Mobile Augmented Reality edutainment applications for cultural institutions

Thomas Chatzidimitris, Evangelia Kavakli , Maria Economou, Damianos Gavalas
Department of Cultural Technology and Communication
University of the Aegean
Mytilene, Greece
e-mail: tchatz@aegean.gr

***Abstract*—The paper focuses on current practice regarding the application of mobile Augmented Reality (AR) technologies for enabling learning in the context of cultural heritage. It also presents ARmuseum, an application developed for the Museum of Industrial Olive Oil Production in Lesvos (MBEL). Finally, it discusses a number of issues related to the evaluation of mobile AR applications for cultural institutions.**

Keywords-component; mobile Augmented Reality, edutainment, cultural heritage

I. INTRODUCTION

Cultural institutions are informal learning organizations where education and entertainment are often combined. To this end, a number of interactive edutainment applications have been developed over the years for conveying cultural information aiming to generate excitement and encourage active participation among people visiting historical locations and museum galleries [1]. The last decade an increasing number of applications make use of mobile, location aware augmented reality (AR) technologies which dynamically align virtual information with the physical exhibits thanks to the knowledge of the user context [2]. Such applications range from mobile guides and educational games to new media art and virtual exhibitions [3].

The launching of versatile operating systems and software development environments such as the android platform for mobile devices in the late 2010's and their wide acceptance by mobile device manufacturers and application developers [4], have triggered a rapid increase in the use of "smart" devices such as tablet computers and smartphones. Smart devices feature direct manipulation interface, rich multimedia support, GPS navigation, versatile connectivity, social networking and significant computational resources. Furthermore, the new platforms can be used on other electronic devices from laptops, notebooks and smart TVs to wearable devices overcoming existing cross-platform compatibility issues.

As smart devices become a mainstream technology, especially among young people, cultural institutions have endorsed mobile AR applications in order to attract young audiences who are more accustomed to, or even expect this type of interactivity [5].

II. MOBILE AR EDUTAINMENT APPLICATIONS

Mobile AR edutainment applications have mainly been delivered through mobile guidance systems used in the context of cultural visits [5-7]. By surveying these approaches, storytelling emerges as a major paradigm, whereby the story narrated by one or more virtual characters, as the visitor moves within a cultural site. The narration sequence may be linear or it might adapt dynamically to the trajectories followed by the visitor based on location-based data ontologies [8]. An alternative approach is the paradigm of pervasive games [9]. In this case users are requested to perform situated tasks, thus contributing to the achievement of some plot, devised by the game designer, often inspired by well known educational museum games like role-playing, treasure hunt, observation or mystery games. The application may be targeted to specific user group or it might be personalized based on the selected user model. In all cases, the games can be solitary or team games, they may take place indoors in museums and galleries, or outdoors games in cities, historical or archaeological sites [3][5].

A. Mobile computational platform

Currently, handheld (i.e., tablet computers and smartphones) are the most widely used devices. However the use of wearable smart devices such as smart glasses smart glasses, wrist watches and headphones is gaining ground as wearable input and output AR system components (see for example the Googleglass project [10]), enabling a more authentic AR experience which is closer to the idea of 'ubiquitous computing' [11].

B. Location awareness

In mobile AR applications, location awareness (often referred to as tracking) is essential since it denotes the presence of the user in the physical environment allowing the application to align, or register virtual information with the physical objects. In most cases the locations of interest are those of the mobile user and of the exhibits. There are several tracking technologies that can be used for outdoor and indoor tracking. Probably the most predominant system for outdoors user tracking is the GPS featured in most mobile devices. With respect to indoors tracking, sensor-based and Wireless-LAN tracking are suitable for locating the user's mobile devices. With respect to the location of exhibits visual marker-based tracking is a very common approach. In this case, the video camera of the mobile device

is used to scan a marker (e.g., a printed pattern) placed near to the annotated physical object. Approaches based on visual object recognition algorithms have also been used. However marker-based tracking is widely used since it still the most affordable approach requiring less processing power [12]. Markers have also been used to determine user position, however this restricts the users' ability to move freely [5].

C. *User Interaction*

Interactivity is mostly based on the users' moving from one location to another. Location change triggers visual augmentation, i.e., layering of digital images or 3D) graphics, over real objects seen through the camera of the mobile device is the most common interaction style. Sound augmentation is also common, usually in combination to visual augmentation providing soundspaces to accompany virtual scenes superimposed in real space.

Alternatively, users may interact directly with their mobile device in order to perform actions (answer a question, display information, take a picture, proceed to the next stage of the application, etc). Natural user interaction that accept user input beyond the device controls for example through voice, gesture, movement, even blowing at the device is also explored in more recent applications [13].

Additionally, user can manipulate virtual objects appearing on the screen (tap, rotate, move) of the mobile device or projected on the AR marker (cover / hide the projection).

Finally, affective augmentation which uses biofeedback signals associated with heart, brain and other organ activity in order to determine for example, the changes in the user's interest towards a real exhibit, is a new and promising form of interaction [16].

III. THE ARMUSEUM APPLICATION

ARmuseum is a mobile guide in the form of a mobile AR game designed for children aged between ten to twelve years old. The game takes place inside the Museum of Industrial Olive Oil Production in Lesvos, which is housed in the premises of the old communal oil-mill. According to the scenario the user has to complete a number of tasks in a specified order according to the stages involved into the olive oil production process. The scenario uses a virtual character, the son of the oil-mill guard who asks the user to assist the olive-oil production prompting her/him to locate selected machinery exhibited in the museum.

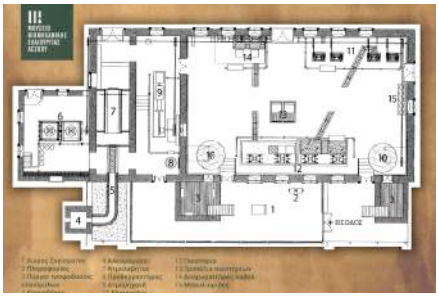

Figure 1. The AR marker

The main navigation tool is the floor plan of the main oil-mill building which also forms the AR marker on top of which a 3D model of the museum appears when the users sees it through the camera of her/his mobile device. Additional markers are placed inside the museum, next to the exhibits which the user is asked to locate (i.e. to scan with the camera of her/his mobile device) in order to successfully complete the game.

In particular, the user is supplied with a printout of the floor plan and is asked to see it through the camera of her/his device. This initial step aims to familiarize the user with the particular AR interaction style. After successfully completing this first task the virtual character asks the user to participate in the olive oil production. To achieve this, the user has to locate and move progressively to the right oil-mill machinery exhibited in the museum building and scan the respective marker.

Figure 2. Gameplay screenshot

After each successful scan the virtual character prompts the user to discover the next exhibit/marker by providing information concerning the mechanized process of oil production in Lesvos as well as the history of the oil-mill, the wider socio-economic background. Further to the camera interaction style, the user is also asked to interact immediately with the virtual environment (e.g., she/he has to press a virtual button which appears on top of the main marker (the 3d model of the oil-mill). When the user completes successfully the game, the 2D floor-plan marker is transformed into a live 3D reconstruction of the main building with all the associated machinery shown in operation, that can accompany the visitor after the visit. As a reward the user can take a photographed of her/himself together with the virtual character, which is uploaded at the museum webserver.

Figure 3: User reward

ARmuseum was developed using a game-engine middleware software. It requires to be installed on a smart device (smartphone or tablet computer) with Android OS connected to the internet. For the display of the virtual 3D models on the visual marker, an SDK for the development of AR image-based applications was utilized [14].

IV. Discussion

Initial experimentation with ARmuseum at the Museum of Industrial Olive Oil Production in Lesvos confirms the results of similar projects. The combination of the physical objects with the virtual information triggers curiosity and generate the need to physically explore the museum space. The use of the virtual character appeals to children who eagerly assume the proposed tasks in order to assist the oil production process. The use of mobile AR technology exposes children to an alternative interaction style, which they can easily master. Initial frustration, gives its place to a sense of accomplishment when they succeed in scanning the right marker or manipulating the virtual objects.

The development of ARmuseum completed last February and so far a limited number of visitors, mainly primary school children from Lesvos visiting the museum with their parents, have used the application. A more extensive use is expected during the high season (late spring and summer months).

In order to systematically evaluate ARmuseum a system for logging and analyzing mobile user behavior has also been developed. The log collection service is executed in the background. Analysis of the collected data can be used to analyze usage patterns as well as evaluate the efficacy of the interface design. For example, the application administrator can detect the application tasks that users commonly fail to complete, repeatedly cause users to discontinue using the application, or calculate the average time spent on different tasks.

Log collection complements existing practices such as user surveys and interviews of involved stakeholders. Evaluation, however, should not focus solely on technology and interactivity issues. Additional evaluation key points should include the informative goals of the cultural institution, as well as administration issues [15]. Informative goals may refer to the quality of the content provided and its ability to maintain the relationship between the virtual and the real. In addition, they address the degree of involvement and social interaction sought or the integration with other educational activities. Temporal constraints with respect to the overall stay in the site or the duration of the stay in a single location should also be accounted for.

On the administration side, institutions investing on mobile AR should take into account that although the smart devices market is growing rapidly, the application will be inaccessible to a significant number of people. In addition, if the application requires some sort of initial installation this process should also be evaluated in order to see that it is not energy and time consuming. If the cultural institution opts to provide the device to visitors then additional issues arise regarding the maintenance of the devices as well as their distribution process.

Finally, mobile AR applications often require an internet connection in order to send or receive information necessary for the progression of the application. Such information is inherently linked to the user location and if personalization of the application is available, to the user preferences. This could potentially conflict with user privacy, especially if this information can be linked to the user identity. Thus, evaluation of the application with respect to personal security and privacy is an additional key point.

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