The Visitor as Virtual Archaeologist: Explorations in Mixed Reality Technology to Enhance Educational and Social Interaction in the Museum

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ABSTRACT

SHAPE, "Situating Hybrid Assemblies in Public Environments", is an EU Future and Emerging Technologies project of the Disappearing Computer initiative, concerned with designing and developing novel technology to enhance interpersonal interaction in public locales: exploratoria, galleries, and museums, for example. This paper outlines a use of hybrid reality technology to enhance users' social experience and learning about antique artefacts and their related history. We describe early SHAPE technical work where we explore whether there are benefits: educational and social, to visitors of extending virtual archaeology or augmented reality archaeology into the public setting of the museum.

Keywords

Augmented, hybrid reality archaeology; disappearing computer; mobile computing; museum experience and use of virtual reality; historical re-enactment and storytelling.

INTRODUCTION

The research concern of the SHAPE consortium[1] is to use alternative and novel technology to enhance peoples' experience with others and their environs in public spaces: e.g., exploratoria, galleries, and museums. As a project of the Disappearing Computer (DC) initiative[2], the aim of SHAPE is to explore "how everyday life can be supported and enhanced through the use of collections of interacting artefacts. Together, these artefacts will form new people-friendly environments in which the computer-as-we-know-it has no role. The aim is to arrive at new concepts and techniques out of which future applications can be developed." In the DC community, we use the term *disappearing computer* to describe our work because it is almost as if we are making the computer vanish – *hiding* computational power in everyday objects, in our environs, and even in our clothing and flooring. We are challenging the 'traditional' desktop conception of the computer, with the aim of making this technology *disappear*, to allow novel and augmented human experience and interaction to emerge. Our argument is that the computer, in its traditional workstation instantiation can limit or obtrude interaction, particularly if introduced for users in public locales or spaces. Our remit, which is based on extensive field study and observational work, looking at users in public settings and evaluating our work with them, is to envision and develop new technologies that will enhance interpersonal interaction in public spaces. On an interesting side note, there is debate over whether the issue should be to make the computer disappear or whether it should be to make it reappear, though in more appropriate ways [1]. However, we do not contribute here to definitional arguments concerning DC but focus on presenting some of our early technical research in SHAPE and how we are directing our future work. As part of our research remit for SHAPE, selected museums across Europe, (currently The Technical Museum, Stockholm, Sweden; Nottingham Castle Museum, Nottingham, UK; and, The Hunt Museum, Limerick, Ireland), will host three 'Living Exhibitions', inviting use of novel hybrid, mixed-reality installations by museum visitors. In our initial technical exploratory work for these 'Living Exhibitions' we explored how we might mix the digital and physical to enhance visitor interaction with environs, exhibitions, and other visitors in the museum.

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[2] http://www.disappearing-computer.net/

As a first exploration, we developed and demonstrated a hybrid reality archaeology scenario, to investigate how we might add value to participants' interaction with antique artefacts and the history they signify. We also explored extending this scenario, for the educational and interactional benefit of visitors, into the museum space proper.

We based this work on the assumption that archaeology offers a number of educational and interactional 'affordances' or opportunities, which we now outline.

2. ARCHAEOLOGY – BENEFITS FOR MUSEUM INTERACTION AND LEARNING?

There are a number of features of archaeological activity that seem to make 'archaeology' an appropriate metaphor for designing technology to enhance education and interaction in museums. Some of our emerging research concerns, coming from our field studies and observations of visitor interaction in museums, exploratoria and other public spaces include: inquiry, discovery, curiosity and fun. We reckoned that simulated archaeological activity, augmented by technology, could help us to address these salient research concerns and enhance visitor collaboration and learning in the museum. We now describe in more detail our rationale for choosing archaeology as a focus or metaphor for our exploratory technical work.

Working in a team at an archaeological dig makes the participant part of a special type of working group or community of practice [2, 3]. Archaeologists collaborate to probe cordoned ground, ultimately to unearth artefacts of various historical significance, interest and impression. Dividing labour, to expedite the work, different personnel take different sections of the dig to explore, and once they have found something in their respective section they must determine what it is they have uncovered. In figuring out what a given object might be, they will often collaborate with colleagues. While they are digging, the possibility also arises that they might uncover something that is historically significant - an exciting prospect. As a collaborative activity, the appeal of archaeology lies, in significant part, in the motivation and co-operation it can engender among participants. Furthermore, archaeology is the principal practical part of historical study, and so offers more intimate interaction with artefacts, (than say a visit to a standard museum or heritage site would normally provide), which can create the potential for more significant understanding of artefacts by participants [4, 5]. Also, besides unearthing artefacts, archaeological work can highlight the complexities and difficulties that arise when objects and the circumstances of their discovery become the basis for generalisations about history [6, 7]. The ostensible inherent benefits of archaeology for education and interaction can be summarised as follows:

1. Practical exploration of artefacts;
2. Collaboration/discussion among participants;
3. Excitement created by curiosity and sense of imminent discovery;
4. Exploration of interesting, problematic issues surrounding the making of inferences about history based on artefacts, the material residue of the past.

Archaeology can provide participants with more insightful, practical engagement with history though its exemplar artefacts, while encouraging collaboration and discussion. This can it seems make it more educationally and socially beneficial than a traditional individual museum visitor experience [8]. In SHAPE, we implement archaeology in augmented reality to enhance people's collaboration and learning in the museum.

3. VIRTUAL ARCHAEOLOGY IN THE MIXED REALITY MUSEUM

Given the seeming intrinsic educational and interactional benefits of archaeology, we considered whether it would be possible to simulate archaeology, or use some similar form of collaborative quest activity, to enhance the visitor experience in the actual physical setting of the museum. By collaborative quest, we mean an activity where participants must work together to uncover or find something – to solve co-operatively a mystery about historical content, for example. Of course, simulated archaeological digs have been used for a number of years to enhance learning about archaeology and history in museums [9]. However, notwithstanding their significant contribution to introducing visitors, invariably young visitors to archaeology, as is our experience with the Hunt Museum in Limerick, Ireland, these simulated pits normally tend to be located in atria or rooms adjoining the actual museum. Therefore, they are usually sited away from the main collection, which disconnects them from the main museum. Caulton [5] notes how this physical *disconnection* can problematise the contribution the interactive makes to visitors' understanding of artefacts in the main collection. It is our contention that an archaeology quest could bridge this disconnection. For example, visitors could use objects they unearth in the pits to embellish their interaction with artefacts they encounter in the main collection – collaborating visitors having to combine their respective objects at certain collections in the museum to solve a puzzle about an artefact and complete a quest related to historical content in the museum; more on this presently. Also, as mentioned above, simulated archaeology is usually only available to younger museum visitors.

Augmented archaeology could be used to make this valuable activity accessible to a wider museum patronage. In SHAPE, in designing and developing diverse interfaces, alternative projection surfaces and novel multi-modal room-sized assemblies, we seem poised to explore the design and technology involved in extending archaeology into the museum, for the educational and interactional benefit of visitors, individual or groups, young or old.

3.1 Archaeology in augmented reality – an initial technology exploration

However, before attempting to extend archaeology using mixed reality technology into the museum space proper, we first developed a hybrid reality archaeology quest scenario, conducted outside of the museum, in attempting to understand more generally how to support collaboration around artefacts in an augmented archaeology quest. The new Jubilee Campus at Nottingham University, UK, which houses the Computer Science Department and Mixed Reality Laboratory, a SHAPE partner research centre, is built on the same site where a Raleigh bicycle factory once was. In terms of developing an archaeology quest,

this perhaps piques the imagination. Maybe interesting artefacts, remnant of that bygone age when the Raleigh factory held part of the local skyline, underlie the ground there. Notwithstanding whether the site contains artefacts or not, we surmised, for the purposes of the demonstration that it did. In the spirit of computer as theatre [10], to set the scene for the initial demonstration, we told participants a fictional narrative [11]. They were informed that when excavating, before they erected the buildings for the new Jubilee campus, builders unearthed four artefacts: a Samurai sword; a Maiolica dish; an ivory domino box and a bell, (content that is actually, physically housed in the 'Every Object Tells a Story' collection at the nearby Nottingham Castle museum). We dedicated the archaeology quest to finding one of the objects specifically, namely the Maiolica dish. Participants were initially not told the identity of the object, this they had to find out for themselves by completing the quest. They were told however that even though the object had long since been uncovered, and removed to the Nottingham Castle museum, virtual residue, associated with three different parts of the object scattered around the Jubilee campus, (a result of the many decades it remained in the ground undiscovered!), continues to 'emanate' its history. This history, participants were told, is still detectable, but only with special, sensing equipment, (which we provided participants with, in the form of a GPS-enabled PDA). Participants, cast in the role of virtual archaeologists, so set out to capture the residual radiating history of the object, to discover its identity and complete the quest. The quest unfolded in two parts.

3.1.1 Detecting and capturing virtual history outdoors

The first part of the archaeology quest involved groups of participants searching for three shards of the virtual Maiolica dish, scattered around an island adjoining the Jubilee Campus. Their position was triangulated using a Gharmin GPS-enabled Compaq iPAQ PDA communicating across a WaveLAN network, which published participants' position to a serving computer in the Mixed Reality Laboratory. The tracked position was then used to update the location of participating groups in a matching virtual world, which was used to orchestrate the experience, co-ordinate the finding of the virtual shards and play related audio for participants.

Figure 1. Capturing shards in reality.

Figure 2. Capturing shards in corresponding virtuality.

As the virtual archaeologists, (their physical position being constantly tracked and respective position in the virtual world being updated accordingly), approached individual virtual shards, they also heard distinct pulsing tones. Three separate audio tones were associated with the respective shards of the virtual dish; and, once a virtual archaeology group was close enough to a virtual shard, it was deemed to have acquired it, hearing just the pulsing tone of that captured shard. So, the GPS device acted like a metal detector, or sonar, letting users know of their proximity to and when they had acquired respective shards. Finally, once located, the virtual shards appeared on the screen of the iPAQ PDA.

3.1.2 Experiencing virtual history in a mixed reality time machine

Figure 3. Experiencing avatar re-enactments of artefact history in a mixed reality time machine.

After the virtual archaeologists collected all three shards of the virtual dish, they returned to the Mixed Reality Laboratory, where they uploaded them to a form of hybrid reality time machine. This time machine like apparatus consisted in a mounted periscope-type device, projection screen, (see Figure 3) and localising sound system. As the groups of virtual archaeologists turned the device through 360^0, they could see different virtual worlds showing various parts of the history of the Maiolica dish: how it was made;

who made it; what it depicted; its benefaction and custodial history etc. They simultaneously heard audio narratives, associated with avatar re-enactments of the dish's history, depending on where they pointed the periscope. Users could therefore virtually explore the history of the object, various stages of its development and ownership. The periscope acted as a kind of mixed reality chronometer, enabling users to choose which periods, aspects of the dish's history to experience.

3.2 Extending virtual archaeology into the museum with hybrid physical-digital artefacts

At Nottingham, some of the potential benefits of virtual archaeology for education and interaction were demonstrated. We will conduct more detailed evaluations of the technology but from initial feedback we found the sense of imminent discovery created by doing the quest helped to pique and maintain participants' interest. In addition, on locating a shard, the virtual archaeologists would discuss and interact around the item displayed on the iPAQ screen, in some ways similar to the way real archaeologists discuss and ruminate about an unearthed object at a real dig. However, the demo took take place outside of the museum. In terms of SHAPE's research concern, of designing and developing technology to enhance people's experience in public spaces, we wanted to explore extending the virtual archaeology quest into the museum proper. To begin achieving this, we completed an initial technology probe using a Sony Glasstron PLM-S700E head mounted display (HMD) and laptop, in The Hunt Museum, Limerick, Ireland.

Wearing the HMD and viewing two pieces in the museum, users could simultaneously see, through the semi-opaque HMD visor, in the same visual field, virtual embodiments of the objects and related artefacts and hear supplementary information about them through the HMD headphones. As users were looking at the actual artefacts encased in the Hunt Museum, they could navigate a virtual world that contained a virtual representation of a second Maiolica dish, (the subject of the Nottingham demo), and a virtual representation of the Da Vinci bronze horse housed physically in the Hunt Museum, Limerick.

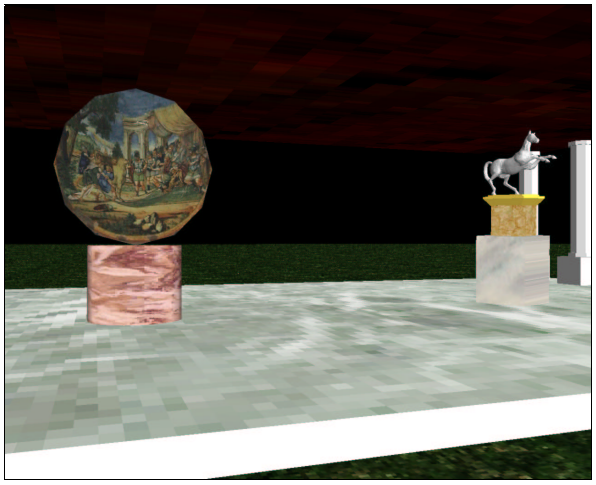

Figure 4. Virtual embodiment of Hunt and Nottingham Castle museum artefacts.

Clicking on the virtual representations of the artefacts, visitors heard related audio content and questions about the artefacts. The first audio narrative, hyperlinked to the virtual Maiolica dish, which was based on the dish used for the Nottingham demo, prompted the user to reflect on the similarities between the dish represented virtually on the HMD visor screen and the actual dish in the Study Collection in the Hunt Museum. The visitor was prompted to reflect on the cultural and physical correspondence of the dishes. The audio narrative hyperlinked to the virtual horse asked visitors to reflect on the custodial history of the object; how and when it was made; and where it probably originated.

Figure 5(a), (b). Visitor using Glasstron HMD in The Hunt Museum, Limerick, Ireland.

With the HMD, we aimed to implement some of the prescient Cyberdocent research [12] and create novel ways to present the visitor with supplementary visual and aural digital information about physical artefacts in the museum. The HMD and virtual museum world functioned by way of a scaled-down version of the time machine in the Nottingham demo.

3.2.1 Future work – the SHAPE *of things to come*

However, although there were significant user difficulties with the HMD in The Hunt Museum, which were anticipated, (e.g., the HMD can be obtrusive; it is also a non-collaborative technology; and novice users invariably require assistance to manage the HMD and required video input device), this initial probe enabled us to envisage a scenario for extending the potential educational and interactional benefits of virtual archaeology, demonstrated at the Nottingham demo, into the public ambience of the museum.

In the Hunt Museum, there are a number of simulated pits in an educational room adjoining the main collection. The scenario, for extending virtual archaeology into the museum, for the educational and interactional benefit of visitors, consists in placing hybrid physical-digital artefacts, replica ancient/antique artefacts containing smart technology, (RFID/Radio Frequency Identification Tags, accelerometers and potentiometers), under the sand in the archaeology simulator pits. Visitors unearth the replica artefacts and bring them to specific artefacts or collections of artefacts in the main museum. There, visitors combine their uncovered objects with objects other visitors have uncovered to reveal information about content in the main collection, the information they unlock in combining the replica hybrid physical-digital artefacts enabling the visitors to complete a quest about the artefacts in the main collection. Collaborative added value should be evident in this scenario, with visitors having to work together to solve quests about historical content in the museum. In an embellished form of the virtual/mixed reality time machine we built and demonstrated at Nottingham, visitors activate sonic and visual effects, depending on how they combine the objects, turn them or depending on where they finger them. For example, on turning objects upside down, visitors hear information about the objects' undersides, which might contain arcane or interesting inscriptions.

In this scenario, hybrid physical-digital objects could enable extension of the potential educational and interactional advantages of virtual archaeology into the museum to enhance visitors' interaction with the historical content it houses.

Furthermore, because the hybrid physical-digital objects in the scenario will replicate actual artefacts in the museum, it is intended that visitors' practical exploration and handling of them will afford some surrogate for there not being direct practical handling of actual artefacts, encased in the main collection. These new forms of museum manipulanda would also form the locus of visitors' learning about the interesting dilemmas that define archaeology, for example: how do we faithfully generalise about history from unearthed artefacts? [6]

To add a further note about practical exploration of objects: concomitant with our SHAPE technology work, we conduct research into the social science of interpersonal interaction in the museum. In terms of The Hunt Museum, in understanding how we might use technology to augment the educational experience of visitors in this specific museum space, we have interviewed docents and curators; recorded visitors; spoken to experts re: the Hunt family; and met with the children, friends and contemporaries of John and Gertrude Hunt, the famous collectors, dealers who established the museum and from whom the museum takes its name. Expert in valuing and appreciating artefacts, and in identifying fakes, the Hunts believed that tactile interaction, physical exploration, afforded the most significant learning about artefacts and the history they represent.

Figure 6. Sandbox for simulating archaeology in the museum.

They never made assumptions about artefacts until they had as close a comprehension as possible of the physicality of given artefacts. Sensitive to the original vision of the museum, we intend the archaeology quest, affording visitors practical exploration of, tactile interaction with replica artefacts, to provide visitors with more significant learning *in situ* in the museum. Some of the interaction approaches we are currently working on to achieve this are: clues to solving quests exist as the physical structure of the replica objects – to solve quests, visitors must attend closely to the physical characteristics of replica hybrid physical-digital objects and what this says about corresponding real artefacts in the museum collection. Also, in solving quests, visitors have to find actual artefacts in the museum's main collection, with comparable physical composition to the replica artefacts they have unearthed and are examining against actual antiquities or artefacts.

We are currently working on an alternative projection surface to display the information at a given collection when visitors have combined unearthed artefacts in configurations that enable information about artefacts to be revealed. From our small intervention in the Hunt, we found that the Sony Glasstrons would not be appropriate for this purpose; they might, for example, be better used as x-ray specs in a scenario involving a mysterious object. Such a scenario is currently under discussion. Also, as a fixed technology, the periscope would not be appropriate, being too obtrusive. However, the periscope is now mobile and usable outdoors. Now, being tripod-mounted, it uses a combination of GPS and an on-board accelerometer and potentiometer to obtain positional and rotational data when used outside. The periscope, now called 'Augurscope', is also suited for use by small groups, so it will be usable, (when rendered for indoor use), for supporting archaeology in augmented reality in the museum, to enhance visitors' interaction. We are also working on a tent interface, which could be used literally as a mixed reality site, adjoining the simulated archaeology pits, where visitors, as virtual

archaeologists, take unearthed hybrid replica ancient or antique artefacts to catalogue them or explore their context.

4. CONCLUDING NOTE

As the major practical part of historical investigation, archaeology inherently promises significant educational and interactional benefits: collaboration and discussion to refine participants' knowledge of artefacts; hands-on interaction with artefacts; the excitement and motivation of imminent discovery; and investigation of the complexities of historical interpretation. We envision and are currently developing a scenario where *disappearing computer* technology, specifically hybrid physical-digital objects, (replicas of ancient/antique artefacts containing RFID technology, accelerometers and potentiometers) and mixed reality, associated assemblies (mobile periscope) enhance the visitor experience by extending the potential advantages of archaeology into the public setting of the museum.

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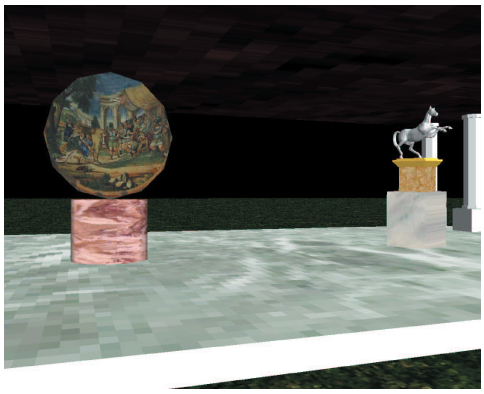
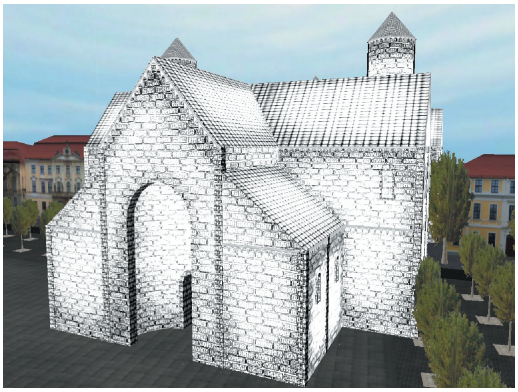
Capturing shards in corresponding virtuality.

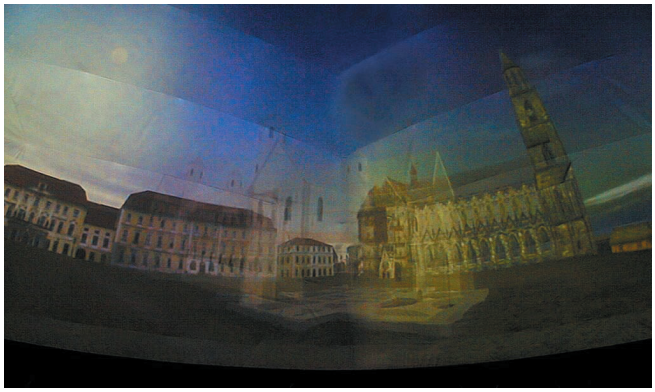


Virtual embodiment of Hunt and Nottingham Castle museum artefacts.

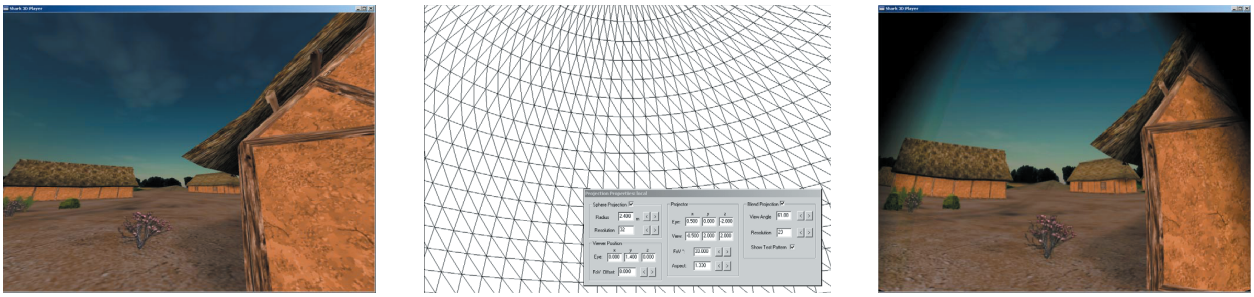
Hall, Ciolfi, Bannon, Fraser, Benford, Bowers, Greenhalgh, Hellström, Izadi, Schnädelbach, Flintham: **The Visitor as Virtual Archaeologist: Explorations in Mixed Reality Technology to Enhance Educational and Social Interaction in the Museum,** pp. 91-96.



Mixing photorealism and NPR in one scene.



Transparent reconstruction in today's surroundings as projected in the dome.



Spherical distortion and soft-edge blending inside the Shark3D game engine: Original frame buffer contents (left), mesh used for distorting (center), distorted image with soft-edge blending (right).

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