

# Exploring and Interacting with Virtual Museums

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## ABSTRACT

*Traditional exhibitions in museums provide limited possibilities of interaction between the visitor and their artefacts. Usually, interaction is confined to reading labels with little information on the exhibits, shop booklets, and audio guided tours. These forms of interaction provide minimal information, and do not respond to a visitor's personalized information preferences. As a result, there is no direct involvement between the visitor and the exhibit. This paper expands on a presentation metaphor, the virtual museum, which through the use of technologies such as Web/X3D, VR and AR offers to the visitor the possibility of exploring a virtual museum, interacting with virtual exhibits in real-time and visualising these exhibits in contexts such as 3D gallery spaces. We offer a 'pot pourri' of novel and cost effective interaction and visualisation techniques that can be integrated into web based virtual museums. In our virtual museums, the exhibit is a digital representation of the cultural artefact, represented in various multimedia formats such as text, images, videos and 3D models/scenes that can be placed inside virtual gallery spaces. Such spaces can be explored, interacted with, and visualised on museum web pages using standard VRML browsers. The interactions provided within our system allow a museum web visitor to: participate in education quizzes about the exhibits; examine them from different perspectives in VR environments; 'pick-up' and freely observe the exhibits in indoor AR environments; and finally interact with an artefacts replica through a safe multimodal interface.*

## INTRODUCTION

Web3D, Virtual Reality (VR) and Augmented Reality (AR) are the latest technologies that a museum can cost effectively employ to engage their web site visitors (Mourkoussis, 2004). This is achieved by using such technologies to create virtual museums rich in multimedia and embedded with these technologies.

We demonstrate in this paper how such technologies can be employed in simple repository driven architectures where museum web site visitors can access virtual museums (which are collections of rich multimedia objects organised as virtual tours), navigate those virtual museums, and interact with virtual objects in VRML browsers and augmented reality table top environments that engage and captivate the visitor.

The museum web visitor can visualise these virtual museums through simple web interface within the museum or over the Internet. We can think of a virtual museum as a 'virtual tour' through the museums digital archives, where the curator has digitised 2D and 3D contents, managed this content into virtual tours grouped into virtual museums, and presented them for viewing over the web or in museum kiosks. Technology is generally cheap and affordable; for example, a museum could easily setup a small classroom of PCs delivering a desktop based VR and AR learning experience for school children. A virtual tour through a collection could be implemented within a reasonable budget. Such a budget could be requested as part of a heritage lottery grant – making such a case is valid because the benefits are large: the technology is exciting for the user, captivating and enhances the user experience, while also facilitating access to collections of diverse visitor groups (Liarokapis, 2004).

The concept of virtual museums has enormous benefits for the end-user in learning about their local heritage in an interesting and innovative way. These benefits are now being recognized by the museum community. Many off-the-shelf technologies are becoming available for museums and service sector organisations to allow cheaper digitisation of collections – however cost does vary with complexity, but digitising software from capturing internet quality 3D can be as little as a few hundred dollars. Such cheap software allows even the smallest museum to create virtual artefacts using simple photography skills (PhotoModeller, 2005), [ REA05] and set these virtual objects into a virtual interactive context that provides a much more rewarding experience (Milosavljevic, 1998) than perhaps seeing an artefact in a museum glass case with a simple description on a card.

These virtual museums can offer much more than what many current museum web sites offer, i.e. a catalogue of pictures and text in a web browser. VR interfaces, interaction techniques and devices are developing at a rapid pace (Roussou, 2001) and offer many advantages for museum visitors. For example, many interaction devices are now available that can be integrated into multi-modal virtual and augmented reality interactive interfaces (Billinghurst, 2001). What does this mean to the museum? It means we can build cheap novel and interesting interaction for the visitor to a museum kiosk – the kiosk could simply be one of the PC desktop systems discussed above rather than an a bespoke and expensive kiosk that only has one use. Standard PCs with cheap interfaces can be re-purposed for new virtual tours simply by replacing repository content.

Going a step further, a museum can have a replica of an artefact embedded with sensors such that the replica can be used to control a story about that artefact through in virtual tour (Epoch, 2004). These sorts of interaction with AR offer many advantages for people with disabilities (Starnier, 1997).

It is important that the use of VR or AR in virtual tours does not just present virtual objects and descriptions; they must be set in a story that reinforces the visitors learning and understanding of the cultural contexts. Museums are one of the best places to exploit VR and AR applications (Mase, 1997) because they offer challenging research opportunities, while providing novel ways to present regional or national heritage, as well as offering new consultation methods for archaeological or cultural sites and museums (Brogni, 1999).

The remainder of this paper is organised as follows. An overview of a cost effective lightweight XML driven system for managing and delivering web based virtual museums is presented, followed by a 'pot pourri' of exploration and interaction techniques that can be employed with the system in virtual museums or tours to better captivate the museum web visitor. Finally, we conclude the paper and indicate future work.

## 1. SYSTEM OVERVIEW

In order to present a virtual museum or tour to the visitor over the internet or to a museum kiosk we have to first create, store and manage the digital content. Our system used to accomplish this task is discussed in more detail in (Liarokapis, 2004), (White, 2004), (Mourkoussis, 2004),

Digital artefacts will most certainly include: text, audio, pictures, object movies (e.g. QuickTime), movies (AVI), 3D (e.g. VRML), and so on, not forgetting metadata. These requirements in effect defined the specification of the system architecture, which is illustrated in Fig. 1.

## 2. EXPLORING THE VIRTUAL MUSEUM OR TOUR

Exploring the virtual museum or tour is as simple as navigating through a web site. All the usual web content accessibility guidelines can be employed (WAI, 2005) in the design and authoring of a virtual museum constructed with our system because we are simply adding innovative interaction and visualisation content to an already well known medium – the web page.

Indeed, the use of technologies in web based virtual museums such as Web/X3D (the addition of 3D content to web pages, virtual reality and augmented reality) enhances the four design principles for web accessibility (WCAG, 2005). For example, the addition of 3D makes web learning content more perceivable and understandable, while commercial VRML browsers such as the Cortona VRML Client (Parallel Graphics Website, 2005) as an interface to 3D and VR content can be operated very easily with the standard mouse or through more sophisticated input devices, see section 4.

Our technologies illustrated in this paper have been tested at museum user trials and are robust because they interface to well known and accepted web browsers through standard VRML and flash plug-ins.

Navigation through a virtual museum is as simple as navigating a museum web site, the only difference is that when 3D content is encountered the visitor switches to navigating through a browser such as the Cortona VRML client to interact with a 3D objects or move through a virtual environment. The visitor can then jump or switch between the web page and the VRML scene by clicking on links in the web pages or anchors in the VRML scene. Innovative input devices can also be used to control this navigation process through a virtual tour, see section 4.

## 3. INTERACTING WITH THE VIRTUAL MUSEUM OR TOUR

There are many ways to interact with a virtual museum or tour. The visitor can interact with virtual content simply by reading and studying as is the case with standard museum websites, but more interestingly the visitor can interact with 3D quizzes in VR and AR, play with interactive galleries, and operate multimodal interfaces based on museum artefact replicas, and so on.

### 3.1 WEB BASED INTERACTION

With this type of interaction the visitor navigates or explores 2D Web pages with embedded 3D VRML models and other multimedia objects. The user is able to navigate through the web pages by clicking on the hyperlinks and browse the digital exhibits. A snapshot of this type of exhibition is illustrated in Fig. 2.

As discussed in the previous section the data that comprises a virtual exhibit is stored in the XDELite repository, in particular in an instance of the 'information resource' schema (White, 2004). For the exhibit of Fig. 2 an image, a 3D model and additional metadata are retrieved and presented dynamically at the visitor's request.

In addition to the simple exhibition discussed above information resource instance is also able to include educational quizzes about a stored resource. Fig. 3 illustrates an educational quiz interaction.

Those quizzes can be displayed in the form of questions with a set of possible answers accompanied with a predefined marking system. According to the user's choice marks are allocated to the user as the experience progresses and the user answers the questions. At the end according to the points accumulated different rewards may be provided. The quizzes are programmed by the museum using an XML script.

### 3.2 INTERACTIVE 3D GALLERIES

Another interesting way for visitors to interact with virtual tours is through interactive 3D galleries. An XDELite schema, known as 'Gallery', has been developed to support the storage and the delivery of interactive 3D galleries. An instance based on the above schema is capable of storing data for the delivery of web layouts such as the one illustrated in Fig 4. Digital exhibits of cultural artefacts and additional digital information that can be used to enhance the VR experience of an interactive gallery are organized in hierarchical XML structures of exhibition spaces. When those spaces are visited the data are retrieved and the exhibitions are created on request.

The visitor interacts with the virtual gallery by dragging and dropping artefacts, movies and textures into the virtual exhibition from the dynamically generated content displayed on either side of the virtual gallery – all embedded on the web page. After dragging the objects into the scene the user can move the objects into the virtual environment. This example illustrates a virtual exhibition presenting museum artefacts in a 3D room or reconstruction of a real gallery – in this case an exhibition gallery in the Victoria and Albert Museum in London (Victoria and Albert Museum, 2005). With this interaction method, visitors can browse virtual objects simply by walking along the room and can retrieve more detailed information using interaction elements integrated into object stands.

### 3.3 MULTIMODAL INTERACTION

Another way to interact with virtual museum content, particularly for museum kiosk displays, is through a multimodal interface design as a replica of a museum artefact. Multimodal input systems process two or more combined user input modes in a coordinate manner with the multimedia system output (Oviatt, 2002).

In this case we have integrated an InertiaCube with a replica of the physical artefact, which is used as the interface to explore the artefact, see Fig. 5. The replica is based on a 11th century carved ivory top of an abbot's crook currently on display in museum of Enniscorthy (Enniscorthy, 2005).

An orientation sensor (InertiaCube) is embedded in the replica and coupled to the digital artefact through an ActiveX control, which allows the user to rotate the digital artefact with 3 degrees of freedom. To build the replica, a rapid prototyping technique called Fused Deposition Modelling, or FDM was used (Epoch, 2004), (Oosterlynck, 2004). The FDM process constructs three-dimensional objects directly from scanned 3D data.

The user sees the digital artefact in a VRML browser embedded in our application behaving exactly as the physical replica, see Fig. 6. In this application the user can initialise and set the sensitivity of the orientation device, restrict the rotation of the artefact to one axis. By adding touch sensors (see the little black spots on the replica in Fig. 5) to the replica the user can explore the story of the object (Epoch, 2004) and learn more information about the artefact. Each touch sensor on the replica can be programmed to perform any type of operation. In our case, eight buttons are strategically located on key parts of the artefact that enhance its inherent symbolism. As a result, the user by pressing a button can navigate to a respective web page related to the particular symbolism. For example, there exist two buttons for the Kromstaf's two Latin inscriptions.

### 3.4 INTERACTION THROUGH AUGMENTED REALITY

One of the most important concerns in designing a computer interface for a virtual museum is the interaction between the visitor and the virtual information. We have seen above that the integration of web browsers and 3D allows us to build accessible interfaces. However, now we want to couple the power of augmented reality to our web based virtual museum. Thus, we need to develop an interface that integrates with the web presentation and an AR visualisation of 3D objects presented in the web page. So the AR interface must not only provide the means for communicating with the augmented environment but it also allows the selection of multimedia content (3D models) via the web. For this we have built two augmented reality interfaces (ARIF and ARIFLite) where interactions can be performed in two distinct ways: either through the tangible manipulation of marker cards in the real world or through the use of sophisticated hardware devices such as SpaceMouse, touch screens, etc (Liarokapis, 2004). Several interaction techniques have been implemented.

### 3.5 INTERACTION BY MANIPULATING MARKER CARDS

Visitors can interact with a digital exhibit simply by picking up a card, turning it, etc. while all the while keeping it in full view of a web camera. This approach was proposed by Billinghamurst *et al.* (Billinghurst, 2001), (Kato, 2000) and was adopted in our AR interface for its simplicity. However, the main disadvantages are: those markers must always be in line of sight of the camera and the marker detection algorithm is prone to a number of sources of errors including: lighting conditions; material of the markers; and range of operation.

In ARIFLite we have implemented a similar approach with (Billinghurst, 2001),(Kato, 2000) with the important difference that the user first visualises a 3D object on the web (as an embedded web browser in our augmented reality interface) and then it transforms the virtual information it into real world coordinate space (Liarokapis, 2004). Furthermore, based on the

MagicBook (Billinghurst, 2001) example we have designed a 'heritage book', which consists of a set of markers, one for each page. A set of virtual objects are queued up for display in the book from the web pages. Fig. 7 illustrates an example screenshot of one page our heritage book displaying a virtual mortar.

The benefit of integrating this approach is that it allows the user to manipulate the superimposed information using a tangible interface (i.e. physical marker cards, pages of a book, etc). Another important advantage of this technique is that no previous experience is required or any knowledge of computer technologies. In other words, the interface can be effectively used by anyone. This makes the system accessible to all kinds of ages ranging from young children to old people.

### **3.6 INTERACTION THROUGH STANDARD INPUT DEVICES**

Interaction with a digital exhibit displayed in the AR interface includes the use of standard I/O devices such as the keyboard and the mouse; VR interaction devices including the SpaceMouse as well as software based interactions (GUIs) (Liarokapis, 2004).

The Magellan SpaceMouse Plus XT is a USB device that provides both a six degree-of-freedom (DOF) mouse as well as a nine button menu interface. Using the SpaceMouse SDK, all nine menu buttons have been programmed to perform simple graphics operations including basic transformations like rotations, translations and scaling operations. In addition more complex graphics operations such as lighting and plane clipping have been implemented. An example screenshot of a user examining (translating) the virtual mortar is presented in Fig. 8.

Each button of the device can be programmed to perform any type of operation. In our case five buttons are used to enable basic transformations (rotation and scaling and translation) and allow the user to perform graphics operations (LOD, lighting, etc), two buttons are used to change camera positions, while the rest are used to provide information about the object (historical info, multimedia presentation of the artefact).

### **3.7 INTERACTING THROUGH THE GUI AND TOUCH SCREENS**

Another way to provide effective interaction techniques is through the combination of user friendly graphical user interfaces (GUIs) and standard I/O devices (Liarokapis, 2004). Museum curators can examine the virtual objects on the table top by changing the visualisation parameters from a menu. Fig. 9 illustrates a very simple GUI to the AR visualisation

Moreover, the use of touch screens that are commonly used for kiosk interaction in museum environments allows the visitor to interact with virtual information by just clicking the appropriate buttons on the touch-screen using their fingers and without having the need to use any other external hardware device.

### **3.8 INTERACTIONS THROUGH A VIRTUAL ENVIRONMENT**

With this approach the user can combine the three different visualization interfaces described: the web page, virtual and augmented reality visualizations. For example, imagine a virtual tour starts with a virtual flythrough of Fishbourne Roman Palace. The visitor can control the tour by selecting different camera points or manually navigate the virtual palace. Further, the visitor can interact with the virtual reconstruction (see Fig. 10) of the palace by selecting various parts of the virtual palace.

There are three different types of interactions in this scenario. The first type of interaction is between the virtual environment and the augmented reality interface. Here if the museum visitor clicks on the ground of the virtual exhibition the AR Visualization environment is started, see Fig. 11, and virtual artefacts that have been excavated at Fishbourne are queued to markers for visualisation.

The second type of interaction is between the web and augmented reality interface. The user by clicking the AR link from the visualization template (see Fig. 2) launches the AR environment (see Fig. 12).

The third type of interaction is between the virtual environment and the web page. The museum visitor can access more detailed information on the web pages and interact with 3D models of archaeological artefacts from the palace by clicking on an object in the virtual reconstruction of Fig. 10 causing a jump to the web page of Fig. 13. In this case the visitor has clicked on a column and access some detail on an excavated piece of column.

## **4. CONCLUSIONS**

A user-friendly and interactive visualisation interface specifically designed for exploring and interacting with virtual museum or tours and associated virtual artefacts has been described. In particular, several interesting interaction techniques have been shown incorporating the use of 3D, virtual environments based on VRML browsers and augmented reality. Our system combines Web3D, VR and AR technologies into a single architecture to allow the exploration of museum visualisation using these technologies.

Special emphasis has been given on providing ways for interaction with virtual information in museum environments. Users can interact with various types of environments including the web domain, VR worlds and AR table top environments. Multimedia information is combined and can be transferred from one domain to another (i.e. from web to AR).

In the AR interface interactions have been designed using either several approaches from simple GUI, manipulation of markers to more sophisticated input devices such as a space mouse, and the design of a bespoke multimodal interface incorporating an artefact replica. By using the Multimodal Interface the user can get tactile information of the replica. Furthermore, by activating touch sensors in the replica the user can discover hidden information about the object through a web interface. Some major improvements that could be implemented in the future include the addition of more interaction devices such as haptic gloves and VR joysticks. Also we plan to design a wearable version of the system so that it can be used in mobile devices, such as PDAs.

## ACKNOWLEDGEMENTS

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## FIGURES

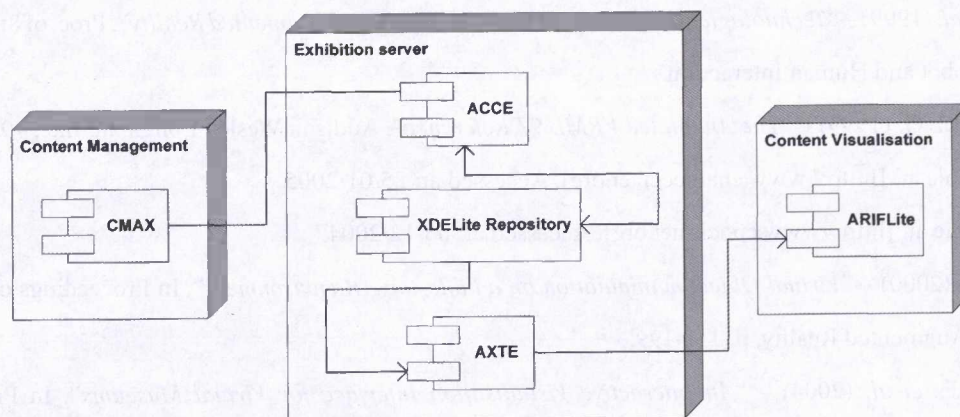


Fig. 1 – Conceptual component diagram of ARCOLite (White, 2004).

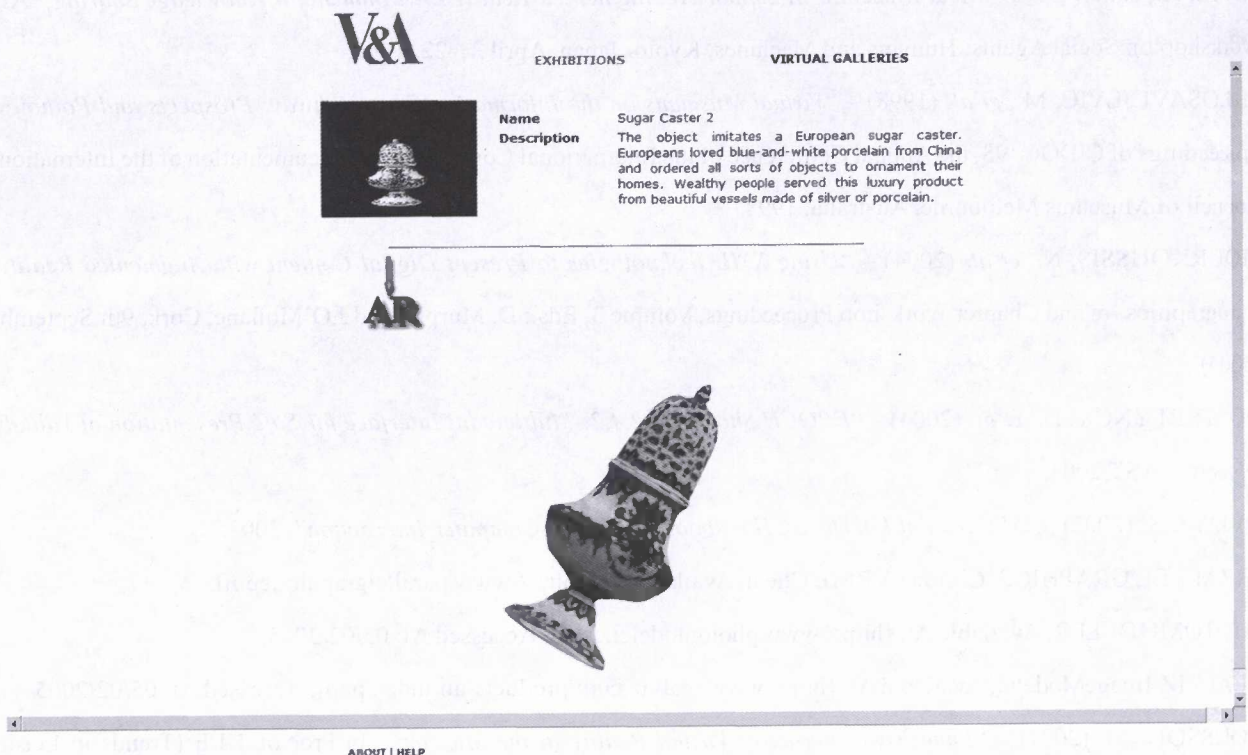


Fig. 2 – Interacting with the virtual exhibit.



**QUIZ:** V&A Objects **Stake:** 3 **Score:** 0 [ ARCO ]

**Question:** What is this object?

**Option:**

**Answer:** A sugar caster  V&A Objects

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Fig. 3 – An educational quiz interaction.

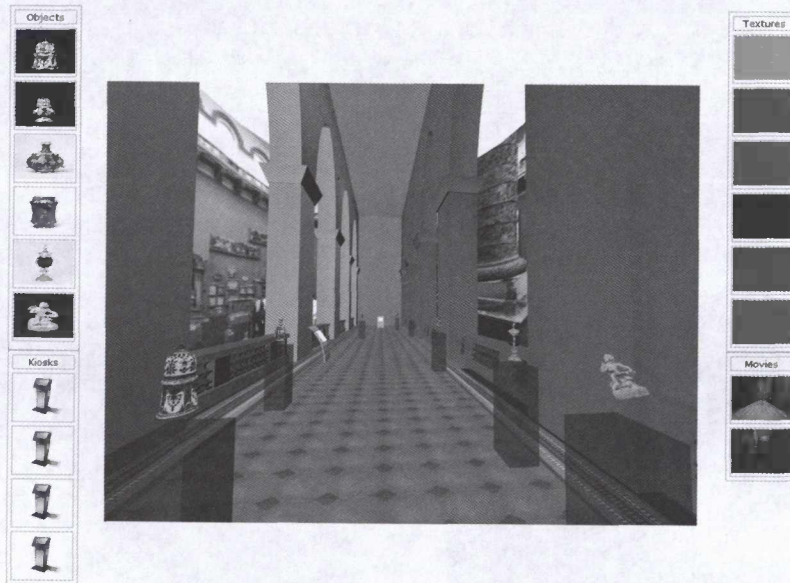


Fig. 4 – A web based interactive 3D gallery.



Fig. 5 – Kromstaf replica with touch and orientation sensors

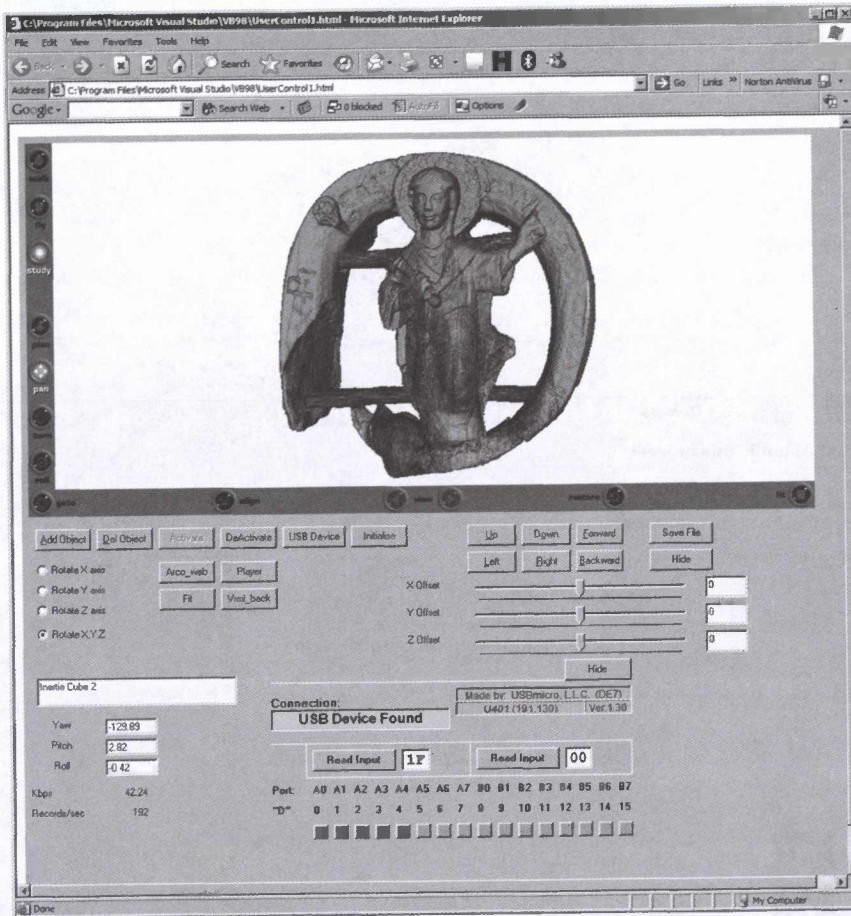


Fig. 6 – ActiveX multimodal interface.

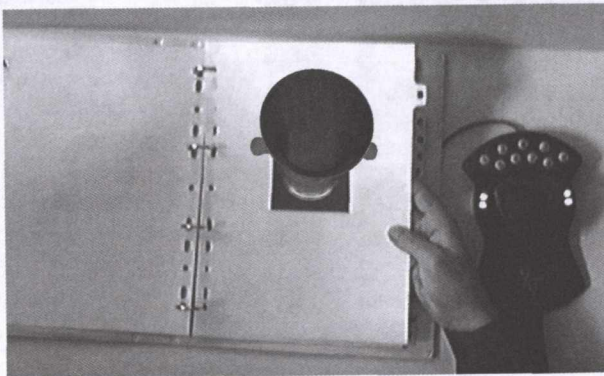


Fig. 7 – Heritage book interaction.

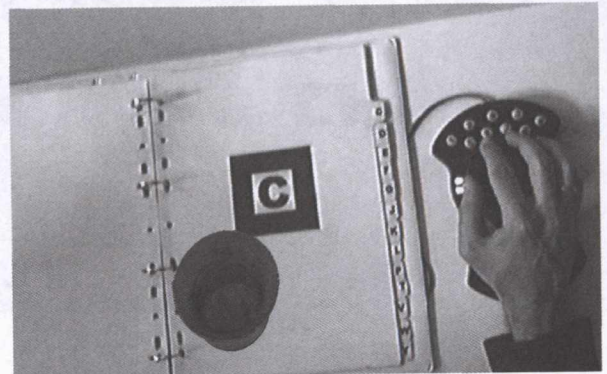


Fig. 8 – SpaceMouse interactions.

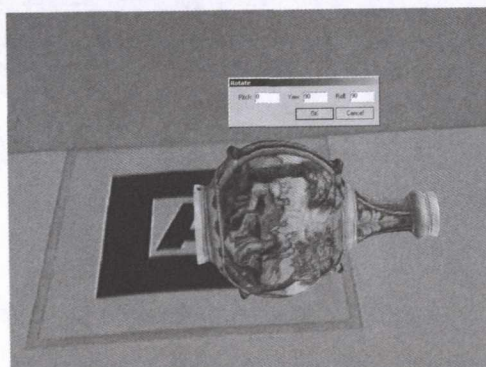


Fig. 9 – GUI interaction.



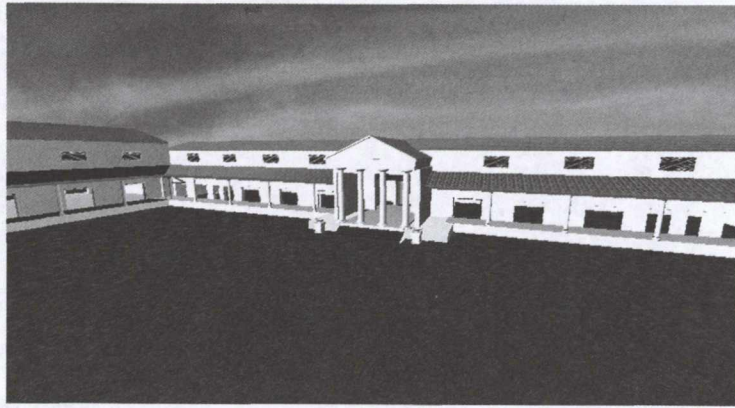


Fig. 10 – Palace virtual reconstruction.

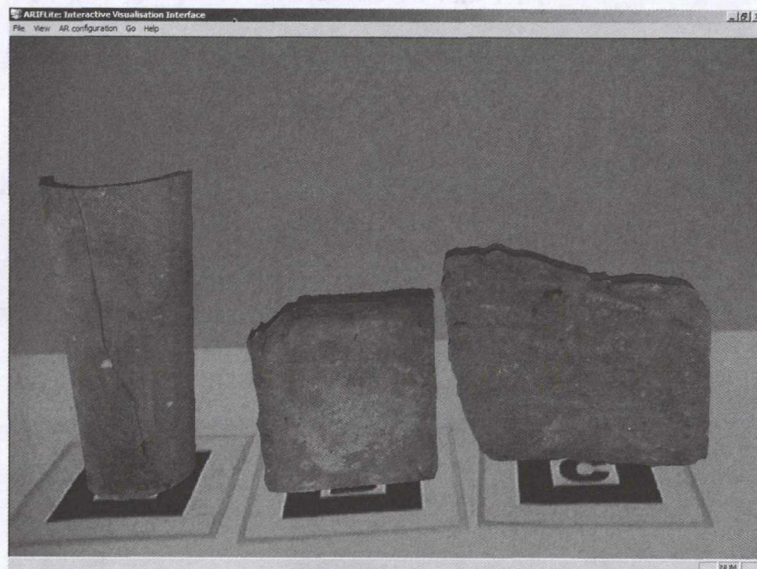


Fig. 11 – Excavated artefacts viewed in AR.

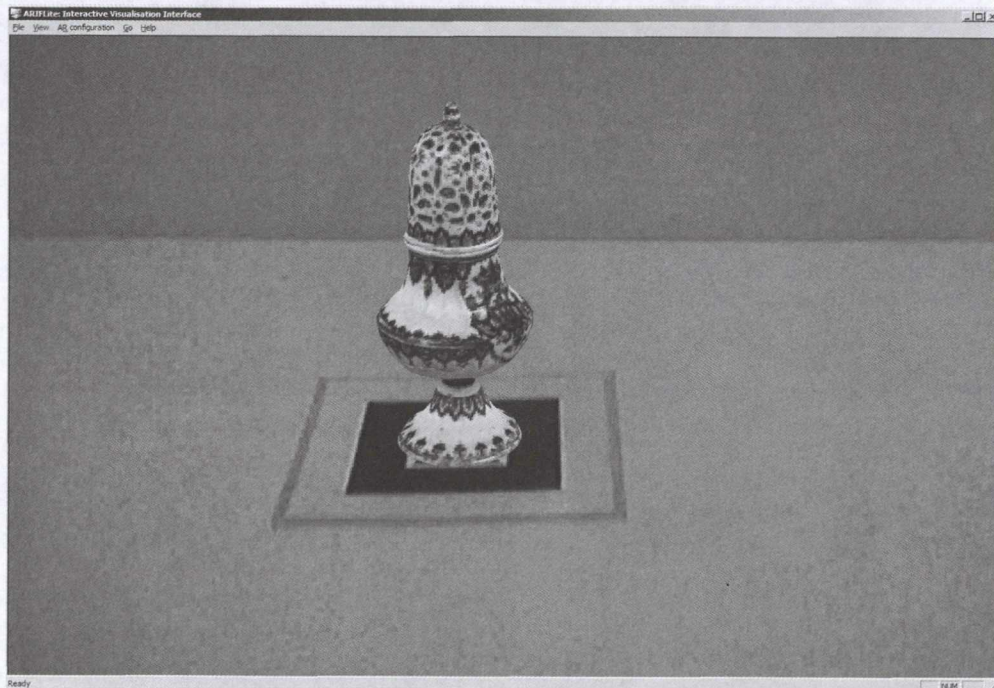


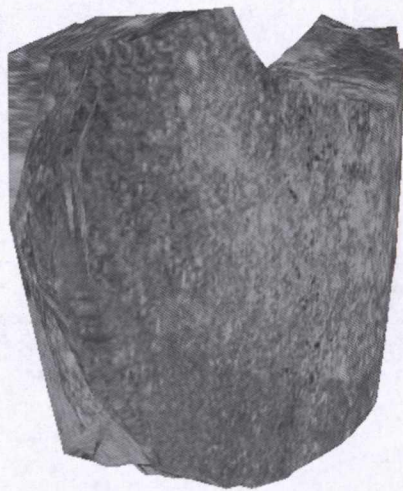
Fig. 12 – Augmented reality interface accessed from the web page from Fig. 2.



Virtual Tour

Virtual Tour > Column Fragment

## PART OF COLUMN



[BACK] [VRML]

The Limestone columns, at Fishbourne Roman Palace, were brought from Brading on the Isle of Wight prefabricated ready for using in the construction of the portico and to embellish the audience chamber and front entrance of the Roman Palace. By measuring the positions of the three column bases which survive in the north west corner of the site it is possible to work out that the columns were 3.96m high and were placed at intervals of 3.60m from centre to centre.

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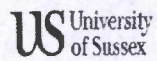


Fig. 13 – Web Visualization Interface.