The use of a visible and/or an invisible marker Augmented Reality System for the treatment of phobia to small animals

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Abstract: Virtual Reality and in vivo exposure have been used extensively for the treatment of several psychological problems, but Augmented Reality (AR) has not been exploited in this field. We have recently presented an Augmented Reality system for treating the fear of cockroaches and spiders that uses visible markers. With this system, we successfully treated ten patients, four with a phobia of spiders and six with a phobia of cockroaches. One important step in the treatment is when the patient must search for an animal that is possibly hidden behind an object. This stimulates patients’ anxiety because they do not know which object the animal is hidden behind or if there is a hidden animal at all. When using visible markers it is very easy to know if animal/s is/are going to appear, because at the moment the patient sees the marker, they know an animal will appear. We realized that having visible markers was a negative aspect of our system, and this is why we have developed a Markerless Augmented Reality system. The system works in the same way as the visible marker system, but in this case the markers are not visible. In this paper, we present the markerless system. At present, we are investigating whether the sense of presence and reality judgment in normal users (those without fear) is the same when using the visible marker system as when using invisible marker system.

INTRODUCTION

Augmented Reality
There are several application areas in which Augmented Reality (AR) is already utilized. Some of the most popular application areas are the following (Azuma et al., 2001; Azuma et al., 1997; Vallino, 1998):
- Medical
- Military
- Education
- Engineering design
- Manufacturing, maintenance and repair
- Entertainment

This list includes some of the areas where AR has been applied, but other areas may be included in this list. Any area where adding virtual information to real world stimulus could help users in their work is a candidate for the use of AR.

In the medical area, AR can offer possibilities to support minimally invasive techniques through image-guided surgery. Surgery planning and surgery training can also be done using AR because of its 3D visualization and interaction capabilities. In psychology, its use for treating patients with phobias is being investigated. Our group has been a pioneer in the use of AR for the treatment of phobias to small animals (cockroaches and spiders; Juan, Alcañiz, et al., 2005; Botella et al., 2005). We have also presented an Augmented Reality System for the treatment of acrophobia using immersive photography (Juan, Pérez, et al., 2005; Juan et al., 2006).

In the military area, AR is used primarily to provide soldiers with real-time information (e.g., maps, occluded buildings, and troop concentrations) in a battle situation. Military training and simulation also benefit from AR.

AR might have the ability to change traditional education methods because it can be used to visualize abstract theories and offers a high degree of interactivity. Geometry and spatial relationships between planets are two examples of cases that have already been investigated.
In engineering design, AR can offer an interactive and collaborative way to construct models. Such virtual models are tangible and can be viewed from different angles. Examples are the construction of the layout of a new city block or the interior design of an apartment.

In manufacturing, maintenance, and repair AR can provide real-time information from instruction manuals to facilitate working processes. This information could be annotations of parts of a machine, instructions for assembly or disassembly, or visualization of hidden inside views.

Entertainment can profit from the interactivity AR offers. AR could change existing gaming concepts, such as board and strategy gaming, and could even make outdoor gaming possible. Interactive story telling is an example of using the application for children.

Marker or Markerless Augmented Reality System?
A marker Augmented Reality System utilizes markers (e.g., a white square with a black border containing symbols or letters). The system recognizes the marker and obtains the position and orientation of the camera with respect to the marker. A markerless Augmented Reality System does not need a marker.

One important step in the treatment of the fear of small animals is that patients have to search for an animal that might be hidden behind an object. This stimulates the anxiety of patients because they do not know which object the animal is hidden behind or whether there is an animal hiding at all. When using visible markers it is very easy to know if animal/s is/are going to appear, because at the moment the patient sees the marker, they know an animal will appear. We realized that having visible markers was a negative aspect of our system, and this is why we have developed a Markerless Augmented Reality system.

The Markerless system works in the same way as the visible marker system, but in this case the markers are not visible. They exist, but they are not visible for users.

**CHARACTERISTICS OF THE MARKERLESS SYSTEM**

The AR system is video see-through. That is, a color camera captures the image of the real world. This image is then treated by the system.

The required information about the position and orientation of the 'invisible marker' is obtained. The virtual elements are overlapped over the desired position in the coordinate system.

**Hardware**
The video stream is captured using a FireWire camera (color image). We have used a DragonFly Camera (Figure 1). The IR Bullet Camera (715nm IR filter) has been used to obtain the infrared image where the invisible markers are detected (Figure 2). The Daeyang i-Visor(DH4400VPD) has been used as a visualization system (Figure 3). The IR invisible Ink Writing Pen – 840 nm Peak has been used to draw the invisible markers. This ink is invisible for the color camera, but visible for the infrared camera.

![Figure 1. DragonFly Camera](image1)

![Figure 2. IR Bullet Camera](image2)
Description of the system
The infrared and colour cameras are situated in known positions, so the transformation matrix from the position of the infrared camera to the position of the colour camera is easy to obtain. Both cameras capture the image of the real world. The infrared image is analyzed to identify the position and orientation of the marker. Later, using the above-mentioned transformation matrix, the real position where the virtual objects have to appear over the colour image is obtained. The cockroach/spider appears over the invisible marker in the colour image. In this way, the system knows the position where the animals have to appear, but the user cannot see it.

The functionality of the system is the same as the marker system (Juan, Alcañiz, et al. 2005).

RESULTS
This section includes some images taken during the execution of the Augmented Reality system with markers and without markers. Figures 4 and 5 show similar situations. As figure 4 depicts, one participant is using the marker system. In contrast, figure 5 presents the same participant using the markerless system.

Before testing the system with real patients, we are carrying out a study to determine the sense of presence and reality judgement when participants use both systems. We believe that the markerless system will be even more effective than the marker system.

The study is still in progress, and at the moment, includes participants recruited by advertisements on the University campus, all of whom are students, scholars, or employees at the Technical University of Valencia (ages 21 to 40). All participants fill out the Fear and Avoidance to cockroaches and spiders questionnaires, adapted from Szymanski and O'Donohue's Questionnaire (1995). Participants are divided into two groups. The first group uses first the marker system and later the markerless system. The second group uses the markerless system first and later the marker system.

In order to check the sense of presence that participants experience using both systems, they fill out an adapted questionnaire by Slater et al. (1994). For checking the reality judgment that participants experience using both systems, they fill out a questionnaire adapted from the Reality Judgment and Presence questionnaire by Baños et al. (2000).

The study is still in progress, and for the moment we do not have enough participants to extrapolate conclusions. However, in a preliminary analysis of the data, we can say that participants have a greater sense of presence and reality judgment using the markerless system than using the marker system. Moreover, these scores are greater if participants first use the marker system and then the markerless system. We will be able to extrapolate the final conclusions once the study is completed.

CONCLUSIONS
We have presented a Markerless Augmented Reality system, which is an improved version of our marker AR system for the treatment of a phobia of small animals (Juan, Alcañiz, et al., 2005; Botella et al., 2005). The system presented here will be suitable for cases in which user must not see the marker, keeping them unaware of where the virtual elements will appear.

We intend to test the system with real patients. The marker version has proved to be effective
in the treatment of real patients. We treated one patient with a phobia of cockroaches (Botella et al., 2005) and five patients with a phobia of cockroaches and four with a phobia of spiders (Juan, Alcañiz, et al. 2005). Before treatment, none of the patients were able to approach or interact with the live animal without fear. In all cases, patients reduced their fear and avoidance of the feared animal in only one session. Moreover, all of them were able to kill the real animal after the treatment.

At present, a study comparing the marker and the markerless systems is being carried out. While we have yet to finish our study, we can say that the participants who have tested the system have a greater sense of presence and reality judgment with the markerless system than with the marker system. The study is still in progress and we will be able to present final conclusions once it is completed.
REFERENCES


