (API).

With the fact that each of a services' functions needs to be evaluated in the context of its entirety in mind, developers should be wary of including any features that redirect to external sources in their applications without proper optimization. This is largely on account of these third-party services having different user interfaces – with the desired contexts of components vastly different from those of the original app.

The aforementioned importance of caution is emphasized when competing with solutions from companies spearheading modern UX design – for example the American travel and restaurant website company TripAdvisor, that doesn't only include third-party services, but makes them a cornerstone of its functionality. While certain reviewed applications only use hardcoded information and simple hyperlinks that lead to sites offering lodging or navigation these features are all integrated into the TripAdvisor application in the form of a browser extension – ticket purchases and reservations can all be done entirely inside the app and in most if not all cases require no redirection, while still offering great detail in communicating all relevant information for the specific use-case. Furthermore, the design complements the content in such a way, that nothing feels out of place.

While redirection towards services that have their native smartphone applications already pre-installed on the operating system may work just as well, we recognized the described approach as the best practice for including external services.

B. Gamification

Gamification refers to the use of game design elements within non-game contexts.[27] This method employs the use of 'building blocks' of games and implements them into real world-settings, often with the goal of motivating specific behaviors within the gamified situation.[28] As the practice has proven to be a success in achieving several different goals, notably the improvement of user engagement[29][30] and learning[31], it is a concept worth exploring in any field, not just application design. Furthermore, it is expected that gamification can also foster the initiation or continuation of goal-directed behavior – i.e. motivation.[32]

Some of the applications we reviewed during the process of our study focus on gamifying the acts of walking, sightseeing and exploration. This is the case with Nexto and Six to Start's The Walk: Fitness tracker game. On the other hand, some others, like Pokemon GO and Ingress, are branded as games, but heavily incorporate the aforementioned acts into their core mechanics.

We found several good executions of sightseeing gamification in *Nexto*. Throughout a guided tour Legends of Piran, the user is met with a plethora of simple game-like mechanics, ranging from quizzes to AR-powered puzzles. Two of the aspects of these minigames stood out as good practices: Their simplicity and diversity. The term 'sustained attention' is often used in reference to a putatively unitary capacity to remain engaged in tasks that are lengthy or characterized by long intervals between relevant events.[33] The gamification aspects of the application not being repetitive is a worthwhile aim of trying to retain both sustained attention and audience engagement, while them (as a service's component) being

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simple corresponds with the Nielsen Norman Group's definition of an exemplary user experience.[34]

The application also utilizes fully voiced storytelling, which is a popular game component on its own, with Time magazine's 2014 Game of the Year creative director Jon Ingold calling video games *'the most fascinating medium for storytelling available right now.'[35]* In addition of interactive storytelling being a trending game design element,[36] building parts of a business around a story is also a global trend in the experience industry, revealing new insights into conceptualizing tourism via story-telling tourist guides.[37]

Another popular form of gamification is the implementation of a visible representations of a player's achievements in the form of collectibles or badges,[38] items such as virtual souvenirs, star tokens or achievement trophies, amassed by performing application related tasks like completing tours or correctly answering quizzes. They confirm the players' achievements, symbolize their merits[39] and serve to numerically represent a player's progress.[40] Additionally, badge-owners can also exert social influence on players and co-players, particularly if they are rare or hard to earn.[41]

Niantic's *Pokemon GO* itself is focused around the amassing of collectible virtual creatures, while also highlighting another interesting form of gamification – a mechanic in which a reward is presented to the user upon completing a certain number of steps.

C. Augmented Reality (AR)

Augmented Reality (AR) is an interactive experience of a real-world environment whereby the objects that reside in the real-world are "augmented" by computer-generated perceptual information. This is sometimes done across multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory.[42]

The usability of this technology resides in the ability to manifest experiences that would otherwise be unreasonably expensive or simply impossible to produce. As our analysis of the reviewed applications will show, when implemented correctly, AR can be used to simulate the inclusion of virtual 3D objects into a real environment in real time – cutting costs and expended time in comparison with manufacturing such objects, while also making them accessible to a wider audience through the inclusion of AR on a user's mobile platform.

The technology's appeal can also be credited to the fact that the emulation of reality and the act of overlaying computer-generated imagery or other synthetic content over physical objects have been some of the more common science-fiction tropes since the late 20th century, prominently featuring in works and franchises like Star Trek[43], Ender's Game[44] and Iron man[45]. However, the capabilities of AR have not yet caught up with the imagination of sci-fi creators and currently still face difficulty displaying objects on non-flat surfaces whilst taking in account camera movements effectively making sure that the projected object abides by the laws of gravity. In spite of its technical limitations, AR offers a very useful tool for creating an engaging user experience, as proven by the reviewed applications below.

The content used most widely in cultural heritage apps relating to AR regularly involves projecting images onto a specific surface. Google Arts & Culture, for example, enables the user to project famous paintings on empty walls, simulating the experience of visiting it in an actual museum. The Nexto app goes even a dimension further by allowing the user to view the 3D Model of a famous composer's violin in the real world. In other instances, the application augments elements of one's surroundings in the pursuit to showcase the state of an object or room in times past – a very useful use-case for an application, showcasing cultural heritage.

However, the UX of applications that include this feature is heavily reliant on the capabilities of the user's terminal. For reference, roughly 77% of mobile devices are running android[46], out of which only around 43% support ARCore - Google's AR software development kit (SDK)[47][48]. On the other hand, Apple's AR SDK - ARKit is supported on 81% of all mobile devices running iOS.[49][50] This represents almost 19% of the mobile OS market share.[51] Consequentially, only close to 50 % of all smartphones can run either ARKit or ARCore. This is mostly due to holographic processing being a computationally-demanding task, as illustrated by leading AR-dedicated devices, like the Microsoft HoloLens headset, including separate processing units, solely devoted to hologram-related tasks.[52] However, several other mobile AR SDKs are available for both Android and iOS. One of them – Vuforia is the kit used in Nexto. These third-party solutions enable the use of AR content for the vast majority of smartphones.[53] In order to support such a large range of less-capable devices, Vuforia uses image recognition technology to target specific real-world objects (targets)[54] in order to correctly project holograms onto actual surfaces. Hence only by using targets can an AR experience reach the majority of end users. The problem with target, as mentioned before, is they have to be present at a given location for the AR content to work. More importantly, the target must remain in sight of the camera or just barely outside of it.

D. Personalization

Personalization is defined as the act of designing or tailoring to meet an individual's specifications, needs, or preferences.[56] With personalization, apps can sift through large arrays of their content and present only that, which is relevant to the preferences of the user. Perhaps the biggest indicator of the value of personalization is the fact that some of the largest companies in the world massively invest in perfecting personalization algorithms.[57] Google, for example, use these algorithms for both delivering relevant ads or further improving their services,[58] some of which were also part of the described study. They are not alone in this – with other examined applications also including features for curating the content they display to an individual user.

Thorough studies have already been conducted in the field of recommender systems and collaborative filtering. The former can be separated into content-based, collaborative and hybrid systems. Content-based approaches recommend content

similar to that a user has liked in the past.[59] As such, the user has to rate a certain number of items for the system's understanding of their preferences – hindering the experience for new users of the platform. In contrast, collaborative filtering systems try to predict the utility of items for a particular user based on the items previously rated by other users, often taking into account the user's similarity to specific user groups by gender, age, area code, education, employment information etc. Additionally, modern iterations of these systems use advanced technologies such as machine learning, clustering and artificial neural networks to determine additional similarities between users. While a pure collaborative recommender improves upon the content-based system's shortcomings, it too has shortcomings – notably with recommending newly added or less exposed items, with a sparse amount of ratings.[60] Due to the drawbacks of both kinds of systems, hybrid approaches have emerged, combining both methods.[61]

Considering the level of complexity of recommender system studies, further expanded upon in the sources referenced in the last paragraph, it would not be very cost and time efficient for developers of a dedicated heritage focused application to work towards a bleeding edge solution in this field. However, some of the reviewed applications have incorporated more basic means of recommending content. Culture trip's approach for instance, gives its users the ability to "like" certain content and later modifies the section displayed on the default Explore page – a content-based approach, augmented with some collaborative elements, mostly utilizing the user's location. Google trips on the other hand, applies Google's own technology by reserving a dedicated 'For you' section, specifically for content that the app deemed the user might enjoy, taking in account the content that the user expressed a liking for, as well as he user's location and search history.

E. Geo-location specific features

Culture and heritage-oriented apps can be separated into two categories. Some, for example Google arts and Culture, aim to bring attractions to the user, no matter where the user is currently located. These types of solutions often offer several features for discovery of new artworks, artists and mediums, as well as include content like written articles, to be enjoyed at the user's leisure. In contrast, other applications (Slovenia's top 100, Nexto, Google trips, Visit London) focus on orienting the user towards the attraction and augmenting the experience of enjoying them in the real world. Admittedly, many of the reviewed applications strive to achieve both, but do prioritize one aspect of use over the other, upon closer examination.

Most of the applications in the latter of the two categories provide several features, relating to the geographic location of the user. Among others, features like visualizing the real world in map form, routing the user from their current location to different points of interest and the discovery of relevant nearby locations are of note here. While some of these features can be done via redirection to third-party services (as is done in Culture Trip and Visit London), advanced use like map customization requires a dedicated in-app solution.

With 99% coverage of the world and 1 billion monthly active users, the Google maps platform is the biggest actor in the geo-location related industry.[62] By using its API or an API of one of its competitors,[63] developers can showcase relevant content on interactive maps, with several added features at their disposal. Nexto, for example, highlights already visited locations in a guided tour differently than those, which the user is yet to visit, also showcasing the virtual souvenirs acquired at a certain location, right on the map. Use cases like this can improve user experience, and with it – engagement, as they allow for further design in the context of the remainder of the application.

Similarly, a lot of applications include a dedicated 'near me' feature, highlighting the points of interest, that are closest to the user, sometimes even combining geo-specific features with their personalization and recommendation systems, as seen in Culture trip.

F. Offline usage

Internet access is seeing better coverage and lower access costs, with 4G covering an average of 91% of EU's population.[64] However, offline features still have a place in mobile applications. In our use case, we can highlight Croatia having the second-lowest DESI connectivity score in the EU[65] as one of the reasons for their importance, but others might include personal preference, privacy, or battery-saving, as the technology behind connecting the 4G LTE network and end-devices is very battery consuming.[66]

While some apps with a thinner range of multimedia content opt to provide most of their services offline by default (Slovenia's Top 100), this isn't a valid solution in applications that strive to continuously upkeep and update their content. In addition, an offline-only application may also consume an amount of storage users aren't willing to dedicate to it.

Most state of the art apps therefore include options to download the most basic type of content e.g. an article (Visit London, Culture Trip, Beyondarts), allowing the users to handpick the content they would like to consume offline. Nexto and Google Trips on the other hand, allow the user to download and locally store large bundles of multimedia content (several times the size of the app itself), relevant to a larger area, containing numerous interest points. By doing this, these applications avoid the negative user experience of downloading data to consume offline, only to find out they want to consume more shortly after. Furthermore, this approach also enables the presentation of the same, wholly experience they offer to connected users, offline.

G. User generated content

Several of the examined applications welcomed some sort of personal input by their users. In most cases, for example in Foursquare or Tripadvisor, this user-generated content (UGC) appeared in the form of user reviews and scores. We recognized that these elements mostly benefited the user in situations, where they would be choosing between competing services: e.g. restaurants or lodging. One study finds that the valence of traveler reviews has a significant impact on the online sales of hotel rooms, as these reviews may serve to

reduce the cognitive load of potential travelers, and thus increase their awareness.[67] This same reduction of the cognitive load may also influence the simplicity of the user experience of a potential application, which may in turn, as mentioned before, improve engagement.

In addition to collecting valuable feedback, a comprehensive rating and review system may also aid the users lacking the time or desire to experience all of the landmarks a given location has to offer. It is important to note that this may actually hinder the experience, however, if the goal of our application is to present the cultural heritage of a certain area in its entirety – as the better reviewed portion of points of interest would receive more exposure than its lesser counterpart.

Only one of the reviewed applications – Nexto, featured a different type of UGC. However, we still recognized it carries particular importance and usefulness considering the developmental circumstances of our solution.

Most of the reviewed cultural heritage applications incorporate content created either by in-house experts or by an outside team of content creators. In this way, the solution's content is guaranteed to be tailored to its desired standards and – at the same time, is exclusive to it. Google Arts & Culture's Home tab, for example, boasts a plethora of expertly written editorial features, written by experts in their field, hand picked by the application team to ensure diversity and quality. This sort of content creation can, however, prove costly and time consuming when contemplating the scaling of an application – thus an alternative might be considered.

This is where Nexto tries to incorporate UGC. The application provides users with a web-based tool, enabling the production of specific multimedia experiences for certain cultural hotspots. While the tool utilizes a very well designed and intuitive UI, with no coding required, Nexto Inc.'s team of heritage interpreters, designers and 3D artists is also available to design said experiences by commission.

While relying solely on UGC isn't a sensible move in designing such an application due to the variability in the content's quality, we recognized several positives in incorporating it – such as the utilization of user engagement to target long-term interactions, loyalty and advocacy through word-of-mouth.

III. Conclusion and Future Work

Throughout the process of our study and the writing of this article, we attempted to feature aspects of applications that stood out as good practices in their specific use cases. It is worth noting, however, that our intent was not to imply that all of the described features should be incorporated in a successful heritage-focused application.

When designing an application, one of the key steps is to define its target audience. The application user's demographic, interests and goals should be heavily considered when deciding on which of the above features to incorporate, and to what degree. Audience groups vary heavily between analyzed applications: from tourists to locals, from those who seek to experience the cultural heritage digitally, from afar or those who seek to engage with it in person.

Furthermore, the authors of this article would argue that including all of the described functionalities could even result in a hindered UX. Instead of implementing all of them, features inspired by those described in sections A through G should only be implemented upon deciding that they will indeed benefit the application's userbase. Otherwise, the oversaturation of features can contradict the application's simplicity – already established as one of the core principles of UX beforehand. Furthermore, an application is never only a sum of its features. Creating a successful and engaging solution may be aided by several techniques not described herein, such as creating a comprehensive marketing plan, following platform-specific UI design guidelines, or the employment of design thinking during the course of development.

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