"Take me Home": AR to Connect Exhibits to Excavation Sites

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ABSTRACT

We present the design and implementation of an AR application that connects museum objects to their original locations in archaeological sites; our aim is both to solve the museum de-contextualization problem and to promote exploration of the archaeological sites in a region. The application projects the museum object upon the archaeological site and its original location, bringing the landscape into the museum experience. We outline technical challenges encountered and solutions adopted. Since this is a work in progress, further user testing remains to evaluate our approach and the app.

CCS CONCEPTS

• **Information systems** → *Information systems applications*; • **Applied computing**; • **Human-centered computing** → *Systems and tools for interaction design*;

KEYWORDS

Augmented reality, Cultural Heritage, Museum, Contextualization

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1 INTRODUCTION

The Archaeological Museum of Tripolis (Greece) is located in the prefecture of Arcadia (around 160 km southwest of Athens). It houses a very important collection of Neolithic (10000 BC–7000 BC), Early Hellenic (200 BC–2000 BC), Mycenaean (1600 BC–1100 BC), Geometric (1100 BC–800 BC), Archaic (800 BC–500 BC), and Roman (146 BC–330 AD) ancient items. Like in most regional museums, the items come from different excavation sites around Arcadia and are exhibited in the central museum of the region. Regional museums like the one in Tripolis are a very good and practical solution in collecting items from different locations and exhibiting them in one place; however, over the years it was realized that an important weakness of this practice was the de-contextualization of the experience. Many researchers agree that a museum exhibit is not merely a material object that needs to be protected and displayed, but mostly a synthesis of practices, values, beliefs, traditions, memories, etc. [4, 12]. Thus, removing the object from its original location and bringing it in the museum may solve many practical problems, but gives rise to important de-contextualization issues regarding the visitor's experience with the object, which need to be addressed by re-contextualizing the object, also addressing visitor needs for "making sense" of the presented content and their relation to their original locations [1].

In this light, the famous Norwegian painter J.C. Dahl (1788–1857) criticized the de-contextualizing character of museums and proposed the landscape as a museum in itself, stressing the importance of the landscape in the museum experience: "This conflation of museum skepticism and the launching of the landscape as museum constitutes an interesting and overlooked contribution to a familiar debate, namely the century-old critique of the museum as an instrument of deadening de-contextualization." [8].

Another consequence of exhibiting items collectively in regional museums, which are usually located in the central, most well-known city of the region, is that visitors are amassed there. In recent years, this tendency of mass tourism to collect in specific locations has led to serious sustainability issues of cultural heritage. Thus, many local authorities, especially in areas not so well-known to tourists, like Arcadia, are trying to find ways to redirect visitors to further locations within their region; this would expand cultural tourism and boost local economies by capitalizing on different tourist routes and alternative cultural experiences [10]. Re-contextualizing the objects in museums has, in this respect, the potential to raise awareness of the respective cultural destinations.

The present study is a work in progress, aiming at connecting specific museum objects to their original excavation site in an attempt to

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- provide important contextual information,
- use landscape as an important contextual element,
- highlight and enrich artifacts,
- highlight historical places and archaeological sites in the wider region of Arcadia,
- direct visitors to less well-known locations and motivate them to visit the archaeological sites around the prefecture of Arcadia.

2 LITERATURE REVIEW

Connecting the museum's objects to excavation sites can be beneficial, since it would connect the artifacts to the places of their origin, thus providing important contextual information. Past efforts showed the importance of contextual experiences in Cultural Heritage (CH) in enhancing the visitor experience, by adding contextual displays and contextual installations in different venues [1]. Different approaches have been tried, from targeted narratives that vividly describe the place of origin of the exhibit and directly ask the user to visit nearby locations [7], to installations and applications that allow sensory interactions involving smell, touch and sound, with visual and aural feedback [2].

Augmented Reality (AR) techniques can enrich the experience and increase the interest of the visitors, as well as enhance the learning experience [15] regarding the artifacts presented, also showing clear cognitive gains like memory enhancement and curiosity [9]. Well-designed AR at museums can significantly affect the quality of experience [13] and the intentions of visitors to revisit the venue [5].

AR has been used successfully to alleviate the issues of museum de-contextualization. In the world-famous Acropolis Museum, AR was incorporated in narratives, in an attempt to place the exhibits to their original location, but also to provide virtual reconstructions, to highlight details, etc. [6]. Other studies have shown that positive emotions and learning benefits were found when AR was used to contextualize museum exhibits [3], and that the effective communication of the original context through AR increased motivation and curiosity [11].

3 CREATION OF A 3D WORLD USING 360-DEGREE PANORAMAS

The AR application that we envisaged for the museum of Tripolis required the virtual artifacts to be placed on the excavation sites at their current state today. For this purpose, it was decided that 360° immersive panoramas was the preferred way of transferring the visitor to the site within a virtual environment.

The usual method to create such panoramas involves a complicated technique for acquiring the panoramic images needed. The photographer must have a modern digital single lens reflex camera (or dSLR), an ultra-wide angle (also called a fisheye) lens, and a sturdy tripod with a special panoramic head. She then has to position herself and the camera at the approximate center of the site, and start taking photos at specific angle increments in order to fully capture the surrounding space in a circular fashion; then the camera is tilted at a specific angle and another set of photos is recorded. Afterwards, photos must be stitched together via dedicated software. If the results are not satisfactory, the photographer has to repeat the complete procedure from scratch. The aforementioned method has the indisputable advantage of very high quality panoramic images. However, the photographer has to carry bulky equipment, often by foot at remote areas, like some of the excavation sites in Arcadia. In order to assemble the set-up, considerable time is needed, which is invaluable in situations where lighting conditions require fast response from the operator (like sunrise or the "golden hour" before sunset). The equipment is susceptible to adverse weather conditions, like extreme heat (often experienced in Greek outdoor settings), that could melt soft camera and tripod parts, or gusts of wind that could cause the tripod to fall and the camera and lens to be damaged. Working with a laptop on-site to acquire the huge datasets produced and stitch them together takes a lot of time, making a re-shot impossible in certain cases.

For these reasons, we followed a hybrid approach. While a traditional setup, as described above, was used for each archaeological site, backup 360° equirectangular panoramic images were captured using the Google Street View application on a current high-end Android smartphone. The application uses the device's accelerometer to understand the orientation of the device. A visual guide assists the operator at capturing all the different angles required for a full 360° panoramic image. After capturing is complete, the software automatically stitches together all the captured images and the photographer can preview the result in almost real time, like a user would view the result on his/her smartphone. As one realizes, the process is much more straightforward than the traditional method. The smartphone used weighs just about 150g, while the traditional 360° photography equipment weighs at least 1.5kg, even with modern mirrorless cameras. Carrying a laptop or transferring the images to a workstation is not required and the automation that the application provides at stitching and presenting the final panorama to the user in nearly real time is indispensable. The photographer can instantly decide if the result is satisfactory or not, and quickly proceed on re-shooting. It should also be noted that modern smartphones possess high resolution imaging sensors with HDR (high dynamic range) capabilities and are able to produce very high quality pictures assisted by computational photography processing techniques.

In our captures, some image stitching errors occurred either with the specialized software or with the smartphone application and were easily corrected using Adobe Photoshop. The final images where resized and compressed so that the experience would be seamless even on modestly powerful smartphones

4 IMPLEMENTATION OF THE AR APP

Our AR app can be used on Android smartphones. Visitors point the camera of their smartphone at AR-enabled exhibits and they can explore the place that the exhibit was actually found in, with their phone as a window to the archaeological site (Figures 1, 2).

Regarding the recognition of AR-enabled exhibits by the app, at first we created a cloud database with various pictures of the exhibits using the Vuforia framework and linked it to Unity, the real time graphics engine that we used for our implementation. Unfortunately, tests of the image recognition algorithms in situ did not yield satisfactory results. Our experimentation revealed that the algorithms were adversely affected by changing lighting conditions.

Figure 1: Archaic head of kore originally found at Mantineia.

Figure 2: Marble stele originally found at the ancient site of Orchomenos.

These are, however, unavoidable in the Archaeological Museum of Tripolis, since it depends mostly on natural lighting and direct sunlight comes through. Therefore, we decided to not use image recognition and, instead, assign a QR code to every exhibit that we wanted to augment. Building the cloud database with the QR codes and their respective information, testing and integrating with the graphics engine produced the desirable results.

As described in the previous section, for each exhibit we acquired 360° panoramic photographs of the place it was found in. Then, in Unity, we built a 3D world as a spherical structure with inverted normals and applied these panoramic images as textures over it. We provided a first-person controller view using the mobile phone's accelerometer and gyrometer to add interaction and control the viewpoint towards the mixed environment, thus giving the ability to explore the simulated physical site via one's phone screen. Finally, we added a minimalistic GUI to our app, providing additional information about each archaeological site (location, directions, etc.).

5 PILOT APPLICATION

In the Archaeological Museum of Tripolis, our AR app was carefully coupled with targeted narratives designed for the various exhibits. The narratives asked visitors to imagine different landscapes and the social circumstances in ancient times, and AR provided a view of these landscapes as they are today. In addition, the museum experience was accompanied by maps that would provide directions to the visitor to reach different archaeological sites in the wider region.

Since technological interference can interrupt the cultural experience happening in the museum, we decided that the AR app should not be accessible during one's initial visit to the museum but only during a second walk. The visitors, holding their smartphone, can then follow a different route, looking for the exhibits that have useful information to be triggered.

6 PATHS FOR FURTHER WORK

Being a work in progress, the present study can be completed and extended on several axes. First and foremost, we believe that such novel methods need to be a part of the greater framework and design of the museum experience. Their outcomes can be maximized when they are incorporated in the design of the exhibition and integrated into the curatorial plan. In our deployment at the Archaeological Museum of Tripolis we made a substantial effort to this end, as outlined above. In the general case, aspects to study further are:

- how to decide which objects will be augmented, balancing the coverage of the museum collection and the number of promoted archaeological sites with the induced costs and complexity for producing the required AR material;
- how to show to the visitor which exhibits are augmented in the museum, taking into account the technologies available and any other factors that may affect their applicability (in our case, for example, we had to use QR codes instead of the more elegant direct recognition);
- what augmentation material to provide, and in what form (text, image, audio, video);
- how to support the cultural experience without affecting it adversely in any way (for example, avoiding visitor distraction);
- what are the visitor expectations out of such technological approaches, in regards to a cost effective app;
- how to evaluate the outcomes of such technological approaches.

We plan on conducting broader testing and summative evaluation of our effort in order to assess usability issues of our app with the wider public, user satisfaction, and effectiveness of the application in regards to its objectives (contextualization, promotion of close-by sites, etc.). This evaluation will hopefully demonstrate the potential of AR in contextualizing museum experiences.

Regarding the app itself, the virtual world implemented and the use of interactive real time graphics on commodity devices can provide a starting platform for gamification efforts and related research; gamification by itself has also been shown to have positive effects on museum experiences [14].

7 CONCLUSIONS

Augmented Reality is a powerful tool that can enrich visitor experiences, increase learning and attract visitors, but also a tool that can support contextualization of museum objects and contribute to directing visitors to less well-known venues and sites. The present

work investigated issues of museum de-contextualization, and introduced the design and implementation of an AR app to bring the original landscape in the museum experience and promote archaeological places in the wider Arcadian region. Technical aspects of the complete process were described, and relevant challenges were explained together with the solutions applied. Finally, our roadmap to complete the present work was outlined, by evaluating its approach as well as its effectiveness and by extending it towards further interesting directions.

Our future works will focus on testing alternative ways of incorporating the AR experience in the museum visit by minimizing possible intrusive elements. We will also work with reconstructions of the original sites and show the objects not only in the landscape, as it is today but also project them in the reconstructions of the sites. In addition, we are already working with a tool for archaeologists and visitors to show the exact position and location of the object as it was found during the excavation. This can be available to visitors of both the sites and the museum.

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