Mobile Augmented Reality for Interpretation of Archaeological Sites

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ABSTRACT
Heritage interpretation plays a key role in understanding, imagining, and appreciating tangible cultural heritage, including historic sites. Interpretation becomes critical for visitors to historic sites that are partially or fully buried or in ruins, which is most often the case for archaeological sites. However, it remains a challenge for developers of AR systems and content to navigate the plethora of technologies and requirements in this evolving area. In response, we present the design of Arbela Layers Uncovered (ALU), a mobile Augmented Reality (AR) system for the ancient site of Arbela, Iraq. The site consists of an accumulation of buried layers left by successive civilizations inhabiting the area. In addition to describing the objectives of ALU, we discuss the development of a proof-of-concept and the design decisions involved. ALU features media for guiding visitors and interpreting and presenting the complex and multifaceted history of the site.

Categories and Subject Descriptors
H.5.1 [Information Interfaces and Presentation: Multimedia Information Systems]: Artificial, augmented, and virtual realities; J.5 [Computer Applications: Arts and Humanities]: Architecture

General Terms
Design, Experimentation, Human Factors

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Historic Sites Interpretation, Augmented Reality

1. INTRODUCTION
Cultural Tourism has become the largest industry in the world, far ahead of automobiles and chemicals [10]. Heritage tourism is considered one of the oldest, most popular, and widespread form of cultural tourism [7]. Not only 21st century civilizations, but also ancient Egyptians, Romans, and the nobility of medieval times all travelled to experience historic places of cultural importance [9]. Heritage interpretation, as an information communication channel, plays a central role in the experience of visitors to heritage and historic sites.

The recent advancements in information and communication technologies (ICT) have revolutionized communicating and accessing information. Consequently, introducing new technology for conveying meaning and narrating stories has become one of the latest trends adopted by cultural heritage institutions. Augmented reality (AR), as an emerging communication technology, has attracted considerable attention for guiding and interpretation. It merges the real and virtual world together by inserting virtual entities into user’s view of their physical environment. This context aware technology enables linking and geo-tagging multimedia content (such as visual, audio, and three-dimensional models) into a physical object or scene, and viewing that content within the scene.

We believe implementing mobile AR systems in historic and archaeological sites will enrich visitor experiences in those sites through enabling on-site access to various source of historic information in various forms - something that would be more challenging and costly to do otherwise. We also believe AR systems increase learning and interaction with historic sites by providing personalized self-guiding and mobile context aware media for presenting and interpreting cultural, heritage, and historic resources.

Despite the potential of AR for heritage interpretation, a relatively small number of pilot AR research projects have been developed and conducted within the context of cultural heritage and historic resource management. There are even fewer of studies investigating the potential for guiding and interpreting historic and archaeological sites, and design and technical requirements.

As a working example to motivate our investigation of AR for historical sites, introduce Arbela Layers Uncovered (ALU), a mobile AR project whose objective is to guide visitors through the ancient site of Arbela in Kurdistan region of Iraq, and help them to uncover its 7000 years buried history. We discuss the development of the ALU proof-of-concept system and its design and technical requirements.

2. RELATED WORK
ARCHEOGUIDE (Augmented Reality-based Cultural Heritage On-site GUIDE) is an ongoing project pursued by a consortium of European organizations. It aims to give ar-
3. THE ALU AR TOUR

The Arbel Layers Uncovered (ALU) AR tour is a research project based on the historic site of Arbela (also called Erbil or Arbel citadel), located in the heart of the modern city of Arbel in the Kurdistan Region of Iraq. The citadel is situated on top of an artificial 32 meters mound that is the accumulation of layers of successive occupation by a number of historic civilizations and empires including Sumerians, Medes, Assyrians, Persians, Greeks, and Ottomans. Arbel’s name appears in many historic scripts and records under different names. Internationally, Arbel is well known as the site of the decisive battle, Gaugamela or Arabela battle, between Alexander the Great and King Darius III (the Persian Empire King) in 331 BC [3].

It is believed that the urban life at Arbel site started around 5000 BC which would make it the oldest continuously inhabited settlement in the world [11]. The Arbel citadel represents a unique example of a town that has nested on top of a hill for several millennia and has, since then, not only accumulated numerous archaeological information to visitors of cultural heritage sites in an innovative and compelling way [2]. The ARCHEOGUIDE IDE system uses AR for on-site visualizing of life-sized, three-dimensional virtual models of missing and reconstructed parts of damaged artefacts and buildings in historic and archaeological sites. Visitors are equipped with a small mobile computer, earphone, and a head-mounted display (HMD) while navigating around a historic site. This enables users of the system to experience the real site while appreciating visualizations of the virtual reconstructions integrated seamlessly into the natural field of view. For example, ARCHEOGUIDE IDE has been used for visualizing some virtually constructed buildings on the ancient site of Olympia in Greece. It not only enhances a visitor’s imagination, but also provides a cost effective alternative for reconstructing and visualizing a historic site in its prime, without interfering with the archaeological integrity of the site.

LifeClipper is another AR system for cultural heritage presentation and interpretation. The system offers an audio-visual walking experience which allows users to see landmarks and streets of St. Alban Quarter from medieval times while walking in the modern city of Basel, Switzerland. Similar to ARCHEOGUIDE, a LifeClipper user wears a portable computer unit and an HMD. Sounds are also augmented into the user’s surroundings and the sounds change according to the user’s location [6]. The three-dimensional reconstruction of medieval city streets, virtual people wearing medieval clothes are visible from the HMD in order to further enrich the AR tour experience [8].

The History Unwired (HU) Walking Tour also applies AR to cultural heritage. In a multi-year investigation of the narrative uses of mobile technology in historic cities, a group of researchers from MIT developed a mobile AR prototype which enables Venice tourists to explore beyond San Marco Square [4]. The aim of this project is to enrich visitor’s visual experience with a historical narrative that expands the appreciation of the sites. It does so by providing personalized, self-guiding interpretative media, that take tourists to lesser-traveled, yet culturally-rich areas of Venice and give them an intimate experience of Venetian life [1].

4. ALU PROOF OF CONCEPT

One of the main challenges we faced in the design phase of ALU was the lack of established design guidelines and the limited research on the application of AR technology in heritage interpretation and visitor guiding in historic sites. For this reason, we conducted a comprehensive survey to examine the underlying technologies of AR to determine requirements for visualization, geotagging, wayfinding, audio and visual guiding, and other functionalities that might enhance heritage interpretation. From this, we developed design guidelines for mobile AR systems for heritage interpretation and visitor guiding in historic sites [5]. The development of our ALU proof of concept is based on these design guidelines as we considered technological and interface options.

4.1 ALU Technology Platform Factors

In selecting a technology platform for ALU we considered four factors from our design guidelines: reliability, mobility, ergonomics, and cost. Recent mobile devices such as smartphones and tablets have made them likely targets for hosting AR applications.

We achieve reliability by using established devices such as the Apple iPhone and Android smartphones, using robust operating systems (iOS and Android). These devices obviously provide mobility typically carrying a full sensor suite and important archaeological layers within but also possesses a very important traditional architectural and urban heritage [11].

On-going archaeological excavation in some parts of this ancient site resulted in finding archaeological artefacts and structures from different eras. The vertical layer over time confounds visual interpretation by the visitors to the site. The most archaeologically and historically valuable layers are buried under the existing urban fabric and (more importantly) structures that are only several hundred years and therefore have heritage value themselves.

While the Arbel citadel administrators are looking for an effective system that communicates the long history of this living, ancient site to its visitors, we proposed ALU AR tour. We believe ALU as a context aware mobile AR tour guide makes an effective user-friendly medium for presenting and interpreting the site history visits. ALU’s objectives are as follows.

- Build a self-guiding AR system that enable visitors to access context-related information while navigating around a historic site using personal lightweight mobile devices like smartphones and tablets.
- Virtually restore partially or fully damaged buildings and structures on a historic site and enabling visitors to see the restorations integrated with their real environment.
- Provide a medium for collecting site visitor experiences, feedback, and suggestions for further development.

The development of ALU project includes an in-depth design, implementation, and evaluation phases. Currently, the project is in the design phase. In the next section we discuss the development of ALU proof of concept.
(camera, global positioning, accelerometers, and compass) and communication links in a small package. Ergonomically, these devices are small making them easy to carry, but some users may find the displays too small. Tablet devices are an option for those willing to carry a larger device to have a larger display and easier touch interaction. Finally, these devices are cost effective, available to many people worldwide.

4.2 ALU Interface Factors

The list of factors considered in the ALU interface design is extensive. We summarize some highlights as follows.

- The interface must conform to the platform hardware specifications including screen size.
- The interface should use a variety of content types such as text, audio, image and video. This is to maintain user interest. Content format must, of course, be compatible with device capabilities.
- Information should be layering in order to avoid overwhelming users.
- Navigating the interface should be easy with minimal learning. For example, providing buttons that provide quick access to the main section of the ALU interface and other components that give cues about certain functionality.
- Content should support multilingualism.
- The interface should integrate a two-dimensional map view for navigation throughout the historic site.

4.3 Visualization

In developing the ALU interface requirements, we visualized the usage through a series of diagrams that follow the interface through its intended use. This subsection presents a selection of those visualization diagrams.

Upon the activation of the ALU application on a smartphone, the user sees a welcoming page which includes a brief message about the application and how to use it. The user can skim through this or continue to the next page. The next page has the language selection option. As previously discussed, ALU supports multilingualism and its content (text and audio guide) is provided in six languages (including Kurdish as the local language and English). Upon selecting a language, the user is directed to the main (menu) page of ALU where the camera view is automatically activated. The main page is divided into three areas (Figure 1).

1. At the top of the display is a status bar that includes a Home button (left), an icon for displaying the device’s orientation (compass) and audio guide option availability (right), and title indicating that the user is viewing the main ALU menu (center).

2. In the center of the display, the user sees a live camera view of their surrounding physical environment, the content, and the augmented view (content mixed with the scenes from the live camera view).

3. Three content buttons are on the left-hand side of the display (when the device is held horizontally). The ALU content can be accessed in three modes each with a corresponding button on the screen: History, Heritage, and Database.

In the History mode, content information (audio and visual) can be accessed for the 7000-year history of Arbel site which does not have any tangible representation visible on the site. The content in this mode is not augmented to the camera view of the historic site since some of the stories are not linked to a particular location or building in the current site and given that archaeological excavations for the buried layers are still in an early stage (Figure 2).

In Heritage mode, content information about Arbel’s visible, tangible heritage and its buildings and traditional architecture are geotagged into the physical environment of the Arbel citadel. Once activated, Heritage mode gives the user three options for viewing the content.

1. A three-dimensional view (or augmented view) shows relevant content information integrated into the live camera view on the screen and linked into a particular location or building on the site (Figure 3).

2. A two-dimensional view (or map view) shows a map with the user’s location and the surrounding content plotted with pins. The size of the pins changes to convey the user’s proximity to a map location. This view allows the user to see a bigger picture of the historic site and its contents geotagged to it (Figure 4).

3. A reconstruct view allows users to see a life-sized three-dimensional virtual restoration of a building or struc-
5. CONCLUSION AND FUTURE WORK

In this paper we presented the design of a mobile AR tour project for on-site guiding visitors and interpreting a historic archaeological site and discussed the design development process, including technical and interface requirements for developing mobile AR tours for interpreting historic sites.

The validation of this work will be achieved by implementing and evaluating ALU. This will reveal the effectiveness of the mobile AR and testing and assessing the design guidelines we summarized from our surveys for the related literature and projects.

6. REFERENCES


