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ARK: Augmented Reality Kiosk*

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Abstract

This paper aims at presenting a very first prototype of an Augmented Reality (AR) system that as been developed in recent months at our research group. The prototype adopts a kiosk format and allows users to directly interact with an AR environment using a conventional data glove. The most relevant feature of this environment is the use of a common monitor to display AR images, instead of employing specific Head-Mounted Displays. By integrating a half-silvered mirror and a black virtual hand, our solution solves the occlusion problem that normally occurs when a user interacts with a virtual environment displayed by a monitor or other projection system.

1 Introduction

The biggest difference noted between Virtual Reality (VR) and Augmented Reality (AR) is the lack of real objects on side of VR. There are two approaches presented so far the research community to develop AR environments: one applies see-through 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).

AR environments imply the combination of real objects together with computer generated ones. When these later are presented using a rear projector or a monitor an undesired effect denominated occlusion may arise making difficult to reach a final harmonised mixing of both worlds. In fact, when interacting with the virtual environment, the user’s hand and the other real objects can potentially hide the projected image, i.e., the virtual objects, thus turning unfeasible to have a virtual object closer than the user’s hand. To solve this problem, it should be possible to project the *virtual* image between the eyes of the viewer and the real objects (Wloka 1995) (Berger 1997) (Breen et al. 1996) (Balcisoy 2000).

In our prototype, we have applied and extended some technology principles behind the Virtual Showcase solution (see (Bimber et al. 2001) for more detail) in order to integrate direct interaction of real and virtual objects, for instance, by using data gloves while implementing a low-cost hardware configuration. Also in ARK we present a solution for the occlusion problem.

In this paper we start by exposing, in detail, the problem of occlusion in AR, then we present some related work in the area. In the next section we describe our own solution – the ARK prototype, in terms of its setup configuration and the results of some initial validation testes. Finally we draw up some conclusions and future work.

2 Occlusion effect

Occlusion occurs between real and the virtual objects in AR environment, typically when the projection of the later ones occludes the view of the real scene. (Wloka 1995) (Berger 1997).

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This phenomenon can be described as follows: when interacting with the augmented environment, the user's hand and other real objects can hide the projected image, thus making it impossible to have a virtual object closer than the hand. One potential solution for the problem is to project the image between the eyes of the viewer and the real objects in order to avoid the occlusion problem. For better understanding this, we can imagine two of the following situations that may occur: in the first one the hand or arm of the user is always on front of virtual object, while in the second one, they are always behind of virtual object (see Figure 1). In both cases the user loses eye contact, thus information, with part of the AR scene (virtual or real).

Figure 1: An occlusion example (left); the planar reflection of Virtual Showcases (right) (Courtesy of Virtual Showcase consortium)

By enabling the user to directly interact with the virtual/real content, another problem arises, namely, the computer generated image displayed at the mirror may occlude the hand of the user when the virtual object is behind the hand. These various aspects of the occlusion problem will be discussed later when we present the ARK prototype.

3 Related Work

As mentioned before, the ARK prototype applies and extends some of technology principles behind the Virtual Showcase solution (Bimber et al. 2001) in order to integrate direct interaction of real and virtual objects while implementing a low-cost hardware configuration.

Virtual Showcases are built up from a transparent material (such as glass or Plexiglass) and are laminated with a half-silvered mirror foil. The sides of the Virtual Showcase can simultaneously transmit the image of the real objects as well as reflect displayed computer graphics. Real objects can be superimposed with virtual supplements by displaying stereoscopic 3D, or monoscopic 2D computer graphics that is reflected by the Virtual Showcase (see Figure 1).

Even though VS solution represents an almost perfect solution for combination of real and virtual objects with relative small dimensions, it does not allow interaction with the objects. Users are passive observers of the created scene. The ARK prototype extends this solution by bringing interactivity with the objects recreated, even if only for one user at each time.

(Fuhrmann et al. 1999) have researched occlusion in AR collaboration scenarios, where real objects could be inserted behind the mirror, in order to solve partially the occlusion problem. Also in the project ARCADE (Encarnação et al. 1999), a large stereoscopic back-projection systems such as the Virtual Table, has been used to create VR environments for different application scenarios such as automotive and aircraft design and planning, while the user was able to interact with the objects in immersive mode. The interaction with such a setup is still mostly limited to camera movement and very simple object manipulation. The resulting exclusive use for design

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review does not exploit the full potential of the Virtual Table. This type of setups are limited to the high-costs involved and are hard to handle due to the dimensions of the devices such as the Virtual Table from TMBARCO. The ARK system allows a simpler, cost-effective solution where the kiosk-format is highly suitable for many type of application scenarios focused on the individual access to AR information that additionally also requires interaction.

4 The ARK system

The ARK prototype applies and extends some of the technology principles and solutions developed in context of the Virtual Showcase. It also adapts reflection and one mirror with interaction. The ARK's projection is obtained by a single monitor instead of by a stereoscopic 3D graphics.

The ARK system adopts a kiosk-format which therefore focuses on the presentation of information both based on real object and computer generated one. Accordingly it does not adopt the see-through HMD based setup but aims at provide a complete AR solution for small to medium sized objects, integrating interaction facilities. The ARK setup includes a monitor as image projection, tracking system, silver glass and shuttle glasses for stereoscopic viewing, as well as data gloves for interaction.

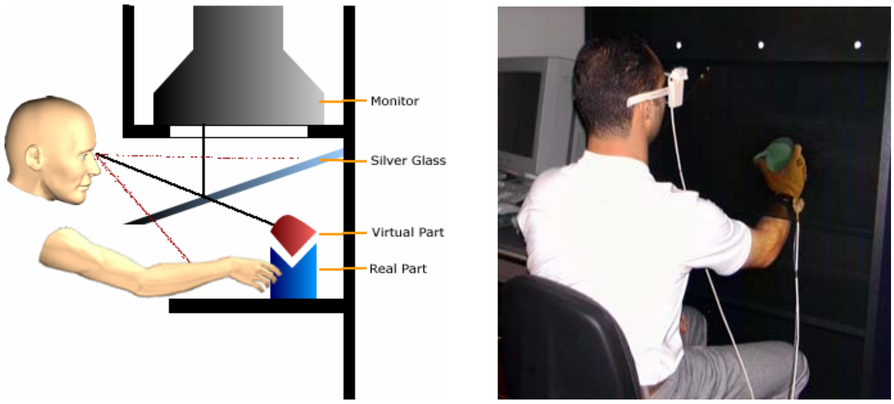

Figure 2: ARK's functional structure (left); aspect of the interaction environment.

The image displayed on the monitor is reflected by the half-silvered mirror, in active stereo, thus creating the illusion that the image space is behind the mirror (see Figure 2).

4.1 Setup of ARK

The current ARK set-up is contained in a wooden structure that supports the monitor face-down and the half-silvered mirror. This wooden structure also reduces the level of outside light that the half-silvered mirror receives, thus allowing a brighter image to be displayed at the mirror. All the ARK structure dimensions are designed to confine a single user alike an information kiosk.

The main structure behind this approach consists of a common 21 inches monitor and a half-silvered mirror. The user interaction occurs directly inside the projection space, by wearing a data glove and by placing the hand beneath the mirror. As mentioned before the occlusion effect arises here when the computer generated image displayed at the mirror occludes the hand of the user when the virtual object is behind the hand. We solve the problem by creating a black virtual hand, which is placed each time at the same spatial position as the hand of the user (see Figure 3).

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Because of the real hand is lighter than the surface of the mirror, the user sees actually his hand inside the virtual environment.

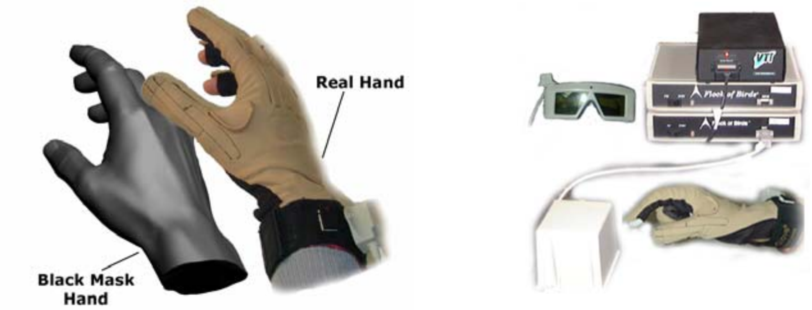

Figure 3: Black virtual and real hand (left); tracking system, shuttle glasses and data glove used in ARK

The input device used in the prototype is a TMCyberGlove with 22 sensors spread by the hand fingers that easily detect any kind of motion in real-time. All finger motions are allowed and, so far, no failures have been detected in order to cause any form of blending. Using this glove, the user can manipulate both, the real and the virtual objects, creating a greater realism effect. The range of the hand is limited (1.00x1.00 meters), however enough to give us the necessary movement freedom inside of the kiosk (Grave et al. 2000). The tracking system in use in the ARK solution is the Tracking Ascension TMFloack of Birds, which integrates two position sensors: one on the glove and the other one on the shutter glasses (see Figure 3).

The position sensors on the shutter glasses and in the glove allows the accurate tracking necessary to project the virtual objects into the augmented scene according to the user's head position, orientation, as well as hand and finger actual position. The computer used is a SGI Octane and the VR modelling software is the TMVirtual Design2 from VRCOM.

The image projection is made through a 21" display (monitor) that lies down over the half-silver mirror at a distance tested and considered sufficient for satisfactory good projection. ARK suits quite well for scenarios of kiosk-based applications as also for small audiences (see Figure 3).

4.2 Initial Validation Tests

ARK initial validations tests, made so far, were of two types: with hybrid objects; and the verification of the occlusion effect. In the first ones we have obtained perfect static hybrid objects, where the blend between the real and virtual worlds was perceptually perfect. However when we tried to test the reaction of hybrid objects with the user head position and orientation, we found some problems: the vertical Y axis presented incorrect values. This occurred because we used only one mirror and the virtual objects were projected in opposite Y axis. Applying a reflection matrix we managed to project the image on the monitor with the wrong axis, but correctly in the silver mirror, thus solving the problem.

Regarding the occlusion tests - even thought the solution was perceptually acceptable for most of scenarios, namely with small and geometrical regular objects such as cans or coups, we have detected some problems arising from the imperfect overlapping effect of the real hand with the virtual black hand. This means the overlapping expected from both objects was not always perfect thus leading to partial occlusion. The solution lies on investing more time on the calibration features which also depend, unfortunately, in many ways on the accuracy of the tracking system adopted (Fuhrmann et al. 2000).

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5 Conclusions and Future Work

In this paper, we have presented the ARK prototype - an augmented reality system which allows interaction between real and virtual objects. Many of the technical problems of AR systems are even more challenging than those of self-contained virtual environments. It is necessary to do additional research to obtain realism of virtual images in real-time. On the other hand, we have the occlusion problem. One would expect the user simply employs his hand to grab the object.

If the user puts his hand behind of the projection surface than we have the occlusion problem, but if he uses a virtual interactive glove this problem disappears. Based on this principle we have designed and implemented a solution based on using a virtual hand as a mask for the real hand.

In fact, the user is not aware that his virtual hand is actually in the scene, even knowing he is wearing an interaction glove. From his point of view - his own hand grabs the object.

For the near future work - one of the biggest problems being faced so far is the high complexity of the calibration step. The black virtual hand must be extremely well calibrated with the hand of the user in order to achieve the desired effect.

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