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ARK multi-user

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Abstract

This paper presents a monitor-based prototype for the visualisation and interaction of an Augmented Reality (AR) system, which recently developed at CCG and demonstrated during the SIACG2002 conference held in Guimarães, Portugal. ARK – Augmented Reality Kiosk - is a set-up based on the prototypes developed in the European Virtual Showcases project to which direct interaction has been added. A normal monitor and a half-silvered mirror constitute the usual set-up for the kiosk By integrating a half-silvered mirror and a black virtual hand, the CCG solution solves the occlusion problem that normally occurs when a user interacts with a virtual environment displayed by a monitor or other projection system. Conceived with limited monetary resources this portable solution can be deployed in different application contexts as, for instance, culture heritage. This paper presents an extension of the solution to a multi-user platform for a Portuguese museum.

Keywords

Augmented Reality, Virtual Reality, Augmented Environments, Visualisation, Interaction, multi-user, half-silvered mirror, Cultural Heritage

1. INTRODUCTION

Opposed to Virtual Reality (VR), Augmented Reality (AR) does not create a totally artificial environment. This last approach consists of three-dimensional (3D) computer generated images that are projected into the real world, thus adding virtual information to human perception. Virtual information normally helps the user to understand the real world. The potential of this technology extends to different areas from industry to tourism and, in particular, cultural heritage.

In industry, for example, AR can be used for the training of assembly operations. In cultural heritage specifically, these technologies currently are being used in the preservation and dissemination of historical and cultural information. For example in respect of AR, it is possible to reconstruct an incomplete or fragmented archaeological artefact. By using 3D computer generated images of the missing parts of an artefact, the user can obtain a very close approximation of the artefact in its original form and the Centro de Computação Gráfica (CCG) has good examples of the use of AR in cultural heritage: the ARCHEOGUIDE and VirtualShowcases (www.virtualshowcases.com) projects.

The first one, ARCHEOGUIDE (Augmented Reality-based Cultural Heritage On-site GUIDE) is a system for providing new ways of accessing information at cultural heritage sites in a compelling, user-friendly way through the use of advanced IT including Augmented Reality, 3D-visualisation, mobile computing and multi-modal

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interaction. The main purpose is to share more information about some places in Ancient Greece, such as the reconstruction of lost parts of Acropolis of Athens (Fig. 1).

Figure 1: An augmented environment from ARCHEOGUIDE (Courtesy of ARCHEOGUIDE consortium)

The second one, the VirtualShowcases project, was the basis for the development of the Augmented Reality Kiosk (ARK) prototype and its extension to a multi-user system. The main goal of this system is the development of new augmented reality display systems for musicological environments and this project will be explained in more detail in the next section.
There are two approaches used so far by the research community to develop AR environments: one applies a see-through Head-mounted Display (HMD) where computer generated images are superimposed over the image of the real world; the other approach employs a rear projection system while mixing the two worlds [Aliaga 1997].
The ARK prototype that is the focus of this article is based on monitors, a technological solution accessible to all when it is compared with other projection systems.
At this moment the ARK is a mono-user system that has user interaction in real time. However, this solution is insufficient for places where the public attendance is very high because innovative technologies attract attention and create long lines of waiting users. To resolve this problem, CCG is developing a solution that will upgrade the ARK to a multi-user system solution.
This article is structured in three main sections. The first one concerns related works; the second section describes the ARK setup and the solution used to resolve the occlusion problem that is inherent in this kind of system. In the last section, "Augmented Room", the evolution of ARK into a multi-user system known by this name is presented.

2. RELATED WORKS

The VirtualShowcases project addresses precisely this issue by introducing a new stereoscopic display system called the Virtual Showcase. The Virtual Showcase looks like a real showcase thus making it compatible with traditional museum displays. Real scientific and cultural artefacts are placed inside the Virtual Showcase allowing three-dimensionally improved presentations. Inside the Virtual Showcase virtual representations and real artefacts can share the same space thus allowing for new ways of merging and exploring real and virtual content. The virtual part of the showcase can react in various ways to the presence of a visitor thereby enabling intuitive interaction with the content displayed (Fig. 2) [VS 2001].
The original Virtual Showcase setup developed was based on a transparent material, enveloped in a silver foil with semi-transparent properties. Through the faces of the showcase the user can see the real objects and the projected, 2D/3D monoscopic or stereoscopic computer generated images on the showcase faces. This can result in the superposition of virtual information in front of the real objects, which is the principle of AR (Fig. 1) [Bimber et al. 2001] [Bimber et al. 2002] [Bimber et al. 2002b].

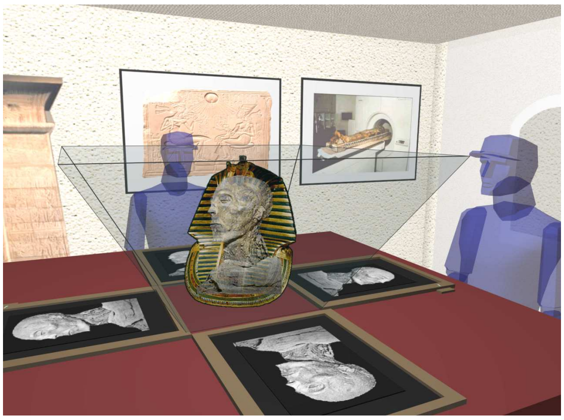

Figure 2: The planar reflection of Virtual Showcases (Courtesy of Virtual Showcase consortium)

This Virtual Showcase setup does not have interaction, so the users can only be observers. The ARK uses some of the technological principles from the VirtualShowcases project but gives something more, the interaction between the user and the virtual or real objects, for instance, by using data gloves. In the ARCADE project [Encarnação et al. 1999], a large stereoscopic back-projection system, like the Virtual Table, has been used to create VR environments for different application scenarios such as automotive and aircraft design and planning, where the user is able to interact with the objects in an immersive manner.
This system for 3D modelling was developed by the Fraunhofer Institute for Computer Graphics in Darmstadt with the objective of integrating Virtual Reality (VR) technologies, such as 6D-input, 3D-output and 3D gesture recognition, in a CAD platform. The combination of these techniques allows for an efficient and precise modelling in a virtual environment [Amicis 2001]. However, the

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weaknesses of this project are the use of video tracking, because this kind of tracking is not able to follow all the movements of the user, and the use of a Virtual Table from BARCO™, which besides being a costly display system, has a size problem when it needs to be transported.

3. ARK

The ARK is presented in a kiosk format. A 21-inch monitor with its face-down and a half-silvered mirror are installed inside this structure. The mirror reflects the images projected by the monitor and at the same time it allows the user to see the real objects, which are located inside the kiosk behind the mirror. The kiosk structure is made of wood, laminated with an opaque layer, in order to reduce the levels of environmental light reflection and to allow more brightly projected images [Matos at. all 2003].
The user interaction happens inside the kiosk, through the use of a ™CyberGlove (Fig. 3a).

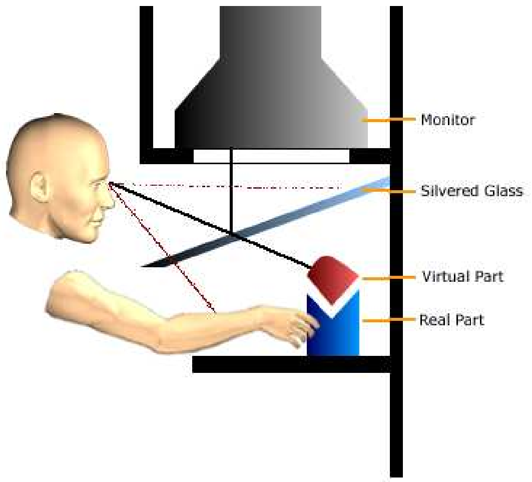

Figure 3a: Functional interaction structure of ARK

The AR effect occurs when there is an overlapping of virtual objects (reflected in the mirror) with the real objects (behind the mirror). The level of visualisation of the real objects is controlled by an artificial light inside the ARK, which illuminates the real objects. The ARK is a system that can be adapted to many situations, making it easier to present augmented or virtual scenarios. With ARK, the limitation on such scenarios is the dimensions of objects, since it is only possible to put small and medium-sized objects inside the structure.
Occlusion occurs between real and the virtual objects in AR environment when the projection of the latter ones occludes the view of the real scene and vice versa [Wloka 1995] [Berger 1997] [Breen et al. 1996] [Balcisoy et al. 2000]. This phenomenon can be clarified by the following example whereby a 3D computer generated image is projected onto a wall and the user is able to interact with the virtual object using his hand. When the hand of the user intersects the projection area, the virtual object is always hidden by the hand, even when the virtual object should be in front of the hand (Fig. 5). This is called the Occlusion Effect.

Figure 3b: User interacting in ARK

In ARK the projected images also occlude the hand of the user, so to solve this problem a complete black virtual hand is used (Fig. 4). This black virtual hand is placed at the same spatial position and orientation of the hand of the user, thus creating black zones on the projected image. Through this black zone the user sees his hand. In other words a black hand overlaps the real hand [Fuhrmann et al. 1999] [Bimber et al. 2002].
Normally when a user interacts directly with virtual/real content the computer generated images can hide the hand of the user when the virtual object is in front of his hand. However, with the Black Hand paradigm the user always sees his hand inside the augmented environment through the hole made by the Black Hand. Fig. 5 illustrates the occlusion effect that occurs in ARK. The input device used in the prototype is a ™CyberGlove with 22 sensors (spread over the fingers of the hand) that easily detect any kind of motion in real-time.
Another limitation of the ARK up to this point is the tracking calibration. The overlapping of the virtual hand (Black Hand) with the hand of the user has to be in an exact spatial relationship. This is very complex and it uses an electro-magnetic tracking system where the precision of this kind of tracking depends on the environmental electromagnetic conditions [Redert et al. 1997] [Summers et al. 1999].

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Figure 4: (Left) Black Hand and real hand; (right) the effect achieved after applying the "Black Hand" paradigm.

In the near future a video tracking test will be carried out with ARK. Using a CyberGlove, the user can at the same time interact with the virtual and real objects, creating a higher level of immersion. The range of interaction is limited to the range of the tracking system, which is 0.76 by 0.63 by 0.30 metres. However, it is enough to give the necessary movement freedom inside of the kiosk [Grave et al. 2000].

Figure 5: Example of the occlusion effect occurring in ARK

The tracking system has two position/orientation sensors: one placed on the CyberGlove and the other on the ShutterGlasses. The sensors are used for calculating the position and orientation matrix of virtual objects in the augmented environment. This matrix is calculated according to the head and hand positions/orientations of the user. The tracking system used is an Ascension Flock of Birds^{TM} and the computer is an SGI Octane with the Virtual Design 2 ^{TM} VR engine from VRCOM. This VR engine is a fine API (*Application Programming Interface*) that makes it easy to install and use with several interaction devices and also for developing the proper interaction beavers.

In parallel, a new solution is being developed based on a PC platform. In this case two VR engines are being used: OpenSG (www.opensg.org) and the VRJuggler (www.vrjuggler.org). The first one creates the 3D computer generated images and other establishes the connection between the interaction devices and the OpenSG.

The ARK uses simple interaction metaphors that make this system very intuitive and easy to learn. The metaphors are very close to real movements. For example, the user has to use two fingers, normally the forefinger and the thumb, to grapple a virtual object and the immersion level is almost complete.

The ARK can be used in exclusively virtual environments or in augmented interaction and visualisation scenes. A good application example of the system is virtual prototyping, where it is essential to visualise and at the same time interact with the virtual objects during the design stage.

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4. AUGMENTED ROOM

The Augmented Room is an extension of ARK being a multi-user version. This system supports up to eight users, four of whom can interact with the system and the remaining four are just observers. This system is called the Augmented Room (AugR), because it is very similar to a room with windows and uses augmented technologies. This "room" is an octagonal structure and each face has a visualisation window that allows users to look from outside to inside (Fig. 6).

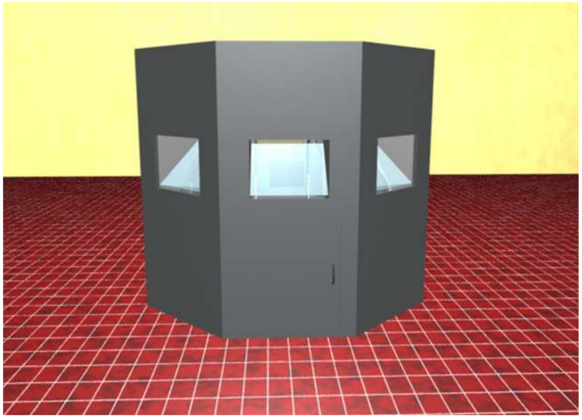

Figure 6: 3D simulation of the Augmented Room

To visualise the virtual and real objects inside the AugR, the system makes use of the same ARK visualisation principle: a half-silvered mirror. Also in AugR it is possible to configure the visualisation level of real or virtual objects by using a central light that illuminates the real objects and at same time affects the reflection level on the mirrors. This light has a luminance intensity controller in order to achieve a balance between the real and 3D computer generated images. The reflection level of the mirrors is opposite to the illumination level of the real objects.

The AugR was particularly designed around an Ancient Roman Tomb theme. It is a 3D simulation of the religious ceremony from the Second Century AD, where the users will first see the artefacts used and later view the virtual funeral ceremony. The funeral ceremony was considered important because it used a pyre, which was unusual in the ancient town of Bracara Augusta and also in ancient Portugal. This type of funeral, which is very common in India, consists in the cremation of the corpse on top of a wooden pyre.

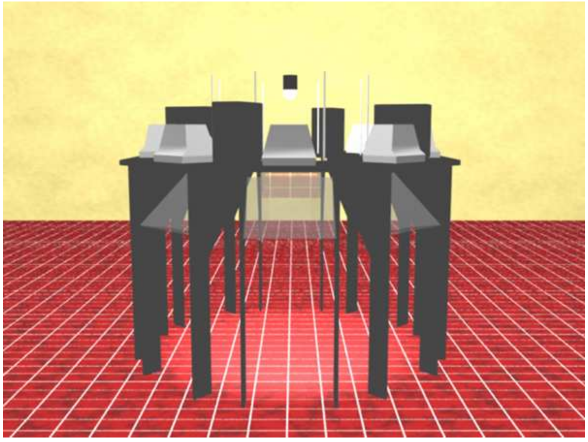

Figure 7: 3D simulation of the AugR structure without walls

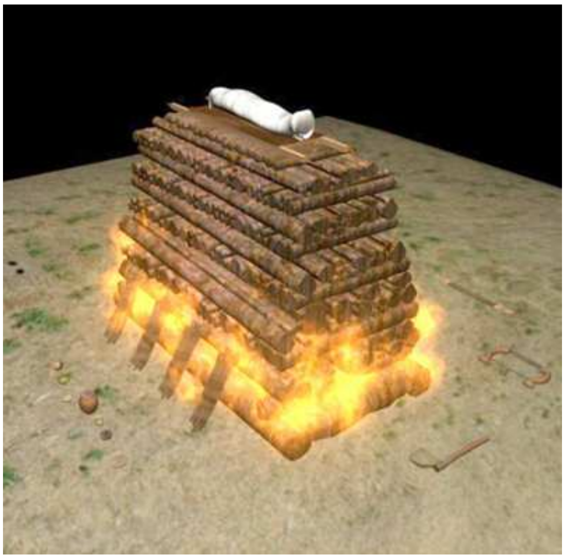

Figure 8: First presentation using the Augmented Room.

The "Ancient Roman Tomb" 3D simulation will create a lively presentation of such an incineration ceremony. As with the ARK, the mirrors of the system reflect the images from monitors, which are face down in the upper part of the structure. The projection is made directly onto the mirrors without a second reflection surface. This causes a problem, because the reflected images are the reverse of the monitor images. To solve this problem the monitor images have to be the opposite way round to correct the reflected images and thus appear in the right position/orientation from the viewpoint of the user, otherwise they would be up side down. To clarify this paradigm it is possible to think of the word "Ambulance" on an emergency vehicle where the word normally appears in the opposite direction so that drivers can easily read the word in their rear view mirrors. This paradigm will be included in a stereoscopic video generated on Alias|Wavefront MAYA 4.5 software (Fig. 8).

The mirrors are set at an angle of 45º inclination to achieve an acceptable image reflection with regard to user height and position. The angle of inclination can be adjusted between 35º and 55º depending upon user height and position. The distance between the mirrors and the monitors can be also adjusted, if necessary (Fig. 7).

This system has been seen to be a passive visualisation system without interaction, even though this system uses the same principles as ARK, but the AugR has a sufficiently open architecture to allow for an interaction component in the future.

To achieve a correct visualisation in eight different viewing windows, the virtual environment has to be generated in eight distinct positions. By looking into the windows the users see an augmented environment in a dark room. To obtain a deeper immersion level and a better sensation of 3D, the use of active stereo visualisation is foreseen. In this kind of system with different viewing positions it is necessary to incorporate head tracking [Redert et al. 1997] and in the near future a tracking system for user head tracking will be included.

The evolution from the ARK to the Augmented Room is an important scientific advance because it has been extended from a single user to a multi-user system.

5. CONCLUSIONS AND FUTURE WORK

In this article, the evolution from the ARK prototype to the Augmented Room - an augmented reality system which allows combining real and virtual objects up to visualisation by eight users - has been presented. Many of the technical problems of AR systems are even more challenging than those of self-contained virtual environments. However, in order to guarantee successful solutions for museums it is necessary to warrant that these are economically attractive in terms of construction and maintenance and available as a multi-user system.

On the other hand, there is the occlusion problem. One would expect the user simply to use his hand to grab the object. If the user puts his hand behind of the projection surface than the occlusion problem occurs, but, if he or she uses a virtual interactive glove this problem disappears. Based on this principle a solution based on using a virtual hand, as a mask for the real hand, has been designed and implemented.

As for work in the near future, the applicability of AR for the dissemination of patrimony and cultural heritage is already a reality, since it is being used in some cultural historical scenes to present merely virtual or augmented (with virtual objects overlapping the real ones) scenarios. With this type of system the entertainment component, as well as the educational one, can be explored in order to attract users to view and interact with the system.

The solutions presented in this article are still being tested as is also the Augmented Room that is partially built for two users at the moment, but already it is possible to glimpse the value that this type of solution can bring. The future work to be fulfilled with respect to the AugR is the finishing of the construction of the structure, the incorporation of the hardware and software system and the testing and playback the Ancient Roman Tomb (fig. 9 and fig. 10). The biggest challenge for the CCG team, however, without a doubt, is the implementation of the first prototype of the Augmented Room in a Portuguese Museum.

Figure 9: First tests on Augmented Room

Figure 10: Outside of Augmented Room

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