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An Augmented Reality and Virtual Reality Pillar for Exhibitions: A Subjective Exploration

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Abstract

This paper presents the development of an Augmented Reality (AR) and Virtual Reality (AR) pillar, a novel approach for showing AR and VR content in a public setting. A pillar in a public exhibition venue was converted to a four-sided AR and VR showcase, and a cultural heritage exhibit of "Boatbuilders of Pangkor" was shown. Multimedia tablets and mobile AR head-mount-displays (HMDs) were provided for visitors to experience multisensory AR and VR content demonstrated on the pillar. The content included AR-based videos, maps, images and text, and VR experiences that allowed visitors to view reconstructed 3D subjects and remote locations in a 360 virtual environment. In this paper, we describe the prototype system, a user evaluation study and directions for future work.

CCS Concepts

•***Multimedia Information System*** → ***Artificial, augmented, and virtual realities;***

1. Introduction

Augmented Reality (AR) combines the user's view of virtual cues with the real-world environment, while Virtual Reality (VR) replicates a simulated real-world scenario in a completely virtual environment. AR and VR technology has been extensively used to create interactive museum and art gallery experiences. This paper describes a novel use case for AR and VR in creating an enhanced exhibition pillar for an art gallery. Four types of content were featured on the 4-sided pillar; (1) AR video, (2) AR static text and image, (3) AR with 3D objects, and (4) VR360 interactive panoramas.

Static photographs and text are extremely common in conventional exhibitions, however they usually do not support visitor interactivity. The initial intention of constructing an AR and VR pillar was to explore how mobile AR and VR could be used as an unconventional form of interactive exhibition content delivery in conjunction with a real object in the exhibit space, a pillar. Recent technological advances have allowed AR and VR experiences to be possible on handheld mobile devices or low-cost head-worn displays. This means it is possible for visitors to experience AR and VR exhibition content using their own devices. However, the user experience and computing performance on users' devices vary subject to several speculated factors including data bandwidth and complexity of digital content.

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2. Background and Approach

Our research builds on previous work on AR and VR [HF04, BCL*15, OT14]. Passa developed an exhibition experience which fits into a pocket size display, with one of the main features that the mobile-based content could be updated periodically by the content provider [Pas14]. Various studies have demonstrated the practicality of having mobile solutions for exhibit experiences [Kos14, FPVV14]. These studies have developed enhanced mobile user experiences which increased visitor numbers to the museum or gallery. For example, the work by Ciurea et al. [CZG14] and Frasca et al. [FPVV14] have demonstrated how mobile AR can increase the visibility of cultural heritage content. One of the ways that museums can consider providing AR and VR experiences is through using consumer mobile devices. However, more research is needed on how to introduce these devices into a museum setting, and in particular how to connect the AR and VR experience to the physical elements in the museum. The main contribution of our work is developing a mobile AR and VR solution which can be easily experienced on usersâĂŹ devices but is connected to a real element in the museum exhibition which contains conventional printed content, a pillar.

2.1. Method and Apparatus

In this section, we present an early prototype of our system that works with mobile devices in an exhibition space (Figure 1). This configuration provides a range of different AR and VR experiences

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Figure 1: *People using the AR and VR Pillar.*

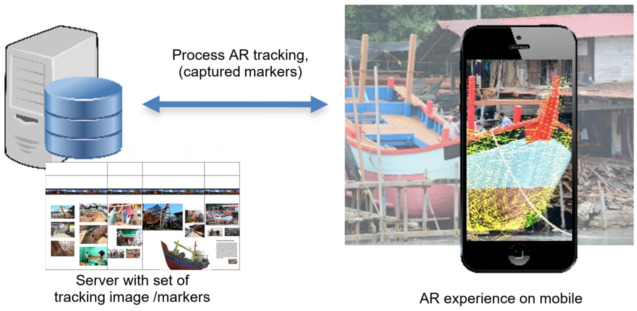

Figure 2: *Basic requirement of server-based mobile AR.*

Table 1: *AR and VR Experiences on the Pillar.*

Pillar Side	Content Design
Type 1	AR with video
Type 2	AR with static text and image
Type 3	VR360 interactive panorama (mobile /HMD)
Type 4	AR with 3D Objects

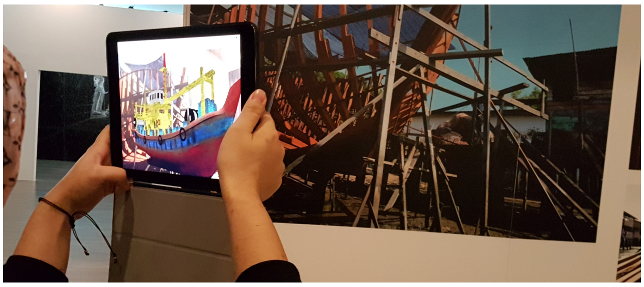

Figure 3: *3D objects on AR Marker.*

around a single pillar. The four-sided pillar featured four different types of AR and VR experiences, as shown in Table 1. During the first attempt of the prototype being exhibited in an art gallery setting, the study took place about 7 days.

The pillar was covered with a set of large photograph images that served as AR tracking markers and to trigger the VR content. A 2D image-based AR tracking method was used, using the server-based Wikitude tracking library [wik16]. Figure 2 shows how the system worked. A series of images of tracking markers was sent from the visitor's mobile devices and processed in real time by the server. When an image was recognized by the tracking library on the server, AR and VR content was then sent back to view on the user's mobile device. The AR and VR pillar system works with multiple users simultaneously, allowing each visitor to have their own experience without interfering with other users (Figure 3).

The installation featured content on the cultural heritage theme "Boatbuilders of Pangkor". This project was undertaken to digitally capture and preserve the livelihood of the Hainan Boatbuilders of Pangkor Island. It involved showing the traditional process of building large wooden fishing boats, using both intangible (tacit knowledge) and tangible (built) forms of heritage that could soon disappear. Through fieldwork, various data was collected and curated over the span of the project, ranging from audio-visual data to 3D models.

One of the types of content that could be experienced was VR360 images (Figure 4). In this case users were looking at specific markers which launched 360 spherical panorama content from the server. Each 360 image was rendered in 8k resolution using WebVR graphics. Using the gyroscope on their mobile devices users could intuitively pan around the 360 content, and they could pinch and zoom into certain areas of interest. The content was also viewable in a Samsung Oculus Gear VR headset [Sam17] (Figure 5).

To explore the visitor's user experience and preferences, we have also included AR with video and AR with static text and images, (Figure 6). When the user looked at a real image they would see virtual video, text or image superimposed over it. For example, AR video-based content such as a dive-in map allows visitors to visualize the location of the boat building site on the island. Figure 7 shows a static text and image AR content of a hand-drawn blueprint of a boat. AR with 3D objects shows a virtual 3D model over the real poster. The 3D content such as a hand-constructed boat structure was originally obtained from photogrammetry scanning, and then simplified for mobile graphics.

When the AR or VR content was shown the user could interact with it using touch gestures on the tablet screen. In the current system all content was tracked and retrieved from the server using WIFI network. This has the advantage of only requiring a small mobile application, and online content could be modified anytime without changing the application. However, the stability of internet connection can be an issue, especially with a large number of people accessing the content server at the same time. The server-based Wikitude tracking library was used for providing the main functions of the test. A customized channel hosted online was created and run on the default Wikitude AR browser with HTML5 and WebVR support.

2.2. User Study

A pilot study was conducted during the exhibition to evaluate our prototype. We collected feedback from 44 visitors, 30 female, and 14 male ranging in age between 11 to 60 years old; 40.9% of the users were in the 11-20 year old age group while 31.8% from the

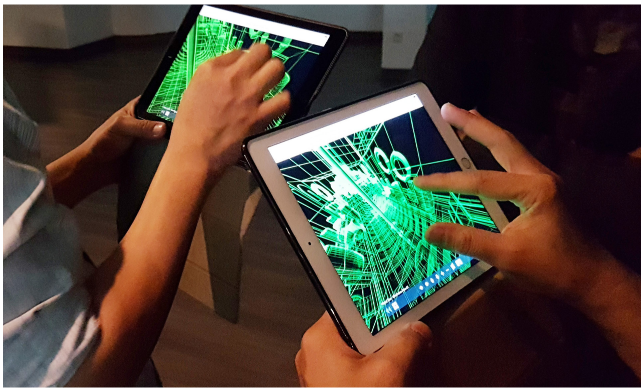

Figure 4: *Virtual Reality 360 content on mobile tablet.*

Figure 5: *Virtual Reality 360 content on HMD.*

21-30 age group. The aim was to measure the usefulness of the prototype pillar. Participants experienced the pillar using a 10.1 inch Android tablets (Samsung Tab 2 GT-P5100), and on the HMD configuration shown in Figure 5 (using Samsung S7 Edge G935FD). The subjects were allowed to move freely and experience the AR and VR content with the assistance of an experimenter. The experiment conductor explained the processes and provided a complete demonstration. Each participant spent about 10 minutes experiencing each of the 4 types of AR/VR content. When experiencing VR360, participants tried both tablets and HMD.

We used a within-subject experimental design, where each participant experienced all four conditions (Table 1) in counterbalanced order. After running the trials we collected participant feedback on how easy it was to use the system. This was done by collecting qualitative feedback in response to the questions shown in Table 2. Answers were captured on a Likert scale of 1 to 7, where 1 was "strongly disagree" and 7 "strongly agree". Our aim was to understand the perceived ease-of-use and usefulness of the prototype.

Figure 8 shows the average results of survey questions from the four different AR and VR experiences. Users found the VR360 configuration most easy (Q1) and useful (Q5). Most of the AR and VR content were rated below average in terms of physical (Q3) and mental challenge (Q4). Users also found it easy to visualize AR in 3D (Q1) and that it was useful (Q5), however they felt it was physically (Q3) and mentally (Q4) challenging to use.

We used a repeated measure ANOVA to analyze the survey data further. We found a significant difference in Q2 (natural to use): $F(3,129) = 5.41$, $p = .002$. A post-hoc test with BonferroniâĂŹs adjustment showed VR360 was more natural to use than AR static image and text. We also found a significant difference for Q5 (usefulness): $F(3,129) = 5.8$, $p < .001$, and a post-hoc test showed that the VR360 was significantly better than all other experiences. Q6 (level of details) also a significant result: $F(3,129) = 4.78$, $p = .003$, and a post-hoc test showed that AR static image and text was significantly lower rated than AR 3D and VR360. There was no significant difference in any other question.

Figure 6: *AR with video and, AR with static text/image.*

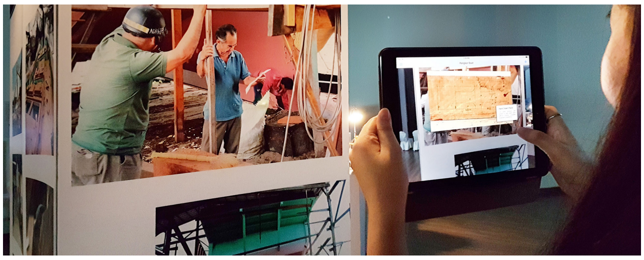

Figure 7: *AR showing a hand-drawn blueprint of a boat.*

In addition to the survey, we asked participants for their comments. On the positive side, users said they liked how the "..3D moves when I move...", "The idea is pretty good, affordable and portable", and "The 360 looks so real!". However users also said that "Still images are overshadowed by everything else, that's why it has the lowest score in my opinion...", "Less video more VR", "Need fast internet speed to load sometimes", "Can we see 360 videos?", "more VR experience?" and "..Can I walk around in 360 feature?". Some of this feedback suggested the need for more VR content in relation to the exhibited theme.

Participants also provided some ideas for improvements:
i. Being able to choose between online or offline application.
ii. Exhibitor-provided devices preloaded with content.
iii. A miniature AR and VR pillar that can be purchased as a souvenir which comes with simplified features.
iv. High-speed internet is provided by the exhibitor.

2.3. Discussion

Most users felt that having the VR360 on mobile devices or a HMD was useful as it provided a higher level of visual experience for location-based content. Further improvement such as 360 videos

Table 2: *Experiment survey questions.*

Question	Description
Q1	I found it easy to use
Q2	I found it natural to use
Q3	I found it physically challenging
Q4	I found it mentally challenging
Q5	I found it useful
Q6	I found the level of details is important

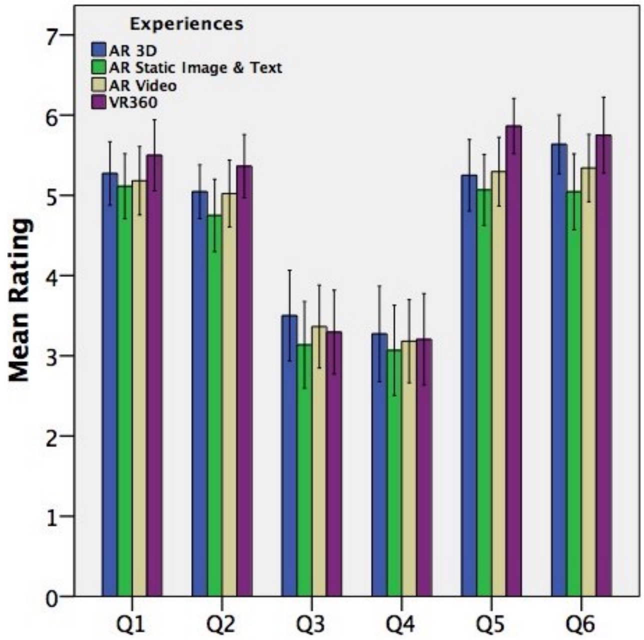

Figure 8: *Average results different AR and VR UX.*

could be included on the pillar content as they could provide featured stories in greater narrative. We also identified differences between using server-based and local-based mobile AR, as shown in Table 3. Although local-based AR and VR content can be more stable in terms of loading time and tracking, this might be less practical as some users had devices with smaller storage space.

Using a pillar to anchor the AR and VR content provided a number of advantages. The users could only see the AR and VR content at a fixed location in the exhibition, so the content presented fit in with the surrounding material. It also enabled the gallery to provide good lighting of the AR markers and so provide good recognition. In additional, content provider could freely update or feature special content without altering the fixture of exhibition settings. Finally, it meant that members of the public had to come into the gallery to experience the AR and VR content.

2.4. Conclusions

This project focuses on the development of an AR and VR pillar solution for an engaging exhibition space. The system runs on existing mobile hardware using image-based 2D tracking and WebVR, and so is low cost and can be easily used in a wide variety of exhibition settings. Users felt that the system was easy and natural to use, and the use of an additional HMD for VR360 elements made the system much more useful and engaging. Participants also made several good suggestions for improving the system. The AR and VR Pillar allowed the users to be able to experience multi-sensory multimedia content that rarely exists in conventional static exhibitions. In the future the system could be adapted to various scenarios and public showcases, such as for airports, tourism expos, education fairs, and more. We intend to explore room-scale VR options in an exhibition setting which provides greater user experience in terms of immersion. The experience could also be extended after the exhibition by providing users with some take-home AR and VR solutions, strengthening the content delivery of the exhibited theme. Finally, we will also explore ways to improve the stability of AR and VR experience such as using hybrid approaches that combine online and offline content delivery.

Table 3: *Comparing server-based and Local-based AR.*

Server-based	Local-based
Unlimited AR recognition	Limited marker recognition
Changeable content (Server)	Limited content in-App
Requires network	Works offline
Stability depends on network	Stable
Small App installation	Large App installation
Shows new content automatically and users does not own content	Requires users to update App and users can own content

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