Future Media Internet Technologies for Digital Domes

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Abstract. The paper outlines the primary challenges and principles for museums and venues that wish to accommodate social and Future Media Internet (FMI) technologies, incorporating the experiences gathered through the EXPERIMEDIA project experiments.

Keywords: Future Museums; New Media; Infrastructure; Smart Devices; EXPERIMEDIA Project

1 Introduction

"The next generation of museums and venues was envisioned as a composite of three metaphors: an information seeking space, a social gathering space and a new artefact, embodying social processes and projects" [1]. Certainly new internet technologies have many engaging uses within a museum context. But which of these technologies, museums choose to sustain with their limited resources should be guided by larger questions of accessibility and inclusiveness. It's easy to equate participatory culture with social media but it is also important to distinguish between them. Henry Jenkins of MIT [2], clearly states the case for focusing on the growing culture of participation rather than exclusively on the interactive technologies that support it. Jenkins defines this culture of participation as one:

- With relatively low barriers to artistic expression and civic engagement.
- With strong support for creating and sharing one's creations with others.
- With some type of informal mentorship whereby what is known by the most experienced is passed along to novices.
- Where members believe that their contributions matter.
- Where members feel some degree of social connection with one another.

Many museum professionals argue that there are some visitors for whom participatory experiences might be entirely off-putting. This is true, but the converse is also true.

There are many people who engage heavily with social media and are incredibly comfortable using participatory platforms to connect with friends, activity partners, and potential dates.

Building on the experience of the Foundation of the Hellenic World (FHW) with social media and other adaptive technologies, particularly during the EXPERIMEDIA project [3], we discuss the primary challenges associated with the use of participatory elements in traditional digital dome shows. The use of such elements may draw in audiences for whom creative activities and social connection are preconditions for cultural engagement.

The initial section of this publication presents what has been done so far regarding large audience dome interactions and our proposed enhancements. The next section describes the technological FMI components used to implement the enhancements and how the experiment was conducted in order to validate these. Further sections analyze the experiment results and establish various impact factors. The concluding section presents future extensions.

2 Dome audience interactivity

The Foundation for the Hellenic World (FHW) is a world leading institution known for its use of 3D facilities and production in culture and heritage [4]. As many high tech museums it deploys advanced 3D virtual reality (VR) installations for virtual tours through reconstructions of heritage sites. Its real-time dome theater 'Tholos' projects imagery on a tilted hemispherical reflective surface of 13m in diameter.

Museums strive constantly to incorporate interactivity to exhibits or virtual reality shows because research has shown that it fosters learning and provides a unique visitor experience [5]. Unfortunately digital dome shows usually host large audiences where the common interactivity techniques and mechanics don't work. Therefore ongoing research is performed on methods incorporating audience interaction and gaming environments in the immersive space of a dome theater [6]. Traditional modes of interaction include button/joystick devices on visitor chairs and wherever possible the usage of dedicated museum educators which adapt the show and can conduct interactive question-answer sessions [7]. Another approach is to use camera based techniques in order to capture the crowd movement for controlling in-game objects or initiating actions [8].

Although research is actively conducted in order to use FMI for learning [9], sports [10][11] or museum visits[12], its potential usage for large audience participation and for enhancing visitor experience in digital dome shows has been largely ignored.

The standard mode of operation of the Tholos may be graphically modeled as in Figure 1. It is easy to see that this is a mainly one-way communication system, as the museum educator controls the system, thus specifying what the Tholos system will project to the visitors, while at the same time commenting on it.

Our proposed mode of operation to enhance the Dome visitor experience provides three additional activities:

1. Before entering the show, the participants are able to use a dedicated AR smartphone application to deepen their knowledge on specific artifacts which will be shown later in the VR show.
2. Live video streaming allowed the contents of the VR show to be broadcast to the internet to be viewed by academic experts and to cast a video feed of the remote experts onto the dome screen.
3. A Facebook based mobile application was developed that allows visitors and experts to connect to a dedicated event page and post messages during the VR walkthrough.

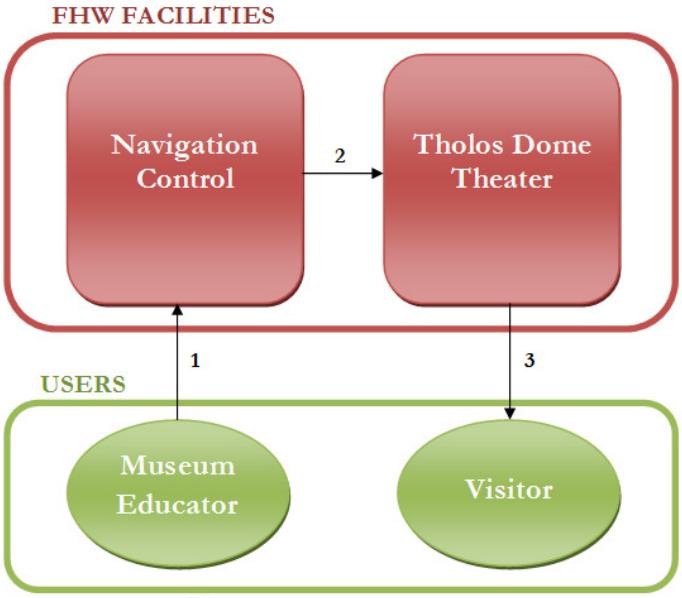


Fig. 1. Standard mode of operation of the Tholos

3 FMI technologies in the Dome

The actual experiment, which was performed to evaluate the FMI extensions, was conducted as part of the EXPERIMEDIA framework over 2 days with a total of 18 participants. The proposed FMI mode of operation essentially consists of two operational parts and aims to enhance the education experience in at least three ways: by allowing multiple perspectives, situated learning and transfer of knowledge. The first part takes place before the show, and uses augmented reality technologies. The second part takes place during the show and includes live streaming and social media usage.

3.1 Live streaming

Since the Experts are on a remote location, the main motivation is to allow real-time interaction between the Experts and the Visitors. To this end, the experts must see and hear of what is shown in the dome and of any questions coming from the audience. Additionally the audience must hear and see the experts.

The actual connectivity and communication between the components is shown in Figure 2. In the bottom part we can see that the museum educator holds the navigation control, which specifies the content that should be displayed to the visitors. This is the typical scenario for the utilization of the Tholos.

With the FMI extensions, the Tholos system also forwards the rendered stream to the video stream server, which in turn makes it available to the experts' application along with the audio feed from the educators' microphone. The Experts use a simple web browser portal to watch the live feed.

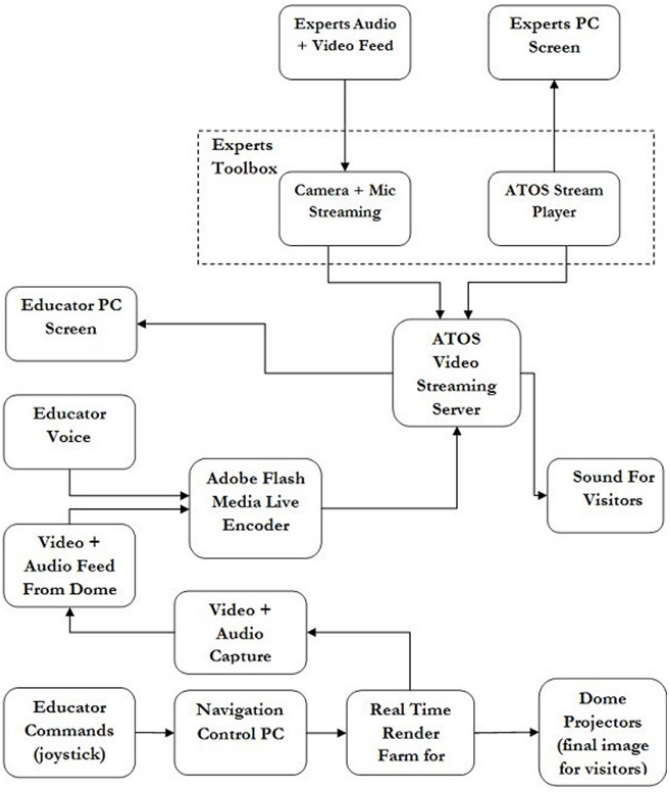


Fig. 2. Flow of information and component diagram for the experiment.

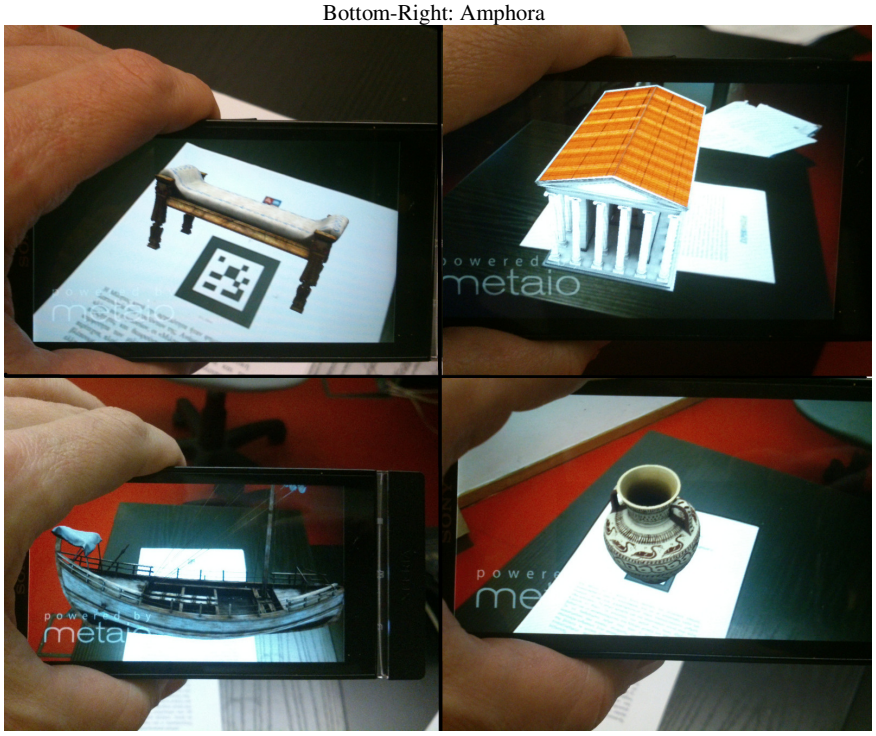
3.2 Augmented reality

The potential power of Augmented Reality (AR) as a Learning tool is its ability to leverage smartphone capabilities to create immersive learning experience [13]. Before entering the show, the participants are able to use a dedicated AR smartphone application to deepen their knowledge on specific artifacts, which will be shown in the VR show.

A dedicated space just before entering the show was created using markers on exhibition tables. These markers can be recognized by an application which superimposes virtual objects on top of the real ones, by tracking the position and orientation of the markers. With the help of FHW historians four points (Figure 3) were identified that are related to Miletus (i.e., the topic of the Tholos projection that was used in the experiment to test the new enhancements). Specifically:

- Point 1 is a 3D reconstruction of a bed that could be found in the city.
- Point 2 is a 3D reconstruction of a building that could be found in the city.
- Point 3 is a physical reconstruction of an ancient ship.
- Point 4 is coupled with the reconstruction of an amphora.

Fig. 3. The 3D models used for AR. Top-Left: Bed, Top-Right: Temple, Bottom-Left: Ship, Bottom-Right: Amphora



3.3 Social networks

In order to leverage the power of social media, a Facebook based mobile application has been developed that allows visitors to connect using their personal credentials to a dedicated event page. Using their mobile device the visitors can communicate with each other and with the experts by posting messages during the VR walkthrough. The experts used a specialized web application to connect to the Facebook event page for chatting with the participants and also embedded a simple flash player for watching the Tholos video stream remotely form their office.

4 The experiment

For evaluation purposes the participants were asked to fill out structured questionnaires. In a duration of two days there were two runs of the experiment inside the Tholos with a total of 18 participants. Each run took 1 hour to complete, with the participants spending 10 min. in the AR event, 35-40 min. inside the show and 10-15 for live Q&A with the remote expert. On the last day a focus group with 4 people of different disciplines was assembled with which a qualitative analysis was performed using simple conversation techniques. The focus group was consisting of an archaelogist/museologist, a curator, a 3D expert and a museum pedagogy expert.

Despite the medium number of samples, the number of questions allows a wide range of statistical values, correlations and graphical charts to be produced. We present below some statistics that we find most informative and interesting. Questions are translated roughly and abbreviated. A standard 1-5 Likert scale (1=Low, 5=High) is used for most questions. The exception is Yes/No questions which are treated with 2 values only (1=no, 2=yes). The values depicted in Table 1 and 2 are the median values of all the answers.

The friends and volunteers of the museum are mainly either young professionals or students studying on relevant to the museum activities disciplines (museology, digital archaeology, education, 3D programming and design etc), or professionals of the same disciplines. This of course meant that the testers were a group specifically invited to participate and not just random visitors of the venue, the main demographics of the tester group were:

- Mainly women (78%), high academic background, between 26-40 years of age

In the tables below we are including the data of the questionnaires interrelated with the comments and data that came out during the focus group for the relevant group of questions.

4.1 Pre Show

In the questionnaire data that there are huge differences in the average values for the different points. It is clear that points such as the ship and the amphorae have made a

bigger impression than for example the bed and we discussed it in this focus group. The participants indicated two different patterns:

- The images of the bed and less of the building were considered less detailed than those of the ship and the amphorae (probably because of the rendering angle)
- The bed was considered to be quite out of context presented on its own without other objects of daily use of the same category.

Also people would be willing to pay money for such an application. This is probably the safest way to conclude that the augmented reality component did enhance their experience considerably. Although we tried to correlate the quality of the images to the quality of the experience (e.g. in the case of the bed) it looks like the overall experience is not dampened by a not so top quality image.

Table 1. Questionnaire analysis for the AR event. All results except where it is designated show the values with 1=Low, 5=High.

Question	Value
Q1: Was the device difficult to have on you? (1=no, 2=yes)	1,22
Q2: General clarity of images in the applications.	4,22
Q3: Clarity of the bed image	4,39
Q4: Clarity of the building image	4,83
Q5: Clarity of the ship image	4,94
Q6: Clarity of the amphorae image	4,78
Q7: General interest factor of the content	4,61
Q8: interest factor of the bed	4,00
Q9: interest factor of the building	4,50
Q10: interest factor of the ship	4,94
Q11: interest factor of the amphorae	4,72
Q12 : General Educational added value of the application	5,00
Q13 : Educational added value connected to the bed	4,50
Q14 : Educational added value connected to the building	4,72
Q15 : Educational added value connected to the ship	4,78
Q16 : Educational added value connected to the amphorae	4,74
Q17 : Was it fun to use the application?	4,83
Q18: Was it fun to watch the bed?	3,22
Q19: Was it fun to watch the building?	4,80
Q20: Was it fun to watch the ship?	4,89
Q21: Was it fun to watch the amphorae?	4,85

Q22: Would you pay 1 euro for this service? (1=no, 2=yes)	1,83
Q23: Would you pay 1 euro for this service if there were more interest points included? (1=no, 2=yes)	1,89
Q24: Would you pay 1 euro for this service if there were more interest points included like the bed? (1=no, 2=yes)	1,89

4.2 During the walkthrough

The Facebook application and the ability of concurrent written communication of the visitors with the expert, as well as between themselves resulted in more questions being asked and answered. The whole walkthrough got instantly more social and exciting allowing the visitors to acclimatize very quickly to the tour and become much more focused. Even the occasional whispers amongst friends diminished since they were using messages to communicate.

The focus group discussion confirmed the questionnaire findings that in many occasions it was quite distracting trying to use the smart device during the Tholos show. The remote expert added value to the information that was given by the local guide but according to questionnaires and focus group results this service is something that people would pay for but not so willingly as for the Augmented Reality service.

Table 2. Questionnaire analysis for inside the show. All results except where it is designated show the values with 1=Low, 5=High.

Question	Value
Q25: was it clear why the specific images were used? (Tholos application) (1=no, 2=yes)	1,78
Q26: was there added educational value to the replies of the expert? (1=no, 2=yes)	1,89
Q27: Was it fun to use the application inside the Tholos?	4,61
Q28: Was the quality of the image and of the sound acceptable during the interaction with the expert?	4,67
Q29: Was it easy to use the Q&A application and its software?	4,44
Q30: The interaction with the remote expert added value to the experience?	4,67
Q31: How much distracting was the use of the smart phone during the show?	3,33
Q32 : Would you like to have permanently in each show a remote expert appearing except the museum guide?	3,44
Q33: How much would you like to have a permanent service with smart phones in the Tholos?	3,89
Q34: The quality of the image of the expert was good (yes/no)	4,11
Q35: The quality of the sound of the expert was good (yes/no)	4,11
Q36: Was there delay in the reception of the expert's voice. Were you	1,56

annoyed by the time lapse between the question of the audience and the reply of the expert? (1=no, 2=yes)	
Q37 : Which service you liked more in the Tholos (1=Q&A, 2=Expert discussion)	1,44
Q38 : Would you play 1 euro for the Tholos service? (1=no, 2=yes)	1,69
Q39 : Would you pay 1 euro for this service if there have been more interactive services? (1=no, 2=yes)	1,72

5 Impact of FMI

The experiment had three major impacts.

Visitor socializing: visitors could communicate with each other and to the expert providing a fertile ground for social activities. The AR event allowed them to explore and interact as a group, the streaming and social network components to communicate during the show without disturbing the main presentation.

Learning: The AR preshow event besides being very interactive disseminated historical information. It created a link and high anticipation about the VR show because the artefacts seen in the AR app are actually seen later in the show. The usage of a dedicated social application and live video streaming during the show allowed visitors to ask freely without hesitation and interruption. The museum educators witnessed an increase in the amount of questions asked especially during the live video session conversations with the remote expert.

Economic: User evaluation showed that the additions can also have a financial impact since most of the visitors were willing to pay additionally for experiences. Also the publicity through the live video feed and chat resulted in higher visitor number on the website and Facebook profile of the museum.

5.1 Parameters that affected impact

We established certain critical factors which could affect the success of using these tools for Dome shows and museums.

Ratio of Devices/visitor: To experience these technologies the museum relies on the visitor to bring his own equipment, meaning his mobile phone or tablet. If the ratio of devices per visitor is very low the social aspects and the enhanced learning is tremendously impacted. The visitors without mobile phones cannot participate in the AR and social activities making oral questions.

Quality of Wi-Fi signal: Without a reliable and working internet connection these technologies are rendered useless. We specifically had to increase and install Wi-Fi spots so as to ensure the whole venue's coverage. The exception lies with the AR event which is autonomous in that respect.

Duration and order of AR event: Initially we tried to use the AR points after the show scattered around the museum in order to motivate visitor exploration. This proved not functional since many visitors could not find the interest points or had the

time and energy after a VR walkthrough of 40 minutes. The AR event should be easily accessible and for a short period of time when combined with a traditional show.

Number of visitors: We run the last experiment with a number of 18 visitors and had 1 expert. The focus group discussion and through observation it resulted that the expert had difficulty in answering all these questions on time and could easily overlook questions or comments. Often the visitors had to wait before getting a response. As the Tholos is a VR system of 130 seats it is evident that a scale in visitors need a analogous scale in experts to have any real value.

Social app and web app UI: The user interface of the social app which is used by the visitors and web app of the expert are of utmost importance. The UI should be self explanatory, easy to use and should not force the visitor to look at it all the time. During all experiment runs we witnessed a lot of failures and problems in that regard. The UI of the mobile app was desktop oriented and required constant button presses and usage of menus. The answers were not refreshed automatically and the visitor for forced to press the 'Refresh" button repeatedly.

This resulted in visitors missing large parts of the show, since they were forced to monitor it constantly. The UI has to try keep people in a heads-up mode to make sure that they are also looking at the historical and art information presented. Therefore a simple design is needed which enables the visitor to quickly find the interest point he wants. It should also feature some form of feedback in the form vibration or a visual indication when a answer to a question arrived.

Latency versus Quality: During video streaming major latency issues were experienced which could range to up to 7 seconds. During the show and interaction with the expert a temporal loss of quality both in picture and in some for also in audio could be accepted but the latency issue made it difficult to conduct a live asks and answer section

6 Avatar Embodiment

Although not incorporated into the experiment described here the next milestone for usage of new FMI technologies in digital domes is avatar embodiment. Avatar embodiment allows the experts to puppeteer a virtual character created by an external authoring application. The process requires that the character mesh is attached to an articulated structure of control elements called bones. Bones can be viewed as oriented 3D line segments that connect transformable joints (such as knees or shoulders). Avatar embodiment within the FHW use case is achieved by allowing users to create avatars, rigged with a pre-defined 17-joints hierarchy (similar to the OpenNI joint tracking structure), as in [14].

The Microsoft Kinect was a breakthrough device for the easy capturing of 3D information. This fact led to the enormous penetration of the FMI ideas to a very wide audience, yet many inefficiencies remain unsolved. EXPERIMEDIA developed sophisticated algorithms to cope with these inefficiencies. The algorithms provide information correction from inaccurate depth estimation, constrain the Kinect's calculated human skeleton data to physical poses to enhance reliability, as well as many

more enhancement that are suitable for avatar motion. Therefore, EXPERIMEDIA clearly offers a unique combination of algorithms that pave the way for more novel application domains.

The goal of using the avatar motion within the FHW context is to provide the means to put the expert on the scene. By doing so, visitors will have the change to meet in "person" with the expert's avatar, which can respond in real-time. It is a step beyond the common practice until now with either voice interaction and/or text messages. The sensation of a guided tour within a museum guided from the expert's avatar will provide a higher immersion sensation to the visitors of the Tholos. Quality of Experience (QoE) measures will be defined to finally assess the overall feedback of the visitor's experience.

7 Conclusion

Museums are increasingly using technology to reach an audience outside their walls. As technology and all its tools change, so do the challenges facing museums. In this paper we have reported on the experience of incorporating such new or emerging technologies in the operations of the FHW museum. It seems that whilst the technology itself is mature enough and it certainly brings added value to what is offered to the visitor, there are some fine lines to tend to as the developers' perspective is not necessarily in line with the museological perspective of things.

There is also significant frustration among curators that museums are leaping ahead with new technologies without proper evaluation. Therefore this experiment despite having a rather limited number of participants provides an very informative pilot study into the possibilities that exist in using future internet technologies for domes. it not only established a proposed method of implementation but also ratified the impact it had on the visitor experience and the several factors that could limit the results.

The three areas where the suggested enhancements had the most impact are of primary importance to any museum venue and vital to its survival and educational goal.

Acknowledgement

The research leading to these results is partly funded by the EU Community's FP7 ICT under the EXPERIments in live social and networked MEDIA experiences (Grant Agreement 287966)

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