Presenting Cypriot Cultural Heritage in Virtual Reality: A User Evaluation

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Abstract. This paper presents a user evaluation related to the overall experience of a number of volunteers obtained by visiting two virtual museums populated with digitized Cypriot cultural heritage/art items using different virtual reality display systems. The two virtual museums used are replicas of an engraving museum and a virtual Byzantine icons museum. During the experiment visitors were able to use a Head Mounted Display or a stereoscopic Powerwall projection in order to obtain an immersive 3D experience. The results of the user evaluation indicate that both ways of presenting the museum received an equal usability score among the users but at the same time a number of drawbacks of each method were indicated. The findings of the research are crucial in enabling the use of a user-centered design process approach to improve the prototypes and develop virtual experiences for additional museums. The ultimate aim of our approach is to develop applications that showcase Cypriot Cultural Heritage in a way that attracts visitors to visit the original museums.

Keywords: Cultural Heritage, Virtual Museums, User Experience

1 Introduction

Virtual Reality has been widely used for the prevention and promotion of Cultural Heritage in the form of standalone applications targeting people who are not able to visit museums in place. The first virtual museums were applications running on a desktop computer or online accessible through the web. However, with technology advances, the current trend is among these applications to exploit different types of emerging technologies [1], Augmented Reality systems [2], multi-touch surfaces [3] and haptic devices [4]. Recent developments in Virtual Reality (VR) hardware resulted in reduced cost in acquiring VR equipment that enables the widespread immersive visualization and interaction in virtual environments.

The evaluation Virtual reality systems [5] is a challenging topic. Works on this area address the evaluation from different perspectives: (i) learning effectiveness of these systems [6, 7]; (ii) user performance evaluation usually using objective

quantitative measurements such as completion time, error rate and user experience and (iii) user enjoyment, engagement and satisfaction.

In this paper we aim to explore the possibilities of presenting Cypriot Cultural Heritage and Art in interactive virtual environments where visitors have the ability to navigate and interact with artifacts. To this end, we describe the results of user evaluation experiments where a number of volunteers interacted with two different virtual environments using two different visualization methods. The two virtual environments are a museum displaying Byzantine icons and an engraving museum. In both cases users had the opportunity to visit the museum using either a Head Mounted Display (HMD) or a stereoscopic Powerwall. The results of the evaluation are useful in shaping our future actions in this area that involve user-centered design and presentation of virtual environments displaying Cypriot Cultural Heritage and Art in public spaces.

2 Case Studies

The two applications evaluated by the users include a virtual museum displaying Byzantine icons in a contemporary way and a virtual replica of a real engraving museum. For both applications the design was done using Autodesk Maya. Real images of artifacts, assorted textures and interactivity were added using the game engine UNITY3D. Both applications are designed as first person perspective applications, where the user can navigate by moving the virtual camera.

2.1 Byzantine Icons Museum (Museum 1)

The Byzantine Icons museum is not a replica of a real one and it contains a number of important Byzantine icons that exist in various Churches and Monasteries around Cyprus. The museum was designed as part of a research project that aimed at developing methodologies that can be used for virtual restoration of damaged Byzantine Icons [8] based on statistical occlusion removal methods [9]. The virtual museum contains two main rooms where non-damaged and damaged Byzantine icons are displayed. Also 3D reconstructions of faces shown in the icons are displayed in the environment, providing in that way a unique way to observe and study Byzantine icons. In the case of damaged icons both raw and digitally restored icons are displayed. Indicative screenshots of the application are shown in Figure 1.

Fig. 1. Indicative Images of the Byzantine Icon VR Museum

2.2 Engraving Museum (Museum 2)

The Hampis Engraving Museum is located in the village Platanisteia, Limassol. The Museum's collection has approximately three thousand engravings and other exhibits such as engraving tools, etching presses, engraved plates, photographs and other documents. The implementation of a virtual replica of the museum aims to re-create the main structure of the building and the surroundings in order to provide virtual visitors an immersive experience through which a sample of the museum contents and related information is presented. The ultimate aim is to generate interest among virtual visitors in order to encourage them to visit the real museum.

The 3D model of the museum was created by a 3D artist who utilized architecture plans and images of the museum in order to produce an environment that is easily recognized as the actual museum. The resulting 3D model was textured using real textures captured at the museum and images of selected exhibits along with information panels, that can be displayed on-demand. In addition 3D models of various tools were created and displayed in the virtual museum. The virtual museum also includes two video rooms, where visitors can watch videos describing the engraving process and museum history. Images of the real museum and screenshots showing the virtual museum are shown in Figure 2.

Fig. 2. Images of the real (left) and screenshots of the virtual engraving museum (right)

3 Evaluation

Our end goal of this effort is to install the technology in public places and allow both locals and tourists to experience cultural heritage in a novel and engaging way. The evaluation is used to inform the use of this kind of technology within suitable locations and employ the benefits of a user-centered approach to its design.

3.1 Methodology Description

The development of the applications follows a user-centered design approach; namely, the application is tested by users at each stage of the development in order for revisions to be made at each phase based on the users' feedback and actions. When the applications were at a fully functional prototype stage, we invited participants to investigate the interaction and functional capabilities of the applications. At this stage of the development process 12 participants were selected (7 female and 5 male) to

take part in the study. The participants ranged in age between 20 and 40 years old and were from diverse vocational backgrounds and of different technological literacy levels.

There were two technologies for the participants to use. The first technology was a virtual reality HMD. For this experiment, we used the Oculus Rift[1]; a low latency 360 head-tracking immersive headset with a stereoscopic 3D view using two 640x800 displays, allowing for 100° field of vision for the user (See Figure 3 (left)). The second technology was a large (3mx3m) stereoscopic display with dual rear projection of 2048x768 resolution with 3D capabilities through passive type glasses (See Figure 3 (right)). Each participant was subsequently put into one of four groups (3 participants per group). This way, each group used a different technology or museum first in a Latin Square method in order to reduce bias and learnability effects as much as possible in our findings.

Fig. 3. Virtual Reality HMD setup (left) and Powerwall 3D setup (right)

A brief verbal explanation on the navigational controls were given to the participants before they were given the freedom to move around autonomously. We should note here, that independently from the used display technology, the interactivity was performed in the same way in all four scenarios, using a standard keyboard. The participants were explained that there was no set tasks to perform while engaged in the virtual museums and could explore the virtual worlds freely. There was no time limit and they were free to ask questions. A think aloud protocol was used to extract the participants' thoughts while engaging in the exercise. The investigator also took notes and asked questions, but was careful to minimize interruption while the participant was using the system. Once the participant was finished navigating and exploring one museum, there was a short break (2 minutes) and the next museum / technology was introduced until all four scenarios were completed. All participants finished the experiment with all four scenarios in one session. After the four scenarios were completed, a semi-structured interview and a questionnaire were used to extract further dedicated information from the participants' experience of the technology and the virtual museums. In the post-study questionnaire and semi-structured interview, the participants were asked several questions relating to the usability, learnability and user satisfaction of the HMD and the Powerwall experience inside the museums. The first question we asked the participants is to rate their overall general experience with the virtual reality and how much they liked it on a scale of 1-5 (1 – Not at all, 2- Not Really, 3 – Undecided, 4 – Somewhat, 5 Very Much) and comment on the reasons behind their answer.

[1] http://www.oculusvr.com/ (05/2014)

Similarly, participants were asked to rate and comment on more specific areas such as navigation, viewing capabilities, learnability, and memorability.

3.2 Findings

Time Engaged in Each Scenario. The participants were permitted an unlimited amount of time to explore both of the museums in each technological scenario. On average, the Powerwall kept participants engaged for longer periods of time, especially in the case of the Engraving museum which included more artefacts such as videos to watch (See Figure 4 (left)). Standard Deviation among participants was very high in all scenarios, suggesting large variations in both personal interests of participants as well as preference in technologies used (See Subsection entitled 'Subjective Ratings of Each Technology'). Interestingly, the time taken to view museum number 2 was statistically higher in the Powerwall scenario using a paired student's t-test ($N=12$ $P < 0.05$); unlike museum 1. We hypothesize, based on the subjective feedback of the participants, that the capabilities of the HMD, such as poor graphics and interaction, as well as nauseousness, limited the interaction capabilities of the medium used and therefore the time taken by participants. We also justify the elevated time in the museum to the fact that there was an availability to watch videos, which the participants only did during the session with the Powerwall.

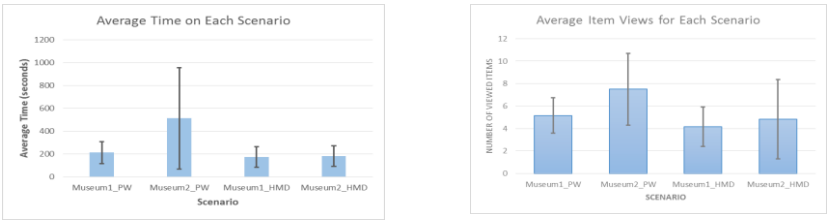

Fig. 4. Average time in seconds that participants took to explore the Museums (left) and average object views (right)

Items Viewed in Each Scenario. Participants were not given a set task or encouraged to view all the items on display. Museum 1 had a total of 21 viewable items and museum 2 contained 59 viewable items. Each museum had different types of items that could be viewed including 3D reconstructions of artefacts, wall mounted paintings, videos and a small scaled model of the museum. Interestingly, the participants did not vary greatly in the amount of items viewed between technologies, although there is a slight increase in the Powerwall (See Figure 4 (right)). The second museum was also scrutinized somewhat more than the first one, but proportionally to the items on display, this is not surprising. Furthermore, the museum's different interaction capabilities, like for example watching two videos, engaged the users into viewing at least part of the video. In fact, none of the users watched the video from beginning to end. A requirement for the next design of the museum was to enable a pause button and an indication of how long the video was. Participants also rarely revisited an item if they have already seen it. Interestingly, the on-display items were

not the only viewed areas. Most of the participants enjoyed walking and exploring the museum's structure and surroundings.

Head Mounted Display Experience Evaluation. The users rated the HMD experience with an average score of 3.92/5 as an overall experience (S.D: 1.24). The participants were mostly positive in terms of the general experience and liked the use of the novel technology which made them 'feel like you are actually there'; in other words, created a high level of Presence. Participants were all considering a heightened sense of immersion [10] as a positive feature. Following from this, participants also commented on the natural way that you can view the surroundings by moving one's head rather than using other controls. Memorability rated high (Average: 4.08/5 S.D: 1.00) in that users could remember where the exhibits were and the different locations available. The learnability of the virtual reality environment in terms of understanding how the navigation and viewing is done also rated high and there were seemingly no problems in the conceptual grasp of how the interaction occurred (after an initial brief explanation from the facilitator).

Although mostly positive comments the use of the HMD also produce some negative factors which were reported on by our participants. For example, although the navigation capabilities of the system were easy to understand, the actual interactivity was less than ideal with participants giving navigation use an average score of 3/5 (S.D: 1.48). The main concern that gave navigation a lower rating is that of using the traditional keyboard controls in a virtual reality environment. The obfuscation of the keys to the user creates difficulty in re-finding the keys with when one's fingers are misplaced. From the subjective feedback we also hypothesize that the rating would drop much lower if the navigation did not include the natural navigation of rotating one's head to the direction one wants to proceed to. The second main disadvantage of the HMD is that of resolution. Participants rated the viewing on the HMD with an average of 3.25/5 (S.D: 1.36). The current setup, being experimental run in 640x800 resolution for each screen and there were noticeable pixilation issues, especially for viewing textual information like the clickable descriptions in Museum 2 and the headings of the 3D reconstruction statues in Museum 1. These issues, we hypothesize, will be reduced with the release of higher resolution HMDs such as the second version of the Oculus (currently announced). One final negative factor of the virtual reality environment is that of physical wellbeing, and in particular nauseousness. 4 out of our 12 participants reported on feeling the nauseating effects when wearing the HMD. One participant stopped the experiment specifically for this reason. Interestingly, there was no visible correlation between the time spent in virtual reality and user nauseousness.

Powerwall Experience Evaluation. The participants rated the Powerwall with an average rating of the overall experience of 3.92/5 (S.D: 1.16); an identical average rating to the HMD experience rating. Interestingly, the merits and limitations of each technology as subjectively reported by the participants differ between the two technologies. Navigation ratings averaged 3.58/5 (S.D 1.08) and were considered much more intuitive to the participants that were familiar with computer games, as they were using controls similar to a 'first person shooter' type game. Viewing was also given a higher score with an average of 4.25/5 (S.D: 0.75). This is unsurprising as the resolution on the Powerwall is higher than the HMD. The textual information

was easily readable and the videos were watched without discomfort. Navigation was also rated at 3.58 (S.D: 1.08). The subjective feedback from the participants indicated that the controls were also easier to learn and use on the Powerwall than on the HMD (Average: 4.0, S.D: 0.95). When asked for limitations of the technology with regards the experience, the participants reported a lack of immersion in the Powerwall museums compared to the HMD scenario. Interestingly, one participant commented that 'it doesn't offer that much more now than conventional technology'.

4 Conclusions

We presented two prototype bespoke museums, created for the purpose of promoting Cypriot cultural heritage in an engaging and novel way. To achieve this, we presented two museums using HMD's and large screen stereoscopic projections. The end goal of this task is to implement the prototypes in public spaces for the general public to use. For this reason, we chose to use a user-centered design approach to maximize usability and user experience.

Our initial study unearthed key findings, some of which compliment previous related work and some which contribute original findings to the virtual reality and cultural heritage domain. Both technologies empowered the user with capabilities which they would otherwise not been able to have. For example, the remote viewing of cultural heritage spaces without having to visit the physical space. We also more importantly note that the interactive capabilities, such as the ability to manipulate some of the objects for more information and go closer or view them from different angles, presents capabilities which are not available during traditional physical museum visits. Elevated interaction time is achieved with different interactions such as videos. Textual information is seldom focused on; rather, 3D reconstruction of artefacts and images are much more engaging to the users in this scenario. Using a Powerwall display is also more time consuming although this does produce some viewing advantages currently due to the higher resolution. Interestingly, both technologies received an identical subjective score from the participants in terms of their overall experience. A common problem which surfaced, common within the virtual reality domain, is that of user nauseousness. Overall, both technologies were considered a positive way to present cultural heritage to individuals and the virtual reality has easy portability for remote setups. Another important issue is the cost of the two settings. Currently the HMD's used cost 220 Euro and the Powerwall set up costs about 8000 Euro. However, we consider the merits of the Powerwall to be taken into account; such as that unlike the HMD, a Powerwall supports multiple concurrent users, thus presenting a better alternative for viewing in public spaces.

In the future we plan to extend our evaluation to include additional virtual environments representing Cypriot Cultural Heritage artifacts from different eras. In particular we plan to include a virtual museum with terracotta figurines (3900-2500 BC) [11] and a wine-production museum (19^{th} century). We also plan to replace the conventional interaction hardware used (keyboard and mouse) with more intuitive interaction based on a MS Kinect device, thus upgrading the overall experience and at the same time address user feedback. The ultimate aim of our efforts is to bring to the

general public the immersive experience of visiting the virtual museums in an attempt to raise interest among the general public and tourists in visiting the physical museums.

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