A Markerless Augmented Reality System for the treatment of phobia to small animals

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Abstract

Augmented Reality has proved to be effective in the treatment of phobia to small animals. The first system developed for this purpose uses visible markers for tracking. In this paper, we present a second version of this system, where the markers are not visible to the user. We use ARToolKit for tracking. The system incorporates two cameras: one colour camera for capturing the real world without visible markers and one infrared camera for capturing the real world whereby it is possible to distinguish markers drawn with a special ink. We are carrying out a study to compare the sense of presence and reality judgment in non clinical populations using both systems.

Keywords--- **Augmented Reality, invisible markers, phobia to small animals, virtual therapy**

1. Introduction

People who suffer from arachnophobia or other types of phobia to small animals become anxious when they are in a situation where these animals can appear. They suffer an unrealistic and excessive fear that makes life miserable. They are always frightened of seeing the animal they fear. Until now these phobias have been treated using exposure therapy and Virtual Reality (VR). Carlin et al. [1] used immersive Virtual Reality for exposure therapy. The first experiment was carried out at the U.W. Human Interface Technology laboratory (HITLab) (www.hitl.washington.edu/projects/exposure). The first patient treated with this system needed 12 VR therapy sessions of one hour. First, she started at completely the other end of the virtual world from the virtual spider. Slowly, she got a little closer. In later sessions, after she had lost some of her fear of spiders, she was sometimes encouraged to pick up the virtual spider and/or web with her cyberhand and place it in positions that were most anxiety provoking. Other times, the experimenter controlled the spider's movements. Some virtual spiders were placed in a cupboard with a spiderweb. Other virtual spiders climbed or dropped from their thread from the ceiling to the virtual kitchen floor. Eventually, after getting used to them, she could tolerate holding and picking up the virtual spiders without panicking. She could also pull the spider's legs off.

Renaud et al. [2] compared tracking behaviour with a virtual spider and a neutral target in fearful and non-fearful subjects.

Garcia et al. [3] explored whether VR exposure therapy was effective in the treatment of spider phobia. They compared a VR treatment condition vs. a waiting list condition (participants waiting for treatment, but without treatment) in a between group design with 23 participants. Participants in the VR treatment group received an average of four one-hour exposure therapy sessions. VR exposure was effective in treating spider phobia compared to a control condition as measured with a “fear of spiders questionnaire”, a behavioural avoidance test, and severity ratings made by the clinician and an independent assessor. 83% of patients in the VR treatment group showed clinically significant improvement compared with 0% in the waiting list group, and no patients dropped out.

Botella et al. [4] presented a telepsychology system that uses VR to treat the phobia to small animals (cockroaches, spiders and rats). Patients follow the treatment in their own house. In this system, a typical kitchen was modelled. The system had different levels at which one or more small animals could appear. The animals randomly appeared when the user opened a door of a cupboard. It was possible to kill the animals and dispose of them in a dustbin.

Juan et al. [5] and Botella et al. [6] used a visible marker Augmented Reality system for treating 10 real patients with phobia to cockroaches and spiders. These treatments reduced the fear and avoidance of the feared animal in only one hour-long session [7]. This system uses a visible marker (a white square with a black border containing symbols or letters) to determine the position and orientation of where the animal has to appear. Although that system has proven its effectiveness, in this paper we present a second version of the system that uses invisible markers. Why is it important that the marker appears or not? One of the steps of our protocol to treat patients with phobias is that patients have to search for the feared animal in the same way they would do in their house. In our case, to simulate this search we use three boxes, under one of which a marker is randomly placed. This is where the animals will appear. When the patient first sees part of the marker, the system still does not show the animals, but the patient knows they will appear. If the marker is not visible, the patient does not know that the animals are going to appear and when they appear they will produce the desired surprise. This is the main reason why we have developed this second version of the system. Our hypothesis is that markerless systems could increase the sense of presence and reality judgment. We are carrying out a study to confirm this.

The paper is organized into four sections. Section two gives an overview of the system. Section three presents some results and in section four we include some conclusions.

2. Markerless Augmented Reality System for the treatment of phobia to small animals

2.1. Hardware

The hardware components and their characteristics are:

- An infrared (IR) camera, IR bullet camera with 715 nm IR filter. The IR bullet camera 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.
- A colour, Dragonfly camera. The dimensions of the Dragonfly camera are 63.5x50.8 mm. This type of camera has a Sony 1/3" progressive scan CCD sensor, which delivers uncompressed 24-bit true colour images at a resolution of 640x480, with a maximum frame rate of 30 fps. The computer connection consists of a 6-pin IEEE-1394 interface. Camera parameters, such as white balance and exposure time, can be changed through image acquisition software, giving it a horizontal field of view (FOV) of 42.2 degrees, and a vertical FOV of 32 degrees. This corresponds to a diagonal FOV of 52 degrees.
- A Cy-visor HMD. The Cy-visor HMD is a closed headset, which integrates two SVGA 800x600 micro displays that have a diagonal FOV of 31 degrees. It supports several video input modes, but can also be configured to display the output of a computer monitor. The distance between both microdisplays can be changed manually.

All the above-mentioned components are shown together in Figure 1.

In order to draw the invisible marker we have used a special ink. We also considered powder, but it was discarded because it needs an external light source. Both have a finite durability. This implies that markers have to be drawn every week. The ink we have used is invisible to ultraviolet light and the human eye. Ultraviolet light is below 400 nm. The human eye can see light between 400 nm and 750 nm. The ink emits 840 nm frequency light and has a 793 nm absorption frequency, which lies in the infrared range. There exist three classifications for infrared light: near-IR, mid-IR and far-IR. This classification is based on ascending light frequencies. The ink falls in the near-IR spectrum, 750 nm to 3000 nm. The ink itself is delivered in the form of an ink pen (IR1PenSM). The tip of the pen is fluorescent green to the human eye. The ink is influenced by ultraviolet light. Anything written on white paper can not be seen by the human eye but, when viewed with a modified camera with infrared functionality, the ink becomes visible. An external light source is not required.

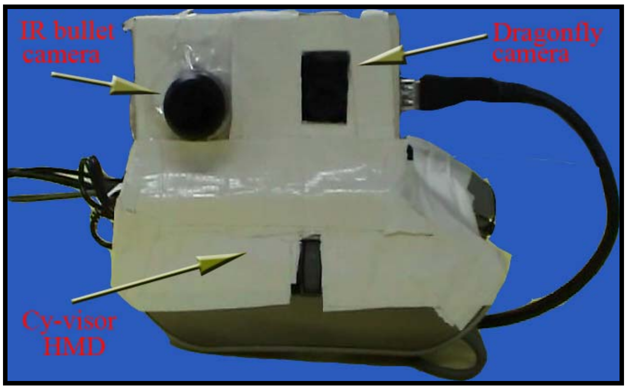

Figure 1. Capture and visualization system (Dragonfly camera, Infrared camera and the HMD)

a) b)

Figure 2. VRML models of: a) the static cockroach b) model of the medium spider

2.2. Software

We programmed the system using Microsoft Visual Studio C++ version 6.0 as the development environment. We used ARToolKit [8] version 2.65 [9] with Virtual Reality Modeling Language (VRML) support to incorporate AR options. The three-dimensional models of the virtual elements were constructed using Autodesk 3D Studio Max, version 5.0. These models were exported to VRML format and edited with VRMLPad, version 1.2. Textures were created in Adobe Photoshop, version 7.0. 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.

The second 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. In Figure 2.a) the resulting model of a static cockroach is shown, after the texture has been applied. The model of the medium spider is shown in Figure 2.b).

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 a video see-through HMD with one colour camera and one infrared camera to view a scene concurrently. It is not possible to detect markers in images captured by the colour camera but it is in images of the infrared camera. The video of the infrared camera is treated by the system and using ARToolKit it is possible to establish the position and orientation of the infrared camera with respect to the marker. As the relationship between the infrared camera and the colour camera is known, it is possible to determine the position and orientation of the invisible marker in the video of the colour camera. In this way, the virtual element is superimposed over the place where the invisible marker is situated. As a result, the user sees a scene where no marker exists, but the virtual element appears in the right position and orientation. The resulting image is finally shown on the microdisplays of the HMD. Figure 3 shows the set up of the system and the place where tests are being carried out.

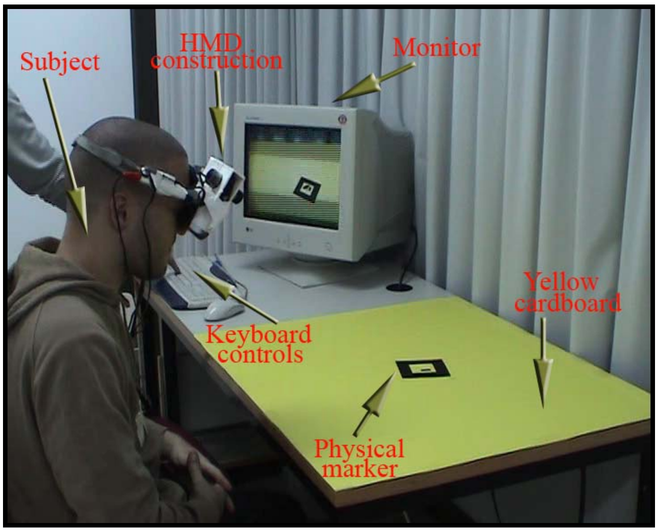

Figure 3. Set up of the system and the place where tests are being carried out

The functionality of the system is the same as the marker system [5]. 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. Results

In this section, several images of the marker and markerless systems running are shown. Figure 4 shows two similar situations. In Figure 4.a) the user is using the markerless system. Figure 4.b) shows the view of the user that appears in Figure 4.a). Figure 4.c) shows a similar image, but in this case, the user is using the marker system. If Figures 4.b) and 4.c) are compared, we consider that Figure 4.b) is more natural than Figure 4.c).

We believe that the markerless system could be even more effective than the marker system, but 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.

The study is still in progress and at the moment it includes participants recruited by advertisements in the University campus, all of whom are students, scholars or employees at the Technical University of Valencia (age range from 21 to 40). All participants fill out the fear and avoidance to cockroaches and spiders questionnaires (adapted from Szymanski and O'Donohue questionnaire [10]). Participants are divided into two groups. The first group uses the marker system first and then the markerless system. The second group uses the markerless system first and then the marker system.

In order to check the sense of presence that participants experience using both systems, they fill out a questionnaire adapted from the Slater et al. questionnaire [11]. For checking the reality judgment that participants experience using both systems, they fill out a questionnaire adapted from the Reality Judgment and Presence questionnaire of Baños et al. [12].

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

4. Conclusions

We have presented the first Markerless Augmented Reality system for the treatment of phobia to small animals. We believe this technique will be suitable for any Augmented Reality System where it is important that users do not see the marker and thus do not know where the virtual elements will appear.

Our next project is to use it to treat real patients. The marker version has been used to treat one patient with phobia to cockroaches [6], five patients with phobia to cockroaches and four with phobia to spiders [5]. In all cases, patients reduced their fear and avoidance of the feared animal in only one session [7] of treatment using the visible marker Augmented Reality system. Moreover, all of them were able to kill the real animal after the treatment.

Before the treatment none of them were able to approach or interact with the live animal without fear.

We are now carrying out a study comparing our Augmented Reality system with markers with the system presented here. While we finish our study, we can say that participants that have tested the system seem to have greater sense of presence and reality judgment with the markerless system than they experience using the marker system. The study is still in progress and we will be able to present our final conclusions once it is finished.

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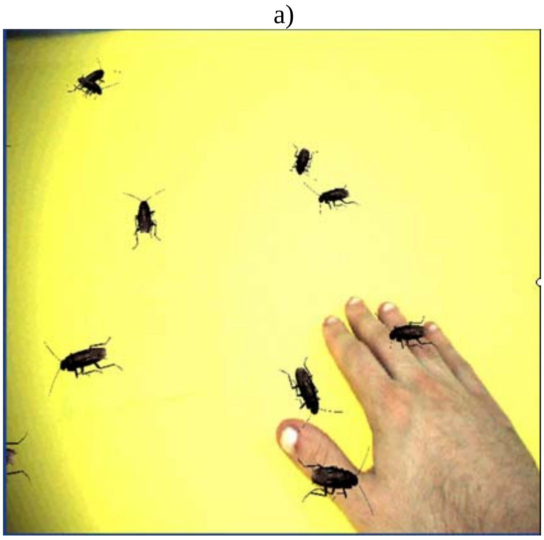
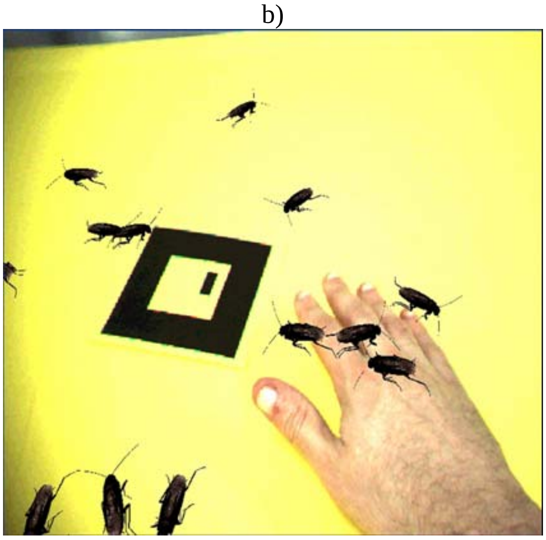
a)



b)



c)

Figure 4. a) User using the system. b) User using the markerless system. c) View of the user using the marker system.