

An Augmented Reality system for the treatment of acrophobia

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Abstract

This paper presents the technical characteristics of the first prototype that uses Augmented Reality to treat acrophobia. The immersive photographs are the virtual elements that represent the locations that the user fears. A total of 36 different immersive photographs have been included in the system (12 different locations with 3 parallel photographs in each location). At first, the system shows the central photograph. If the user rotates his/her head and stays in the same position, he/she can spin over the immersive photograph, changing his/her point of view inside the photograph. If he/she moves to the left/right (i.e. the physical position) the photograph will change and the related left/right photo will appear.

Keywords--- Acrophobia, Augmented Reality, immersive photographs, virtual therapy

1. Introduction

In an Augmented Reality (AR) system, users see an image made up of a real image and virtual elements that are superimposed over it. The most important aspect in AR is that the virtual elements add relevant and helpful information to the real scene. AR can be a successful tool in many fields as it can be applied to any field where the information superimposed on the real world can help the user.

This article presents an AR system for the treatment of acrophobia. This is the first system that uses AR to treat this type of phobia, but it is not the first system that treats acrophobia using Virtual Reality (VR) [1]-[5].

VR is currently a very useful tool for the treatment of several psychological problems (fear of flying, agoraphobia, claustrophobia, eating disorders, etc.). The number of studies showing the efficacy of VR environments as therapeutic tools has increased in the last few years.

AR and VR share some advantages with respect to traditional treatments. However, AR also presents advantages with respect to VR. In the specific case of acrophobia, creating different locations of high quality is extremely costly. VR applications could include avatars that simulate patients' bodies, however they cannot see their own feet, hands, etc. as can be seen in AR.

Our group has recently presented an AR system for treating phobias to small animals (cockroaches and spiders) [6]. In our work, we have demonstrated that, with a single one-hour session, patients significantly reduced their fear and avoidance. The system was tested on eleven patients. Given that this first application has proved to be effective, we believe that AR will be also effective with acrophobia.

1.1. Immersive photography

Immersive photography is a technique wherein the entirety of a space is captured from a single point and digitally processed to create a 360-degree photograph. When an immersive photograph is viewed, it appears to be a standard two dimensional photograph, but when manipulated by the user, it spins 360-degrees in any direction. This allows a user to look around a terrace, for example, in any direction that he/she chooses. He/she can look at the view out the balustrade, the hammock to the right, or the sky over him/her. He/she can even turn all the way around and look at all the details.

Immersive photography was widely developed during the 1990s [7] [8]. There are panoramic visualization systems like QuickTime VR [7] or Surround Video [9]. These systems are based on 360° cylindrical panoramic static images.

Immersive photography has been used to create VR environments, but it has not been included in an AR system. For example, Videalab Research group (videalab.udc.es) has used immersive photography in several VR projects.

1.2. Acrophobia

According to the DSM-IV [10], specific phobias consist of the persistent fear of a circumscribed stimulus and consequent avoidance of that stimulus, where the person having this fear knows it is excessive or unreasonable. The phobia interferes significantly with daily life. Acrophobia is an intense fear of heights. A person who suffers from acrophobia tries to avoid: balconies, terraces, lifts, skyscrapers, bridges, planes, etc. People who suffer from acrophobia are fearful in any situation that implies heights; they even become anxious when other people are in those situations. The greatest fear is falling.

The incidence of acrophobia ranges from 2% to 5% of the general population; twice as many women as men suffer from this fear. Acrophobia usually has an early onset and is usually associated to having an aversive experience in a high place. It can also be indirectly acquired, by receiving information about distressing experiences related to closed spaces or by seeing someone having such a distressing experience.

The first treatments for acrophobia were graded exposures in-vivo. In these treatments, the avoidance behaviour is broken by exposing the patient to a hierarchy

of stimuli. After a time, habituation occurs and the fear gradually diminishes.

The first VR system used to treat acrophobia was tested on 32 patients and had offered a 90-percent success rate [1]. Later, other VR systems have shown that VR is effective in the treatment of acrophobia, for example [2][3]. Several experiences comparing the effectiveness of VR with exposure in vivo have also been presented, two of these are [4][5]. These experiences have shown that VR exposure is as effective as in vivo exposure.

2. Material

2.1. Hardware

There are two types of hardware components: the hardware needed to run the system, and the hardware needed to obtain the immersive photographs. Immersive photographs were taken using a digital colour Coolpix 4500 Nikon Camera and the FC-E8 Fisheye converter. The system can run on a typical PC, without any special requirements. The real world is captured using a USB camera. We used Logitech QuickCam Pro 4000. The AR image is shown in a HMD and on a monitor. Thus, the therapist has the same visualization as the patient. We used 5DT HMD (5DT Inc., 800 H x 600 V, High 40° FOV). The camera was attached to the HMD so that it focuses wherever the patient looks. The system must also know the position of the patient's head in order to spin the immersive photograph in according with the patient's head movements. We have used the intertrax2 tracker to detect the patient's head rotation. We have also attached the tracker to the HMD.

2.2. Development tool

The application was developed using Brainstorm eStudio (www.brainstorm.es). Brainstorm eStudio is an Advanced, Multiplatform Real Time 3D Graphics presentation tool.

We have included ARToolKit [11] into Brainstorm as a plugin which was programmed in C++. ARToolKit is an open source Library in C that allows programmers to easily develop AR applications. It was developed at Washington University by Kato and Billinghurst. The required elements of 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 over these markers.

By including ARToolKit possibilities into Brainstorm eStudio, we have AR options in a 3D graphic presentation tool, which offers many advantages. ARToolKit recognizes the markers and obtains the position and orientation where virtual 3D objects must be placed. Brainstorm eStudio uses this information to draw the virtual 3D objects. This plugin can work with more than one marker. The position and orientation of each marker is assigned to as many different 3D objects in Brainstorm eStudio as needed. The plugin is loaded as a dynamic library (dll) in execution time.

3. AR system for acrophobia

The system allows the therapist to perform a graded AR exposure. The patient starts with the minimum height, in case of our study a first floor. The therapist can change to the next height when the patient is prepared to do so. The maximum height is a 15th floor. Twelve different places have been included.

The patient is treated in a room with a balustrade and five markers on the floor. The markers are located in front of the balustrade. At first, the patient is placed next to the balustrade and in front of the central marker. If the patient rotates his/her head and stays in the same position, he/she can see the corresponding part of the immersive photograph. The patient has the same sensation/visualization as if he/she were rotating his/her head in the real location. If the patient moves to the left/right (the physical position) the photograph changes, and the related left/right photo appears. This process is shown in Figure 1.

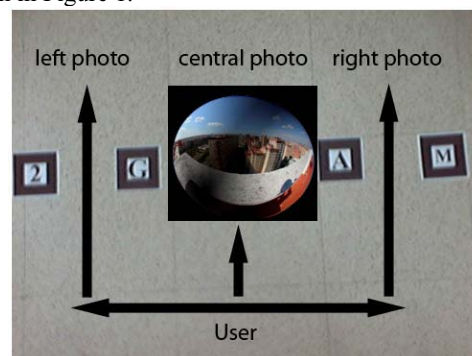


Figure 1 Possible movements of the user

The development of the system can be divided into two main steps:

- The creation of the immersive photographs
- The development of the application

3.1. The creation of the immersive photographs

The steps that were followed to create a 360-degree photograph that is suitable to be mapped as texture in Brainstorm eStudio were:

1. To take a 180-degree photograph
2. To retouch the photograph
3. To create a 360-degree photograph
4. To assign a transparency to the 180-degree white image

1. Taking a 180-degree photograph

We used the digital colour camera and the fisheye converter mentioned in section 2.1. The digital camera together with the Fisheye converter cover a field of view of over 180 degrees and is capable of capturing a full spherical panorama.

We took photographs of twelve different locations. In each location, we took three parallel photographs. The process was the following: The photographer was located next to the balustrade if there was one, or as closer as

possible to the edge. The photographer took a photo and moved one meter towards his/her right, maintaining his/her parallel position with respect to the edge of the location. Then he/she took another photograph and repeated the process. Once this was done, there were three parallel immersive photographs that were one meter apart. Figure 2 shows this process.

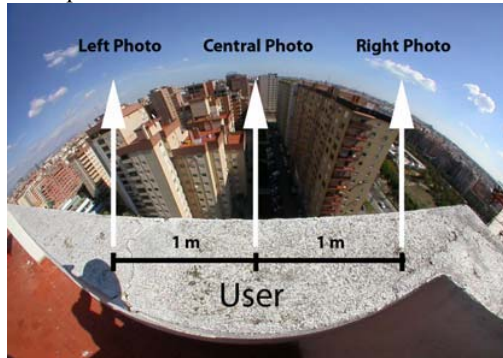


Figure 2 Process of taking 3 immersive photographs

2. Retouching the photograph

The photographs were retouched using Adobe Photoshop. In this step, undesirable information was removed from the image (for example, the feet of the photographer).

3. Creatint a 360-degree photograph

As the photograph is 180 degrees, a new 360-degree image must be created. In our system, we created a 360-degree image by sewing the 180-degree photograph and a transparent 180-degree image. We used PTStitcher to achieve this goal. This program belongs to the software Panorama Tools of Helmut Dersch (fh-furtwangen.de/~dersch). Figure 3 shows an image of this process.

4. Assigning a transparency to the 180-degree white image

Brainstorm eStudio uses the 360-degree image as texture. The 180-degree white image must be converted into a transparent image, otherwise the white 180-degree image would cover the user's position and he/she would not see his/her body. The system maps this new image as a 360-degree texture. This process was performed using Adobe Photoshop.

3.2. Characteristics of the system

As mentioned above, Brainstorm eStudio is the tool we used to develop our system. The plugin of ARToolKit included in Brainstorm eStudio is used to deal with the AR part of the system.

The system includes 12 different locations/levels. These locations were chosen by expert psychologists. We attempted to select typical locations that a therapist uses in the treatment of acrophobia. The locations are the following:

- Images taken from a window of a building located on the first floor, the second floor, the third floor, the fourth floor, the fifth floor and the fifteenth floor.

- Interior of a University. View of the stairwell from the second and third floors.
- View of a dam: both sides.
- Images taken from a terrace located on the second floor and third floors.

At first, the system shows the first level (the minimum height). Changing from one level to the next can be done using the option menu or control keys. The system uses five different markers that ARToolKit recognizes. If the camera focuses on the central marker, the system shows the central photograph of the selected level on this central marker. If the camera is focuses to the left of this central marker (left markers), the system will show the left photograph of the selected level. The same occurs for the right photograph. The immersive photograph is mapped as a spherical texture on a sphere. The appropriate image of this sphere is determined by the orientation of the user (information given by intertrax2 tracker) and is shown over the marker. Therefore, the marker focussed that is focussed by the camera determines the immersive photograph that must be shown at the selected level. The part of this photograph to be shown is determined by the intertrax2 tracker. Figure 4 shows the initial position and orientation of the user with respect to the sphere. If the user rotates his/her head, 90 degrees (up) or -90 degrees (down), the user will visualize part of the immersive photograph. If the user rotates his/her head, more than 90 degrees (up) or less than -90 degrees (down), the user will visualize part of the immersive photograph and part of the image taken by the USB camera (real image).

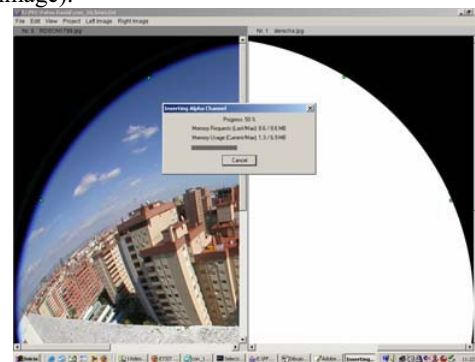


Figure 3 Creation of a 360-degree image using PTStitcher

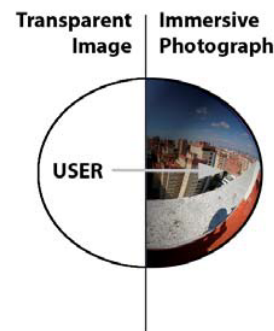


Figure 4 View of the user inside the 360-degree sphere

4. Visual examples

In this section, we include two examples captured during the execution of the system. We are currently testing the system with patients suffering from acrophobia.

Figure 5 shows an example taken during the execution of the application with an immersive photograph of a dam. In this figure, the virtual elements are the mapped images (immersive photographs), and the real images are the floor of the room and the feet of the person that is using the system. Figure 5.a) shows a view of the immersive photograph where the user is totally inside the 180 degrees of the immersive photograph. Figure 5.b) shows a view of the immersive photograph where the user is partly inside the 180 degrees of the immersive photograph and partly inside the 180 degrees of the transparent image. Figure 5.a) alone does not indicate that the image has been captured from an AR system; however, Figure 5.b) clearly indicates that it is an AR application.

5. Conclusions

AR and VR share advantages with respect to exposure in vivo. One of these advantages is that both realities offer control over the feared situations. Our AR system has one great advantage over VR. It offers more versatility than VR. With immersive photographs, the system can create on demand as many environments as the therapist desires with a high level of realism (the photograph is real) at a very low cost.

We have developed an AR system to treat acrophobia and we have added immersive photographs as virtual elements. This is the first prototype that uses AR to treat acrophobia and it is also the first time immersive photographs are included in a system like this. We are currently testing the system with patients suffering from acrophobia.

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a)



b)

Figure 5 Examples. View of a dam. a) The user is inside of the immersive photograph b) The user is partly inside and partly outside of the immersive photograph