Mobile Augmented Reality Interactive Systems for Urban Tourism

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Abstract. *This paper discusses current trends in augmented reality interactive systems for tourists. Tourists need accurate and relevant information mainly about following points: tourist attractions, accommodation, restaurants, shops etc., in order to make the most of their city tour. Augmented reality systems have possibility to enhance tourism experience by supporting context aware information presentation. Literature review revealed current state of the art of mobile AR in city tourism. Summary of findings will be used as requirements input for the new version development of the tourist augmented reality system for city Varazdin (VarazdinAR).*

Keywords. Augmented Reality, eTourism, Interactive Systems, Context-Aware multimedia

1 Introduction

Technological advancements have introduced many changes in the way we communicate and access information. Computer hardware is becoming each day smaller and more powerful, as consequence it brings fundamental changes in the ways we interact with the technology. We are now living in the world of ubiquitous computing technology that mediates our daily activities. Augmented reality (AR) interactive technology has increasingly gained public interest during the last few years [1]. AR research and application has become very popular in the defence industry, construction industry, architecture, medicine, marketing, gaming, education and tourism.

Tourism is one of the largest industry in the world. Every country invests significant amount of founding to support the development of the tourism sector. Using information technology is one of the ways how this can be achieved. AR is considered to be new technology that could enrich the manner in which tourists experience heritage and historical sites. AR technology creates the illusion that virtual objects coexist with objects from the real world, thus enabling richer and broader experience of the real world. Mobile devices started becoming more powerful, small enough to be carried and to support registered computer-generated graphical overlays in a dynamic mobile environment. However, commercially viable applications are limited, due the poor usability where screens are often cluttered with information and usually recognition of objects is limited. And sometimes for users it is not always feasible at the same time to look at screen and walk through the city, or even the visibility of a mobile screen can be compromised through sunlight [2].

The main goal of this study was to discover characteristics and functionalities that are suitable for this kind of applications, and gather the suggestions for the new version development of the augmented reality system *VarazdinAR*.

2 History of Augmented Reality

First example of AR product was developed 1960s by Ivan Sutherland and his students at Harvard University and the University of Utah to present 3D graphics [3]. Among first appearances of the term "*augmented reality*" was in work of the authors Caudell and Mizell [4]. They worked at Boeing on the design and prototyping the implementation of a heads-up, see-through, head-mounted display (HUDset). The intention was to allow a computer-produced diagram to be superimposed and stabilized on a specific position on a real-world object in order to "augment" the visual field of the user with information necessary in the performance of the current task. AR offers a more intuitive and natural means for people to interact with real world objects by augmenting the reality with artefacts from virtual world (2D/3D models, audio/video files etc.). Rather than replacing reality with virtuality, AR enhances/augments real world environment. Azuma summarized previous research on augmented reality and defined AR as supplements to the reality where it appears to the user that the virtual and real objects coexisted in the same space [5]. In order to avoid limiting AR to specific technologies, following three characteristics of augmented reality systems are defined [5], [6]: (1) *blend real and virtual objects in a*

real environment; (2) *are interactive in real time*; (3) *align real and virtual objects (e.g. 3D objects) with each other (registered in 3D).* Milgram and Kishino [7] defined augmented reality as a term to refer to any case in which real environment is "augmented" by means of virtual (computer graphic) objects. The focus of their research was on factors which distinguish different mixed reality display systems from each other. For them the augmented reality is just one part of the general mixed reality on the reality-virtuality continuum.

Azuma et al. [8] state that mobile augmented reality is one of the fastest growing research areas, due to the emergence and widespread uptake of powerful smart-phone devices that can easily support augmented reality features. Modern mobile smart-phone devices and tablets have integrated fast processor with powerful graphics hardware, a large touch screen, and embedded sensors, integrated camera, GPS, Wifi, compass, accelerometer, therefore making them ideal for both indoor and outdoor augmentation.

AR systems enable images, objects, and shapes recognition on which virtual objects (in the form of video, 3D, 2D, text etc.) will be superimposed over it. We can differentiate several types of tracking [9]: (1) *fiducial marker based tracking - black and white squares which enable high contrast compared to background environment. and can thus be quickly recognized*, (2) *hybrid based tracking - combines two or more data sources such as GPS, compass, accelerometer to calculate actual position and orientation*, (3) *modelled based tracking – based on the edge detection uses the geometrical representation of 3D objects*, (4) *natural feature tracking – usage of real world features as markers.*

Today there are numerous development frameworks and toolkits who enable easy development of AR applications. In table 1 similarities and differences between several development frameworks are presented. Metaio SDK is powerful augmented reality engine that support recognition, tracking, and content rendering. This framework supports marker or marker-less 2D and 3D tracking, LLA Marker tracking, QR code and barcode reading, enables 3D rendering, has optimizations for mobile chips, etc. Vuforia framework enables efficient 2D and 3D target types and includes multi-target configurations, cylinder targets to track images on a cylindrical surface, marker less image targets and frame markers. ARToolKit is library that enables creation of augmented reality application. It is available as open source. D'Fusion SDK supports the marker-less tracking using different sensor (GPS, compass, accelerometer, gyroscope, etc.) and tracking of 2D image, 3D objects. As well, it support tracking of body movements, natural feature tracking, face tracking where algorithm focuses on eye and mouth detection.

Table 1. Augmented Reality Framework Comparison Based on the Marker Tracking and OS Support

Frameworks	Marker Based	Location Based	Natural Feature Based	OS support
ARToolKit	*Supported*	*Not supported*	*Supported*	*iOS, Android, Windows*
Vuforia	*Supported*	*Not supported*	*Supported*	*iOS, Android*
Metaio	*Supported*	*Supported*	*Supported*	*iOS, Android, Windows*
D'Fusion SDK	*Supported*	*Supported*	*Supported*	*iOS, Android, Windows*

3 Augmented Reality Systems for Tourism

In museums the information technology has been used for quite some time in order to demonstrate visitors more vividly the artefacts, characters and events from history. Museum artefacts are often supported with extra material such as descriptions, pictures, audio files or even with the video files. But the usage of mobile technology to support the cultural heritage goes the step further and now the institutions can provide adapted information to the user to his location and his context of use.

One of the very first examples of using AR outdoor in tourism emerged at the end of the 20th century. The Columbia Touring Machine was an early prototype of an outdoor mobile augmented reality system, named MARS, that presented 3D graphical tour guide information to campus visitors, registered with the buildings and artefacts the visitor sees [10]. The Archeoguide system is also interesting early example of mobile augmented reality systems for outdoor personalized cultural heritage tour, launched in 2001 at Olympia, Greece. Nowadays many cultural heritage institutions have made their own mobile augmented reality systems with cultural heritage resources, some of the example are: (1) *Philadelphia Department of Records*, (2) *the Berlin Wall*, (3) *the Museum of London*, (4) *the Netherlands Architecture Institute*, (5) *the Powerhouse Museum in Sydney* and (5) *Tuscany Visitor Guide etc.*

Mobile AR systems can provide the tourist with context-related information in the very moment and location the user needs it. Yovcheva et al. [11] made list of functionalities the tourist AR mobile application should have: (1) *search and browse – to provide fast access to relevant information*; (2) *context-aware push – system notifications about surrounding points of interest*; (3) *routing and*

navigation - possibility of obtaining directions and navigation to a selected point of interest; (4) *m-commerce - possibility of using mobile booking/reservation or payment*; (5) *feedback – possibility to provide and/or see feedback of other tourists*; (6) *tour generation – possibility for tourists to plan and manage their tours by defining their likes and time span*; (7) *map services – possibility of seeing current position on the map and to have an overview of a larger territory*; (8) c*ommunication – possibility to establish direct contact through the system with accommodation providers, exhibition owners etc.*; (9) *exploration of visible surroundings - possibility to explore information about their surroundings without pre-defined criteria*; (10) *interactive AR view – possibility to discover more information about points of interest by taping on AR annotation;* (11) *filtering of AR content – possibility to filter and change interactively the visualized content in AR view*.

Author would like to add to the existing list one additional criteria named *multimodality*. Multimodal systems can combine visual information with voice, gestures and other modalities (handwriting, touch, gaze, etc.) in order to enable more natural dialogue (*two-way communication*) between humans and the systems. Users of multimodal systems can choose the modality that best suit their context of use (situation) or their preferences. Visual displays are very useful however, sometimes they have their drawbacks as well. Most often the screen size of the display is limited so the screen (window to the real world) can be cluttered with annotations. Further, the visibility of a screen can be compromised through sunlight (e.g. reflections, over brightness) and sometimes is not always feasible at the same time to look at screen and walk through the city. Providing visual and audio content together is next step of system improvement. Further, by implementing voice control there are possibilities for easier accessibility to the desired content. Voice modality has potential to reduce the shortcomings of the visual displays and therefore can improve the experience for tourist. Tourists can choose the modality they prefer and which suits the best to their context of use. Yovcheva et al. [11] conclude that when it comes to mobile AR tour the system needs to support *access to location-based information, relevant to the immediate surroundings of tourists*, *access to variable and timely updated content*, *flexibility in terms of delivering text, video, or images* and *to provide interactive annotations which are integrated with map-based services and additional information*.

Table 2. Comparison of Augmented Reality City Tour Guides

Criteria\Apps	***Then and Now City Guide***	***GeoTravel AR Guide***	***City Travel Guide by eTips LTD***	***Tuscany+ Visitor AR Guide***	***VarazdinAR City Guide***
Search and browse	+	+	-	+	+/-
Context-aware push	+	-	-	-	-
Routing and navigation	+	+	+	+	+
m-commerce	-	-	-	-	-
Feedback	-	-	-	+	-
Tour generation	-	+	-	-	-
Map service	+	+	+	+	+
Communication	-	-	-	+	-
Exploration of visible surrounding	+	+	+	+	+
Interactive AR view	+	+	+	+	+
Filtering AR content	+	+	+	+	+
Multimodality	*No*	*No*	*No*	*No*	*Yes*
Online/Offline usage	*Online*	*Online/Offline*	*Offline*	*Online*	*Online*
Pricing	*Paid*	*Paid*	*Free*	*Free*	*Free*

4 VarazdinAR project

The use of AR system in tourism should enable tourists easier discovering of relevant information about city landmarks or access to useful information (e.g. restaurants, accommodation, cafes etc.). The goal of *VarazdinAR* project was to develop mobile interactive city tour guide for tourists of city Varazdin in order to presents the context based information based on the their location and personalize the content to their requests. *VarazdinAR* 1.0 app is currently available for iPhone/iPad systems. It is developed based on Metaio SDK. The system is organized in

four modules: *(1) AR view of points of interest; (2) Map view of points of interest; (3) Door view; (4) Magic book view.* Main screen is shown on figure 1. The first module is the display points of interest (POI) through the real world view. Based on the current location of tourists annotations are enriched with the distance and direction of particular POI (Figure 2). Tourist information can be filtered by distance and by groups: *landmarks*, *restaurants*, *bars*, *accommodation*. The second module displays points of interest on the Apple maps. Tourists can easily see where they are currently located on the map and what surrounds them (Figure 3). Points on the map can be filtered according to the groups: *landmarks*, *restaurants*, *bars*, *hostels.*

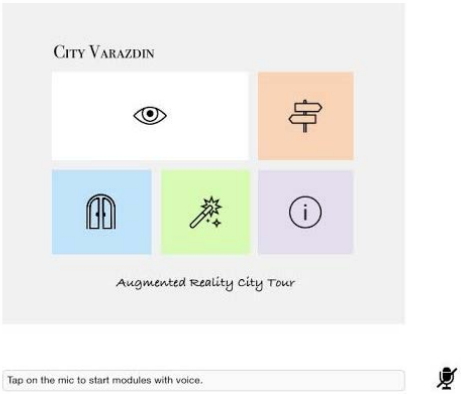

Figure 1. Main Screen of the VarazdinAR App

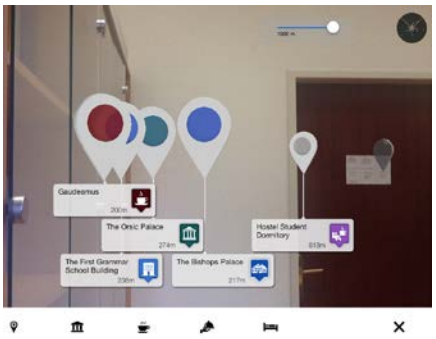

Figure 2. Augmented Reality Points of Interest View

Figure 3. Map Points of Interest View

Selecting an individual pin tourist can see more information about the point of interest, how to get to it and link to the official website of POI. If this is a historically relevant points, two additional possibilities are enabled to start module of recognizing and tracking the door of historical buildings and module of recognizing and tracking the content of the official 2015 Varazdin brochure. These are the third (Figure 4) and the fourth module (Figure 5) of *VarazdinAR* system.

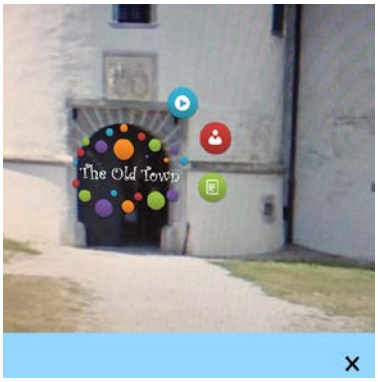

Figure 4. Augmented Reality Landmark Door View

Figure 5. Augmented Reality Magic Door View

All mentioned system modules are interconnected. For example, tourists by reading the official Varazdin brochure and using the module *Magic Book* can see additional multimedia content and by exploring multimedia content can decided what city landmark they want to visit, and choose the navigation option how to reach to that specific landmark. When tourists are in front of the landmark they can start multimedia content on the spot by using module *Magic Doors* (figure 4). The process of displaying the augmented reality content includes the following steps, first the camera shows the actual environment, then the system's algorithm captures video images and creates a pattern, the pattern is compared with a sample from the database, and if the system finds similarity, displays and positions the content depending on the sample (marker). In order to use the system smart device should be connected to city Varazdin free WiFi or use the sim card's 3G internet access.

If we compare the current version of *VarazdinAR* system (1.0) based on the functionalities the tourist AR app should have (table 2), we can see that there is lot of possibilities for improvement. In current system version search and browse are partially supported. Using the *voice control* tourist can start modules and filter the content, but the text input is not enabled in this version. However, users can filter the content by selecting one of the main groups (landmarks, cafes, accommodation and restaurants) or by choosing the distance range from their current position. The VarazdinAR doesn't support the mobile payment, neither communication between other tourists (through the feedback), neither with service providers (hotels, museums etc). The additional advantage of the *VarazdinAR* system is support of audio files for each *landmark*, so the tourist doesn't need to look at display all the time in order to find out more about the history of the landmark. Instead of the reading, they can choose to listen.

The critical analysis of current most popular augmented reality tourism systems revealed several key functionalities which should be considered for the implementation in the next version of the *VarazdinAR* system. This functionalities are: *communication possibilities i.e. possibility to establish direct contact via phone call or e-mail with the service providers (e.g. museums, hotels etc.)*; *feedback options i.e. to ensure tourists to leave and see feedback of other tourists (or ratings); push-notifications options i.e. to enable notifications when tourists are close to the POI they specified they want to visit; m-commerce possibilities i.e. to enable booking or to payment via mobile system* and *tour generation possibilities i.e. based on the preferences and time span tourist have to suggest and offer best routes in order to explore the city*.

5 Conclusion

In tourism, smart interactive systems can help the tourists to access relevant and valuable information and improve knowledge about the tourist attractions in the city or of the surrounding area. The use of augmented reality system can have a positive impact on the tourists travel experience, and on the process of discovering and learning about new cultures. As technology improves significantly each day, smart devices will become even more powerful in future.

The greatest value of augmented reality information systems is possibility of content personalization based on the user preferences and adaptation to the user context. When designing the augmented reality systems it should be taken into the consideration the quantity and quality of the multimedia content for each attraction. Too much content without proper design and/or filtering option can clutter the screen and have great impact on the acceptance of these systems. Another major problem is that visual displays are ineffective or inappropriate in some situations, so providing haptic and audio displays together or even multimodality control has potential to offer the best experience for the users.

Developers should not waste too much time and energy in the development of the features that are just fun, new and interesting, but primarily should focus in developing the features that user really needs, and which are useful for their contexts of use. For example, most of AR application often require WiFi or 3G connection, so if the city doesn't provide the public Internet connection majority of the tourists will choose the *offline* systems instead of the *online* even if online version have many cool additional features. Then, as additional value, they should offer something special, unique which distinguish their system of the others on the market e.g. *multimodality*.

References

[1] T. Olsson, T. Kärkkäinen, E. Lagerstam, and L. Ventä-Olkkonen, "User evaluation of mobile augmented reality scenarios," *J. Ambient Intell. Smart Environ.*, vol. 4, no. 1, pp. 29–47, Jan. 2012.

[2] S. Wei, G. Ren, and E. O'Neill, "Haptic and audio displays for augmented reality tourism applications," in *2014 IEEE Haptics Symposium (HAPTICS)*, 2014, pp. 485–488.

[3] D. van Krevelen and R. Poelman, "A Survey of Augmented Reality Technologies, Applications and Limitations," *Int. J. Virtual Real.*, vol. 9, no. 2, pp. 1–20, Jun. 2010.

[4] T. P. Caudell and D. W. Mizell, "Augmented reality: an application of heads-up display technology to manual manufacturing processes," in *Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences, 1992*, 1992, vol. ii, pp. 659–669 vol.2.

[5] R. Azuma, *A Survey of Augmented Reality*. 1997.

[6] R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier, and B. MacIntyre, "Recent advances in augmented reality," *IEEE Comput. Graph. Appl.*, vol. 21, no. 6, pp. 34–47, Nov. 2001.

[7] P. MILGRAM and F. KISHINO, "A Taxonomy of Mixed Reality Visual Displays," Dec-1994. [Online]. Available: http://search.ieice.org/bin/summary.php?id=e77-d_12_1321. [Accessed: 03-Jun-2014].

[8] R. Azuma, M. Billinghurst, and G. Klinker, "Special Section on Mobile Augmented Reality," *Comput. Graph.*, vol. 35, no. 4, pp. vii–viii, Aug. 2011.

[9] D. Amin and S. Govilkar, "Comparative Study of Augmented Reality Sdk's," *Int. J. Comput. Sci. Appl.*, vol. 5, no. 1, pp. 11–26, 2015.

[10] H. A. Karimi and A. Hammad, *Telegeoinformatics: Location-Based Computing and Services*. CRC Press, 2004.

[11] Z. Yovcheva, D. Buhalis, and C. Gatzidis, "Smartphone Augmented Reality Applications for Tourism.," *E-Rev. Tour. Res. ERTR*, vol. 10, no. 2, pp. 63–66, 2012.