A digital look at physical museum exhibits

Designing personalized stories with handheld Augmented Reality in museums

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***Abstract*— In this paper we present the design of handheld Augmented Reality (AR) experiences that are seamlessly incorporated into interactive museum narratives, specifically for the Acropolis Museum. The experiences start by forming a visitor profile that later dynamically adapts the narrative, including the AR activities, to the user's behaviour. In this cohesive narrative context, the AR activities provide four ways to digitally look at the exhibits: virtual reconstruction of the original aspect; placement in the original location; visual highlighting of interesting details and annotations; and recreation of mythological appearances. The challenges of this design are presented, conluding with a discussion and lessons learned.**

Keywords—Augmented Reality; Museums; Digital Storytelling

I. INTRODUCTION

The increasing technical capabilities of Augmented Reality (AR) technology have raised audience expectations, advancing the use of mobile and wearable AR in cultural heritage (CH) settings. At the same time, the attention regarding the use of AR has shifted from merely attracting and entertaining audiences, to finding suitable ways of providing contextually relevant information that can enhance visitor experiences. Studies show that AR – although technically still immature – has both the unique ability to engage visitors and to provide quantifiable learning outcomes [1].

However, in most current applications, AR is usually isolated, either because it constitutes a proof-of-concept; because it works only at single points or exhibits, e.g. through special hardware installations [22]; or because it aims to replace the landscape of existing digital mediators [15]. Museum exhibitions, though, are designed in such a way that although comprising multiple mediators, the result is a completely seamless, flowing experience. This raises several challenges with respect to the incorporation of AR in the museum. Firstly, how to blend into a pre-existing exhibition design, aimed at a specific purpose and relying on another technological infrastructure. Secondly, how to track original archaeological objects, where no physical marking is possible, with computer vision (CV) technology. Finally, how to make visitors understand and follow in the context of the museum visit the interaction paradigms required by handheld AR.

This paper addresses these issues through the example of the CHESS project, which aims at designing and evaluating personalized interactive stories for visitors of cultural sites [16][14]. First, we introduce an overview of handheld AR in museums; then we present the role, design, and implemntation of AR in our project; we conclude with a discussion of the issues and lessons learnt.

II. HANDHELD AR IN CULTURAL HERITAGE SETTINGS

The arrival of smartphones and tablets has paved the way for a multitude of AR applications in CH, most of which are enhanced museum guides, visually augmenting physical exhibits with background or interpretive information. The majority of these applications are object-oriented, based on the principle of the video-see-through or magic lens [10][4][15]. The few storytelling-driven projects, which use AR to convey the history of a place in the context of a guided tour, are mostly implemented for the outdoors; in these cases, the mobile device is used to get AR views of a building, to receive additional location-based information, or to listen to audio- and 3D-enhanced narrations [19][24].

Several research projects propose well grounded ways to use AR [17][20]. Yet, due to their novelty, these often take the shape of technological proof-of-concepts aimed at illustrating the potential of AR and leaving AR's integration in the pre-existing transmedia landscape unaddressed. Yet, in terms of technical implementation, easy-to-install AR browsers[1] that rely either on geospatial data or 2D CV tracking techniques have emerged. As CV tracking technologies have proven to be stable enough, at least for (arbitrary) 2D tracking targets, the need arises to develop AR applications for (heterogeneous) transmedia landscapes in which AR does not aim to replace existing mediators, nor work only at single points or exhibits, but instead merges in the communicational and spatial environment [9][7]. To that end, we have sought to seamlessly integrate AR in a non-linear storytelling context.

III. AR AT THE ACROPOLIS MUSEUM

The CHESS project explores the use of personalized interactive storytelling experiences linked to or illustrated by museum exhibits and delivered through mobile devices. Unlike [19] the storytelling content is not standardized and linear but rather personalized at several levels, e.g. different themes, information depth, language style, visiting style, and activities. These activities comprise diverse multimedia assets (audio narration, images, 2D and 3D reconstructions, video, games, and AR) that are interweaved in alternative story plots and tailored to each visitor thanks to an initial matching with predefined profiles [14]; as the experience unfolds, the story

[1] e.g. http://www.layar.com, http://www.metaio.com/junaio/

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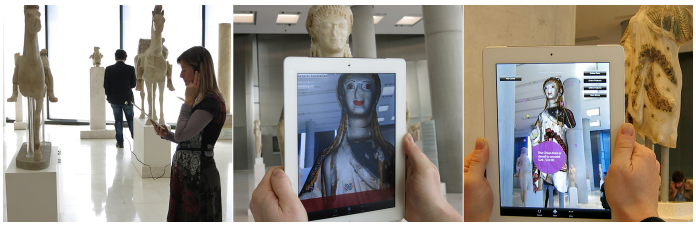

Fig. 1. AR at the Archaic Gallery of the Acropolis Museum.

adapts to the visitor‘s inputs, positions, and behaviours. Hence, the AR experiences need to be personalized as well, e.g., by creating different versions of AR activities to be dynamically injected into the story by the system depending on the initial profiling or the subsequent real-time inputs.

One of the cultural settings where this approach is designed, implemented, and tested is the Archaic Gallery of the Acropolis Museum of Athens (Greece). Located on the first floor of the museum building, the Archaic Gallery displays archaeological objects found on the Acropolis hill. The exhibits are arranged in thematic and chronological clusters, accompanied by discreet mediators (labels and panels; Fig. 1).

A. Description of AR Activities

Several stories have been designed by the Acropolis Museum in which AR has been incorporated. In the first story, a horse acting as main narrator brags about his importance for ancient Greeks from different perspectives (war, sports, mythology, daily life). This provides the opportunity for personalization at the plot as well as the content level. The story was designed for two different visitor personas: one plot is for a child, who has to help the horse get his friends back to their time and hears about mythological beings; and the other for an adult, who is guided to get a glimpse of the ancient Athenian society.

The first example is linked to an exhibit representing the mythological being Medusa, who had snakes instead of hair and whose gaze turned mortals into stone. It was an architectural ornament, and was most probably placed on the apex of the pediment of a big temple located where the Parthenon stands today. The AR activity has a different version for each of the two profiles and in both instances it is tightly integrated in the story plot as part of a transmedia environment. In one case, the path will be “interrupted” by the narrator warning the user about Medusa standing behind him. Using the device as protection the user will see Medusa‘s eyes glowing and eventually the screen will be virtually “cracked” by her power (Fig. 2). In the other case, the ornament is reconstructed with illustrative 2D sketches and placed in its original position on top of the temple.

The second example is related to a Kore (maiden) statue. In this case we give more room to AR as a medium and mediation channel. By turning the principle around, we bring the narration into AR and connect it with interaction as a means to control information delivery through motion-based interaction techniques [6]. When visitors raise the device, they can see the statue in its original bright colours. Subsequently, first and third person annotations and audio narrations that are spatially coupled to the physical objects appear and start playing depending on the user´s movements (Fig. 1). Content and language style are again adapted for two different personas.

The main advantage of mobile technologies for museums is that they help connect (digital) information to a physical object in real time, thus expanding the information spaces related to the exhibit. Yet, the results of different evaluations have shown that a) these extensions may break the flow of a tight exhibition discourse [5]; and b) that it is confusing/disrupting for visitors to split attention between the physical objects and the mobile device in order to obtain information about them [2][8]. AR appears to be a suitable solution to conciliate the digital and the real environments, since it visually superimposes information directly over the point-of-interest as the user looks through the screen. On the other hand, we deploy AR so that it does not rely exclusively on an autonomous, object-centred, descriptive approach, but is embedded into interactive stories that are technologically composed of diverse activities. In other words, AR activities are like story units within a general story plot. This is possible because the stories are staged (i.e., they develop in space and time [16]) and the main reference points are the exhibits.

B. Mediation Principles

Although (visual) augmentation/presentation types and interaction techniques have been widely discussed [11][21], the mediation level has been only rarely addressed beyond the technological possibilities of visual augmentation methods. We argue that mediation techniques are a powerful way to shape user experiences, following classical design approaches to visually mediate information [13] but in a new medium/way. Virtual reconstructions may create a strong impression but their mediation level seems to be limited [12]. It may be more important to lead the visitor´s attention through the relevant aspects by means of visual indications, highlights, or spatially annotated information. AR provides an emphasized reality, either by adding, modifying or filtering it [23].

In the case of the Medusa exhibit, for the child persona, we chose an empathic experience that shows how ancient Greeks imagined Medusa´s powers. For the adult, the goal is to show statues in their original architectural context, where the non-photorealistic representation [23][6] not only expresses the hypothetical character of the reconstruction but also highlights aspects that are considered important (location, shape, etc.).

In the case of the Kore statue, we chose to work not only with visual superimpositions but to seamlessly switch between first and third person annotations, which, coupled with their audio version, transform the statues into characters with their own history and attitude: first-person narration brings the statues alive by giving it a voice; third-person narration alludes tothe archaeologist, who is now addressing the user. Both create a seamless narrative, an interactive personalized experience within the story context.

In summary, mediation takes place in two different ways: one is rather explorative and experience-driven through interaction and mixed media; the other rather formal, more descriptive, and explanatory.

Fig. 2. The Medusa scenario: eyes glow for the child persona (left); the original shape of the statue is completed in a stylized form (right).

C. Implementation

Our technical setup is based on a server-client architecture working with wireless networks. The mobile devices act as clients and are in constant communication with the backend, which manages and composes the story-related activities and profile-based plot through a Storytelling Engine [16]. Although the backend acts like a hub, for some AR activities we deploy huge (3D) assets and core data (such as feature maps) on the mobile, to keep loading times over the wireless network low. Once visitors start the experience, the mobile client communicates with the backend, which prepares the story plot and delivers or triggers related activities to the mobile with the help of an activity management component. This ensures that relevant activities are available on time.

A single application, instantAR, is used for the mobile devices [3]. The mobile AR framework for iOS devices comprises a webkit-based browser component, an X3D render engine, a configurable tracking engine, and a video preview in the background. The story-based activities and the user interface are implemented in HTML5, CSS and JavaScript. All application elements are responsive, i.e. display correctly on different screen sizes and device form factors.

From the point of view of tracking, the Archaic Gallery constitutes a quite controlled environment, both in terms of object position (statues usually stand on high marble bases and therefore are not occluded by other visitors), and in terms of lighting (which is very stable throughout the day). In order to ensure a suitable user experience, we implemented the AR activites with some core requirements: avoid cluttering the environment (and archaeological originals) with artificial markers by employing CV-based tracking that is able to track with high accuracy and that uses natural features; processing the CV based tracking of 3D targets in real time on the device, which is a necessity and enabling technology to work with the physical objects interactively; and finally establish scalable, efficient ways to generate reference models for the tracking.

For tracking, we use 3D-feature maps and 2D reference-contours extracted from video sequences acquired directly with the mobile devices and based on Simultaneous Localization and Mapping (SLAM). The feature maps are generated in a post-processing step with [18] and are used on the devices afterwards. After the feature maps have been acquired, we match them with a 3D model of the physical object, to connect the coordinate spaces of 3D visualization(s) and CV tracking. The result averages a frame rate of around 25 to 30 fps.

IV. Discussion

The deployment of the AR activities faced several challenges and constraints. On a technical level, the web-app approach facilitates the incorporation of storytelling in AR, whether AR is part of the story plot at some point (i.e., integrated in transmedia), or where AR itself becomes the medium in which the narration happens. Howeveradapting AR to different profiles and visualizations is quite time consuming in terms of media and asset production. To overcome this, we are exploring the possibility to work with more unified templates, in which the activity concept stays untouched, while the graphical assets are replaced to fit each profile.

From a user experience point of view, the evaluation of the Horse story showed that visitors want to obtain more exhibit-related information. AR is a suitable tool for a descriptive, object-oriented approach, yet the challenge is to balance descriptive annotations and the main storytelling line. Leveraging personalization may offer a solution. For example, by accentuating the sense of discovery for visitors who like active roles instead of being guided. Additionally, features will be offered, such as the ability to stop/pause the story, obtain more in-depth information, or keep it for later.

Reliable tracking technologies are crucial for the fidelity of the experience but 3D target tracking solutions still pose some challenges (e.g. extracting stable features from the white marble surfaces of the statues from all viewing angles).Our approach requires users to stand initially at a specific position, but evaluation results indicate that this influences negatively the experience, as visitors are not sure whether the system works or not. To overcome such situations, the system should give strong feedback and guide the user, e.g. by asking him/her to wait or to move to a specific point.

Finally, our AR interaction paradigms require the user to move around the object and look at it through the device´s screen from specific distances. On crowded days, being too close may disrupt other visitors´ contemplation of the exhibit; while on the other hand, large guided groups standing around the exhibits impede the AR experience. Hence, how can different visiting behaviours around exhibits coexist? The tracking system's working distance and obliquity range should increase, so that bigger flexibility with regard to the environment conditions is achieved. We are also exploring a novel concept of what we call information persistence: the idea is to shift AR-related interaction principles from the object to the content/context, so that the information does not vanish if the device is not anymore pointed at the object. Since we already use a 3D model of the physical objects as a reference in the virtual space, once users lower their device, we are able to present 2D and 3D information without the video-background; that is in a contextually and informational persistent manner.

V. Conclusions and Further Work

In this paper we have discussed the design constraints, implementation and initial lessons learnt from incorporating AR into a transmedia landscape. AR is not seen as a stand-alone application, nor does it replace the entire landscape of existing mediators. Instead, we integrate it as another channel inside a comprehensive and coherent framework based on

personalized interactive non-linear storytelling on mobiles. In this context, we use inherent values for visual mediation techniques, such as leading attention through visual emphasis and annotations, to which we add an emotional character to create digital looks for heritage objects that may be more engaging and effective in terms of communication.

Based on a web-app approach, we deploy a mobile experience system that uses web technologies to create interactive AR experiences with computer vision based markerless 3D. Using web technology eases the development complexities, allowing us to create early prototypes as well as high fidelity scenarios inside a broad, cloud-based system architecture. A promising approach might be streamlined AR templates, fitting to specific application and story-plot needs, that might also be (automatically) created and integrated through authoring tools.

An appropriate novel interaction design is needed to respect different approaches in the context of museum visiting, and specifically for the Acropolis Museum. We look into this with spatial interaction techniques as well as with keeping information accessible, even if AR is not employable anymore.

With our test scenarios we have been able to prove the technological foundation of our concepts. However, evaluating visitor experience is paramount. In the coming months, we will be conducting formative and summative evaluations of the AR activities within the wider framework of the storytelling experience, aimed at testing the added value of AR storytelling for museum visits; technical robustness; and usability/interaction aspects.

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