An Optical See-Through Augmented Reality System for the Treatment of Phobia to Small Animals

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Abstract. This paper presents an optical see-through (OST) Augmented Reality (AR) system for the treatment of phobia to small animals. Our group has already presented two AR systems for this treatment. The first system was a video see-through (VST) AR system. The second one was a markerless AR system. And now, we present a third version using an OST approach. To check whether the OST AR system is more or less effective than the OST AR system, we have carried out an experiment comparing both systems. In this paper we focus on the anxiety level of participants during the experiment. Results show that both systems provoke anxiety in participants even if they do not have fear to cockroaches/spiders. OST AR system provokes slightly more anxiety than the VST AR system.

Keywords: Augmented Reality, Optical see-through, virtual therapy, phobia to small animals.

1 Introduction

The term Augmented Reality (AR) is used to describe systems that blend computer generated virtual objects with real environments.

AR has been used in many fields such as military, entertainment, etc. AR has been recently used for the treatment of different psychological problems. Our group developed an AR system for the treatment of acrophobia using immersive photography [1]. Other problem that we also have treated is the phobia to small animals where two different versions of the same system have been presented. The first system was a video see-through (VST) AR system [2][3]. It was a marker-based tracker, used a colour camera and a VST Head-Mounted Display (HMD). In these works, it was demonstrated that, with a single one-hour session, patients significantly reduced their fear and avoidance. Initially, the system was tested in a case study, and then was tested on nine patients suffering phobia of small animals. The second system was a markerless AR system [4], where the markers were not visible to the user. This second system incorporated two cameras: one colour camera for capturing the real

world without visible markers and one infrared camera for capturing the real world whereby it was possible to distinguish markers drawn with a special ink.

In this paper we present a new version of these systems for the treatment of phobia to small animals that uses an optical see-through (OST) HMD and an infra-red (IR) bullet camera.

This is not the first time an OST HMD has been used in AR, but it is the first time it has been used for the treatment of phobia to small animals.

In this paper, we are going to cite several AR systems that use OST HMD for different purposes. Grasset et al. [5] proposed an OST AR system for collaborative applications where users are around a table. They can interact with AR applications such as architectural design, gaming and planning simulation. Ivanovic and Plate [6] implemented an OST AR system which shows elements of structures that are hidden behind the already built buildings. Ozbek et al. [7] presented a gaming environment. Leebmann [8] presented an OST AR system as a tool for disaster management such as earthquakes. Schwald and Laval [9] presented an AR system for training and assisting in maintaining equipment in industrial context.

2   OST AR System for the Treatment of Phobia to Small Animals

2.1   Hardware

The system requires a camera to capture the real world in order to determine where the virtual elements will exactly have to be drawn.

We have used an infrared (IR) camera, but it could also be possible to use a color camera. After processing the captured image, the system obtains the real camera position and orientation relative to physical markers, and determines where the virtual elements have to be drawn. In this case, only these elements are drawn because the user is seeing the real world. For achieving this, we have used the LitEye-500 OST HMD. A more detailed description of these elements is included next.

- An image of the monocular OST HMD used, LitEye-500, can be seen in Fig. 1.a. The resolution of the HMD enables 800x600 with a FoV of 28 degrees.
- Fig. 1.b shows the IR bullet camera used. It has a 715 nm IR filter and comes in a lipstick sized tube 2.5 inches long, with a diameter of 0.8125 inches. The diagonal FOV of the camera is 92 degrees. The image sensor is 1/3" CCD with 290,000 CCIR pixels, capable of delivering a video stream at a frame rate of 30 fps in several image formats, among them 640x480. The output of the camera is a composite video signal. A regulated 12 VDC power supply is needed for proper operation. USB2.0 Video Grabber converts a video composite signal into a USB 2.0 signal. It delivers a frame rate of up to 30 fps at a resolution of 640x480. The device is compliant with DirectShow.

2.2   Software

We programmed the system using C++ and ARToolKit with Virtual Reality Modeling Language (VRML) support to incorporate AR options. The system uses visible markers.

ARToolKit is an open source vision tracking library that enables the easy development of a wide range of Augmented Reality applications. It was developed at Washington University by Kato and Billinghurst [10]. The required elements for the application are: a USB or FireWire camera, and a marker. Markers are white squares with a black border inside of which are symbols or letter/s. ARToolKit uses computer vision techniques to obtain the position and orientation of the camera with respect to a marker. Virtual elements are drawn on these markers. ARToolKit includes code for image acquisition, the detection of markers in the video stream, the calculation of the three-dimensional position and orientation of the markers, the identification of markers, the computation of the position and orientation of the virtual objects relative to the real world, and the rendering of these virtual objects in the corresponding video frame.
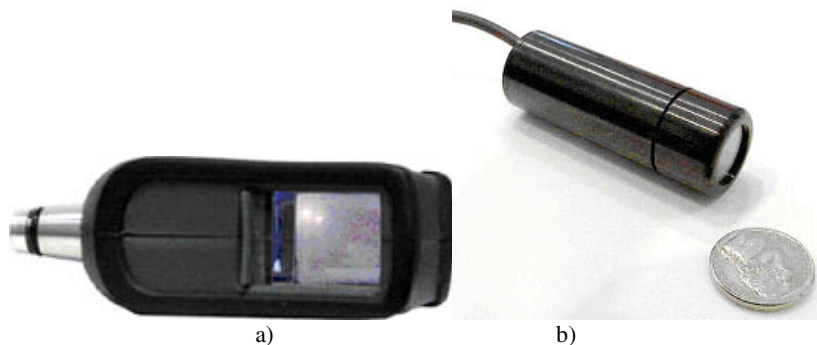

a)   b)

Fig. 1. a) The LiteEye-500 monocular OST HMD. b) The IR bullet camera used.

The virtual elements that appear in the system are spiders and cockroaches. The three-dimensional models of these virtual elements were constructed using Autodesk 3D Studio Max.

The graphical user interface was created with the OpenGL Utility ToolKit (GLUT)-based user interface library (GLUI).

Sound support is provided by the OpenAL sound library.

As the system is OST, the calibration process is much more complicated than in a VST system because the human subject is an inseparable part of the eye-display system. Several procedures of calibration for OST system have already been proposed, for example: [5] [11] [12]. Kato and Billinghurst proposed a calibration method for OST HMD based on marker tracking [10]. We have adapted it for the calibration of the OST HMD used.

The third version of the system uses the same four VRML models as the first system used. We have three different spiders and one cockroach. For each type of animal, three models have been created; a non-moving, a moving and a dead animal. To obtain as real a result as possible the moving cockroach is animated with moving legs and moving tentacles, and the spiders move their legs.

When the animals are killed the system produces a sound similar to that of a real animal being killed. The system includes two sounds: a squirting sound similar to the

sound of a real can of insecticide; and a squishing sound similar to that of a real cockroach or spider being crushed.

2.3 Description of the System

The system uses an OST HMD with an infrared camera to capture the scene. The video of the infrared camera is treated by the system and using ARToolKit is possible to establish the position and orientation of the IR camera respect to the marker. After this step, the system draws animals in the right place.

The system loads a calibration file. The calibration process has to be realized before running the system. This process was realized and a default calibration file was created. The system loads this file and normally works properly, but for better results this process should be realized for each user (differences in visual perception among users).

The functionality of the system is the same as the VST AR system [2]. Therefore, in this paper we only comment on its functionalities briefly.

- The user can select the number of animals to appear:
    - one animal
    - increase/reduce in three animals
    - increase/reduce in 20 animals
- The animal/s can increase/reduce its/their size
- The animals can move or stop
- It is possible to kill animals using two different elements. When this occurs the system plays a sound related to the tool used and one or more dead animals appear.
- If the spider system is used, it is possible to choose among three types of spiders.

3   Study

To check whether the OST AR system is more or less effective than the optical see-through AR system, we have carried out an experiment comparing both systems. In this paper we focus on the anxiety level of participants during the experiment.

3.1 Participants

In total, 23 subjects took part in the experiments: 11 men and 12 women.

The interval of age lies between 20 and 44. Mean age of the subjects is 31.2 years.

Participants were divided into two groups: low fear subjects, with fear score equal or less than 50 (13 people) and more fear subjects, with fear score more than 50 (10 people).

Participants were counterbalanced and assigned to one of two conditions: a) Participant first used the VST AR system and later the OST AR system, b) Participant first used the OST AR system and later VST AR system. Therefore, four different groups have been defined:

G1 - Participants with low fear (LF) use first the OST AR system.
G2 - Participants with low fear use first the VST AR system
G3 - Participants with more fear (MF) use first the OST AR system.
G4 - Participants with more fear use first the VST AR system

4 participants were not asked for the anxiety level during the experiment. As a result, the participants that answered for the anxiety level in the four groups were:

1. 5 people
2. 7 people
3. 3 people
4. 4 people

We have to highlight that the anxiety level was only asked the first time the participant used one of the systems. That is, if a participant used first the OST AR system, he/she was asked for the anxiety during this experiment and he/she would not be asked for the anxiety when he/she would use later the VST AR system.

3.2 Measures

We have used several common testing tools, which we adapted to our AR system. In this paper we only cite measures related with the results presented here.

- *Fear and avoidance scales.* These scales were adapted from Szymanski and O'Donohue questionnaire [13]. Participants rate the level of fear/avoidance on a 0-10 scale.
- *Subjective units of discomfort scale (SUDS).* Following [14], we asked the participant to rate her maximum level of anxiety on a 0 to 10 scale (0=no anxiety, 10=high anxiety).
- *Consent form:* The participant read and signed a consent form accepting the treatment that he/she was going to receive, allowing us to videotape the sessions, and allowing us to use his/her data in our research.

3.3 Study

First, participants filled out the fear and avoidance questionnaire for cockroaches and spiders. If the score was higher for cockroaches, this was the animal that would be shown during the experiment, otherwise, spiders would be shown.

The higher score is also used for assigning participants to the group with less fear (<=50) or to the group with more fear (>50). After that, participant was assigned to one of the two groups of systems (use first the OST or the VST). This assignation was done in order to counterbalance the experiment.

Before using one of the two systems, a narrative was introduced so that the experience had more sense and interest to them. Then, the first exposure session began. During this first exposure session, participants were asked about their current level of fear. They were asked three times: at the beginning of the session, when animals crossed his/her hand and at the end of the session. In order to measure the anxiety, we used SUDs; as it has been commented, the scale used ranges from 0 to 10, whereby 0 is the minimum fear level and 10 the maximum fear level.

4   Results

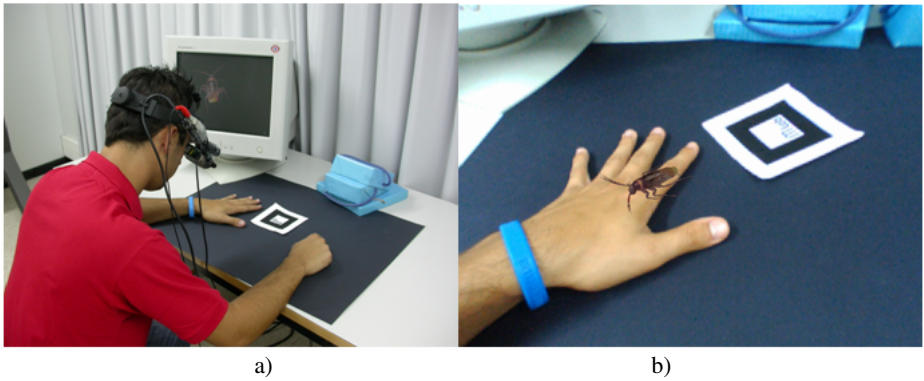Examples of a participant using the OST AR system are shown in Fig. 2-4.

Fig. 2. Participant lets a cockroach approach and cross over his hand. a) Participant b) Participant's view.
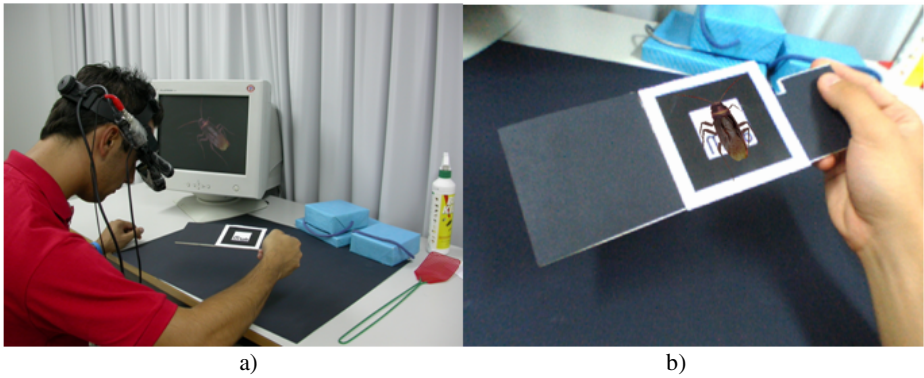

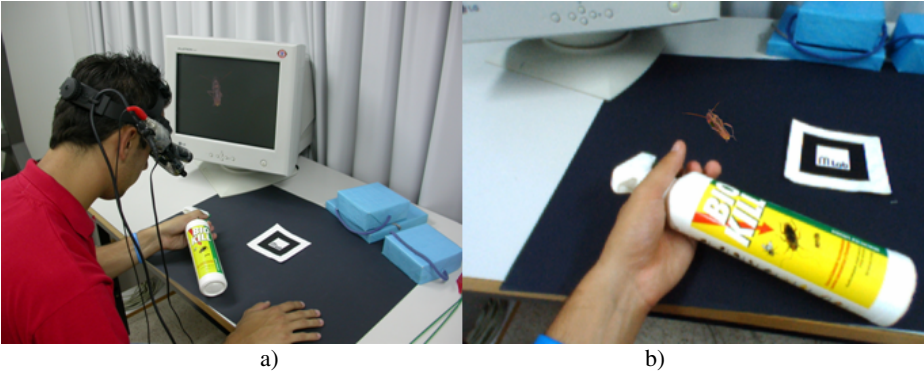**Fig. 3.** Participant looking closely at the animal. a) Participant b) Participant's view.

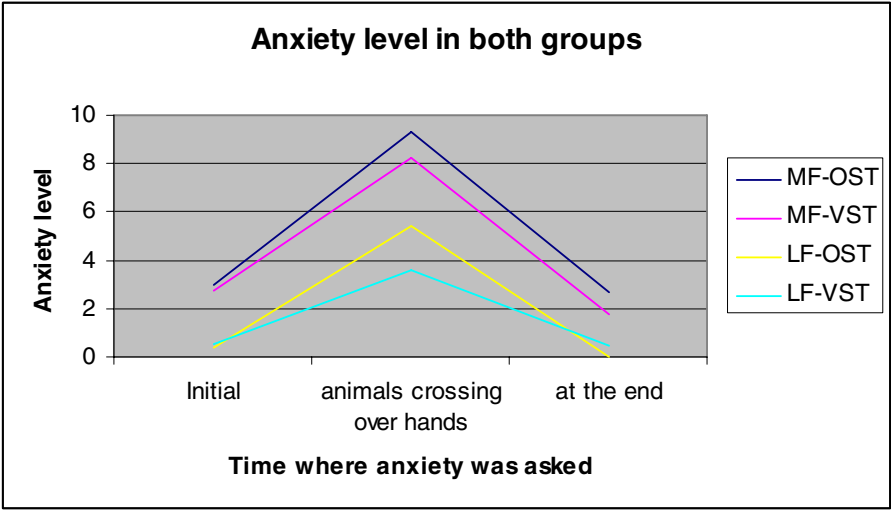**Fig. 4.** Participant killing a cockroach. a) Participant b) Participant's view.

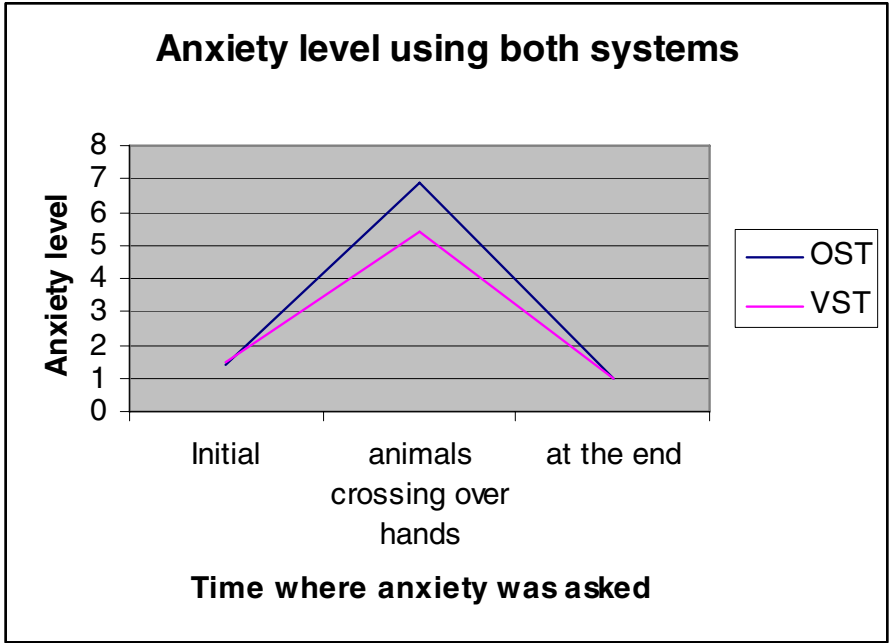**Fig. 5.** Mean Anxiety Level in both groups

Fig. 6. Mean Anxiety Level using both systems

The means of the anxiety level of the four groups described in section 3.1 during the exposure sessions are presented in Fig. 5. We also have grouped participants by

the system used and not by the fear score, that is, G1+G3 and G2+G4. These means are presented in Fig. 6.

Fig. 5 shows that both systems provoke more anxiety in participants with more fear, but they also provoke anxiety in patients with less fear.

Fig. 6 shows that the OST system provokes more anxiety than the VST.

5   Conclusions

Following with our research in AR systems applied to the treatment of psychological problems and especially to phobias, we have presented a third version of our AR system for the treatment of phobia to small animals. AR has already proved that is effective for reducing fear and avoidance in patients' suffering from this type of phobia [2] [3]. But we would like to develop the best AR system for this type of phobia and this is why we are working on the development of different AR systems. In this paper, apart from presenting our OST AR system, we have presented results comparing it with the VST AR system. Results show that both systems provoke anxiety in participants even if they do not have fear to cockroaches/spiders. OST AR system provokes slightly more anxiety than the VST AR system.

The study's main shortcoming is the small sample size. We need to study both systems with larger samples.

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