Enhancing Campus Tour Experience Through Mobile Augmented Reality Applications: A Literature Review

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ABSTRACT

The rapid advances in the mobile technology and the high growth in the use of mobile devices have created many new opportunities for the developers to explore better solutions for complicated problems. Over last few years, Augmented Reality applications become available on mobile devices and providing the users relelvent information of the surroundings anytime and anywhere becomes less of a futuristic vision and more of a reality. AR will enhance our experience with our surrounding environment and assist us to interact with it in new and enriched approaches. This review presents current state-of-the-art, comparisons of frameworks for mobile AR development, technical and social challenges and limitations that might hinder the process of development.

Keywords

Augmented Reality; Mobile applications; Tourism; Ubiquitous learning; Limitations

1. INTRODUCTION

Imagine yourself being on a university campus that you have never been before. With the assistance of a student or a person who has been there for a while, knowing your location and destination would be difficult. You will need to have a traditional map and ask random strangers to know where a certain building or what the purpose of that building is. Augmented Reality is one of the technologies that will be able to provide a ubiquitous learning environment in the near future. Although Augmented Reality as concept has existed since the 1960s, it is only in recent decades that the technological advances make it a possible research field.[6] Yovcheva and et al. pointed out that the strength of mobile based Augmented Reality application is that they can be used to access personalized and updated information at any time and place and, by using them, the users will be able to view information about an object of interest in their surroundings.[9]

ACM ISBN 978-1-4503-2138-9.
DOI: 10.1145/1235

This paper offers a survey of the use of AR mobile applications, tailored specifically to the needs of tourists in unfamiliar areas. I will discuss the current state of the art of Augmented Reality and also analyze available frameworks in the market for the development of mobile AR applications. Moreover I will identify the potential challenges or limitations in the process of developing mobile augmented reality applications.

1.1 Definition

Augmented Reality is a variation of Virtual Reality. [2] While, in Virtual Reality, the real world of the user is replaced with a virtual environment that the user is immersed inside, Augmented Reality allows users to see the real world with virtual objects superimposed upon the real world enviroment. It makes the users feel that the virtual and real objects co-exist in the same space. Therefore the users will be able to get additional superimposed information while they can still see, hear, touch and feel in the real world. Within an AR-enhanced context, the information becomes interactive and easily manipulated in a digital manner. [6] Azuma defined Augmented Reality as a system that has the following three characteristics:

- Combines real and virtual
- Is interactive in real time
- Is registered in three dimensions

This three characteristics widen the realm of Augmented Reality and I will use this definition as principles in designing AR applications and as a gauge for this survey paper.

2. CURRENT STATE OF THE ART

The beginnings of AR go back to Sutherland's work in the 1960s, in which he used a seethrough HMD to present 3D graphics in an AR prototype. However, only over the past decade has there been enough work to refer to AR as a research field.[1] The field starts to get its attention and is proven to be useful because Augmented Reality enhances a user's perception of and interaction with the real world. [2] As mentioned, AR applications superimpose 3D and/or 2D graphics on top of the real world view. Therefore, the available information can be continuously updated through new objects. In turn, these objects and 2D graphics are inserted and handled by the AR applications with the help of GPS data, or AR fiducial markers, which can be easily recognized by mobile devices and computers. [6].

Along with an increase in power and capability, and a decrease in cost and size of computing devices, the ability to artificially create simulations in real time offers opportunities for Augmented Reality to reach its full potential.[3] One of the major requirements for the development of Augmented Reality technologies is the development of the required components. [4] The technological demands for AR are much higher than for Virtual Reality, and that is the one of the reasons why the field of AR took longer to mature than that of VR. However, the key components to build an AR system have remained the same since Ivan Sutherland's pioneering work of the 1960s. Displays, trackers, and graphics computers and software are still essential in creating Augmented Reality experiences.[8]

Yuen and et al. have researched that Augmented Reality research tends to purse either (a) the development of new devices and technologies for the essential components of the tracking, display, and input of real world and virtual data, or (b) the development of applications utilizing such existing technologies. [10] According to Zhou and et al., AR research has focused primarily focused on five core areas essential to deliver AR applications: (a) techniques for tracking (20.1%), (b) techniques for interaction (14.7%), (c) calibration and registration issues (14.1%), (d) developing AR applications (14.4%), and (e) display techniques (11.8%). [11] Although the field of Augmented Reality is still immature compared to Virtual Reality, recent advanced researches in AR and rapid growth of the capabilities of mobile devices becomes AR technology relevant in many areas such as medicine, education, military and entertainment where rapid information transfer is critical.

3. DESIGNING A MOBILE AUGMENTED REALITY APPLICATION FOR TOURS

3.1 Determining Services

According to Kennedy and Gretzel, travel apps are the seventh most popular category of apps being downloaded within the mobile apps business. They pointed out that 60 percent of smart phone users have downloaded travel apps and of those individuals, 45 percent use the apps for travel planning and research. Furthermore, 55 percent of travel apps are purchased within 3 days of travel or while travellers are at the destination , which helps demonstrate how important mobile apps are in influencing en route decision-making.[5] Therefore it is very important to build a mobile application that will help the visitors learn more about their surroundings.

When designing a mobile application that is specifically tailored for tours, it is important to include useful functions or services that a tourist might need during the tour. According to the analysis of Kennedy and Gretzel on travel-related apps from a value chain perspective, 7 categories emerged: Navigation, Social, Mobile Marketing, Security, Transactional, Entertainment, and Information (Figure 1). Under Navigation, we can see Augmented Reality as a subcategory. However, with current advances of AR, it is possible to implement AR in every category as a way to enhance user experience with those services provided. While some of these may not directly relate with campus tours, they are services that visitors may use during their visit. Each service or function will be highly dependent on the nature of the tour or visit. However, this taxonomy will serve as a guideline when a developer plan to design a mobile Augmented Reality.

3.2 Tools for Augmented Reality Applications

Several years ago Augmented Reality applications constituted mainly pilot projects. However, due to recent technological advances, companies that focus on AR emerged and made possible the development of a number of frameworks and toolkits, which streamline the development of AR applications. Easy integration of AR devices and quick creations of user interfaces can be achieved with frameworks.[8] Kouvanis and et al. presented a comparison of various useful frameworks and the OS availability of frameworks. [6] [figure 2, 3] By comparing the available frameworks on the market, we can choose the suitable framework for the purpose of the AR application we are developing. OS availability of frameworks is also of importance because not every framework will support all popular operating systems that exist in the market as it is shown in Figure 3. According to Figure 3, Layar will be the best framework if we would like to create a mobile application targeted for a high user base. Therefore we have to select the most suitable framework depending on the functionality of the application and the target audience.

One of the frameworks mentioned by Kouvanis and et al. is Layar. Layar is today one of the most popular mobile AR platforms, boasting over 10M installs, 9,000 developers and 2,500 individual AR applications, offered as layers. Layar is available on most operating systems such as Android OS, iPhone OS, Symbian OS and BlackBerry 7 OS devices.

Some of the more powerful toolkits need more expertise and extensive knowledge of the subject than other toolkits. One of them is ARToolKit. ARToolKit is a free, open-source, C language software library for creating AR applications. ARToolkit was originally created by Hirokazu Kato in 1999 and its ongoing development is being supported by the Human Interface Technology Laboratory (HIT Lab) at the University of Washington, HIT Lab NZ at the University of Canterbury, and ARToolworks, Inc. ARToolKit uses computer vision techniques to calculate the real camera position and orientation relative to markers, allowing the developer to overlay virtual objects onto these markers.[8] [10]

Wikitude also offers powerful APIs to add Augmented Reality content to the mobile application. It is a powerful programming platform that provides the developers SDKs to create their own mobile AR applications. [10]

3.3 Advantages of Mobile Augmented Reality Applications

There are many advantages to using mobile devices to support Augmented Reality applications. First of all, Augmented Reality exists in the real world. Craig stated that, by using mobile technology, the AR application can be experienced at the location where it makes the most sense. [3] If the application is built upon a specific location, then the user would need to be at that location to experience AR. In case of mobile AR, the users would already be carrying the required hardware in their pockets whether or not they were planning to experience AR at any given moment. This is a prominent advantage for tourism based AR applications.

Mobile Augmented Reality supports the idea of ubiquitous learning by giving the user the ability to learn wherever they are when they need to. A person can learn more information

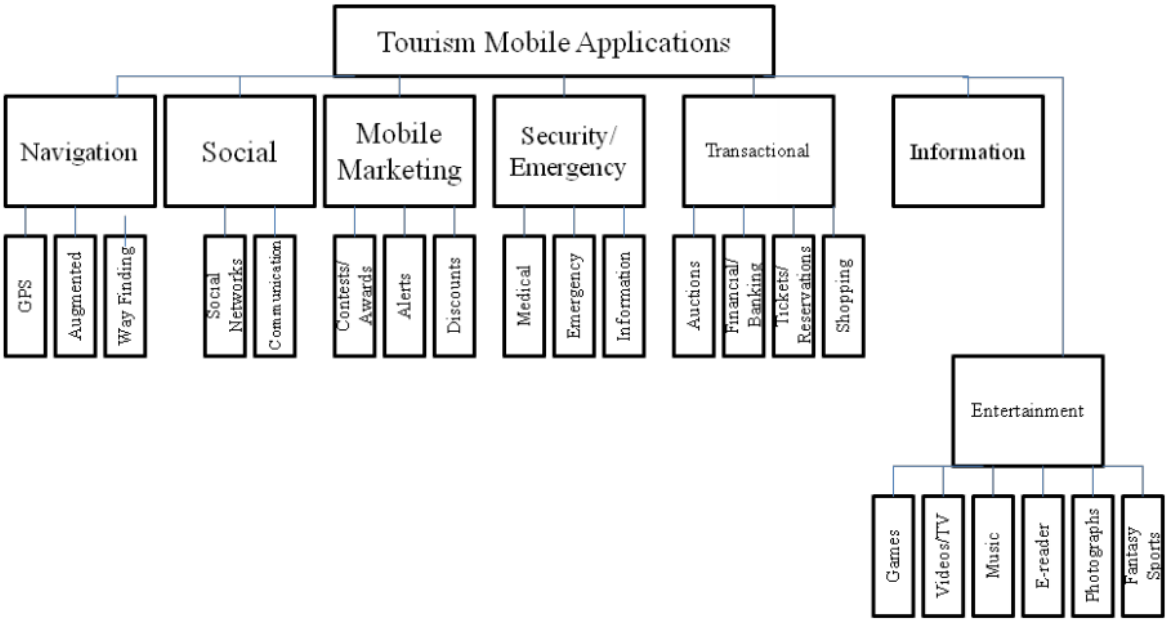

Figure 1: Tourism Mobile Applications by Services provided [5]

	Location Based	Marker Based	Image Based	Laptops	Palmtops
DroidAR	X	X			
DWARF	X			X	X
Layar	X				
IN2AR		X	X	X	
FLARManager		X		X	
PanicAR	X				
SudaRA		X		X	
FLARToolKit		X		X	

Figure 2: Summary of frameworks [6]

	iOS	Android	Symbian	BlackBerry
DroidAR		X		
DWARF				
Layar	X	X	X	X
IN2AR				
FLARManager				
PanicAR	X			
SudaRA				
FLARToolKit				

Figure 3: OS availability of frameworks [6]

about the historic place he or she is currently visiting just by using his or her mobile devices' AR systems.

The key advantage of mobile Augmented Reality Application is that the mobile devices are less expensive compared to other devices that are produced to solely support Augmented Reality. Most people already own some sorts of modern mobile phones or tablets and these devices already contains the components necessary for most mobile AR applications. Having a large number of potential clients is a big strength for commercial uses.

3.4 Challenges And Limitations of Mobile AR

Along with advantages, there are also a number of disadvantages with mobile technology and using mobile technology to create Augmented Reality applications. The challenges and constraints can be categorized into three categories:

1. Technical limitations
2. Environmental limitations
3. Social limitations

Most of the challenges and limitations are generally related to the limiting capabilities of current mobile devices and these categories are interrelated.

3.4.1 Technical limitations

The main technical limitation is the limited resources of mobile devices. Mobile devices have limited computational capability, limited memory, limited input/output options as well as limited graphical power. The capability of the AR application is highly dependent on the capability of the device it is implemented on. According to Craig, Memory is a primary limitation on the amount of content that can be resident on a mobile device at any given moment. [3] He

proposed two primary ways to overcome the limited memory available on a device. The first is to use clever schemes to limit the amount of memory that the content occupies. One way to do this is to limit the number of polygons and size of textures that are associated with visual objects and to limit the applications in the number of objects that are expected and/or required. The other way to overcome the issue of limited memory is to create a scheme by which content is loaded onto the device when needed and off-loaded when not needed.

Real time 3D tracking is also an issue that limits the full potential of Augmented Reality. The complexity of the background scene and the motion of target objects, including the degree of freedom of individual objects and their poses. [11]. Zhou and et al. proposed to use marker-based tracking to enhance robustness and reduce computational requirements. However, the markers need maintenance and suffer from limited ranges. The method is not scalable when the application is used in an outdoor environment. Tracking in unprepared environment also remains an unsolved problem. [1] This is related with both technical limitations of devices and the environmental factors.

Another obstacle is the lack of interoperability across mobile platforms.[6] Even though there are many frameworks and toolkits for developing mobile AR applications, the applications cannot be used across all operating systems.

Augmented Reality devices may also need data network connection to download relevant contents. Not all places are fully equipped with Wi-Fi networks and data roaming charges will make the users hesitant to use the applications. This constraint can hinder the application to reach its full potential. [6] [3].

3.4.2 Environmental limitations

Apart from the constraints of the devices themselves, there are environmental factors that will hinder the development of mobile AR applications. The developers have no control over the environmental conditions such as lighting, noise, weather and other factors. In all cases of augmented reality applications and devices that use computer vision for tracking, it is essential that there is enough ambient light of the appropriate wavelength in the environment for the vision system to "see" the world. [3].

Moreover, there can be locations that might restrict the types of devices that you are allowed to carry/use. Virtually all devices are restricted on commercial air flights during takeoff and landing, and only certain devices are allowed while the plane is at altitude. Facilities where electromagnetic interference is hazardous may not allow the use of mobile devices. Mobile devices are also not suitable to use in areas with extreme environmental measures.

3.4.3 Social limitations

The challenge with society is whether the society will embrace the new technology and accept it. If it is too hard for the user to understand the technology, then the user will not welcome that technology. Mobile Augmented reality presents the challenge that there could potentially be content anywhere. [3] The users will have to know which targets would produce augmented reality contents in order to trigger those targets. Sometimes, they might even to need to use the application from a certain pose or point to activate those AR contents. If there are multiple AR applications in their mobile devices, finding right targets for the right application would be difficult.

Azuma pointed out that perception is what counts, even if the technological reality is different. [2] In his example, if people perceives lasers to be a health risk, they may refuse to use a system that uses lasers in the display or trackers, even if they are perfectly safe.

Moreover, security and privacy concerns cannot be overlooked. It is easy to imagine that spam would overwhelm the augmented world with unwanted advertising or information. [3] Malicious applications might mislead the users by giving wrong informations or steal valuable personal information by scanning. Roesner and et al. argued that, while the field of Augmented Reality is young and malleable, we should consider security and privacy issues posed by the AR systems and explore new technologies to create novel privacy and security enhancing applications. [7]

4. CONCLUSIONS

In this paper, I surveyed the state of the art of Augmented Reality and important issues to consider when developing a mobile AR application for Campus Tours. Implementing and developing mobile AR for visitors is related with making a number of critical design decisions. Moreover, I explored the available frameworks and toolkits for developing mobile AR applications. It is noticeable that there is no best framework available yet to develop mobile AR applications. Since the field of Augmented Reality is not as well developed as Virtual Reality is, we can see that there are many challenges waiting for us. AR has come a long way but there is still distance to go before the technology is widely accepted and utilized as a familiar user interface. Future research within this field of mobile AR should be focused on creating better solutions for markerless object recognition such as natural feature detection, improving computer vision algorithms to analyze and determine the object's representation, deciding whether content should be stored on the device or remote server and protecting the privacy and security of the users ethically.

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