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VR TESTBED CONFIGURATION FOR PHOBIA TREATMENT RESEARCH

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ABSTRACT

Previous research has shown that Virtual Reality can be used for treatment of phobias. To further investigate these and other types of VR applications a testbed is needed that is both effective in phobia treatment and easy to adapt. This effectiveness is in general associated with the sense of presence experienced in a VR. Presence depends in part on characteristics of the VE, such as interactivity and vividness. This paper describes the requirements for such a testbed and a possible hardware and software configuration that meets those requirements.

INTRODUCTION

Multimedia has become an important aspect in research concerning user interfaces and human computer interaction in general. Multimedia is not only associated with stimulating several of the user's senses simultaneously, but also with enabling the user to interact with the computer system in a natural way. Multimedia enhances traditional text-only computer interfaces and yields measurable benefit by gaining and holding attention and interest; multimedia improves information retention and, when properly woven, multimedia can be very entertaining. (Vaughan, 1998)

Virtual Reality (VR) is a special kind of multimedia. In immersive VR, several senses are stimulated almost exclusively by the computer; stimuli from the real world are shut out. Furthermore, the metaphor used for the human-computer interaction is that of everyday three-dimensional space. This metaphor should suit almost all humans, novices and experts alike, and enable users to interact in a way that is natural and fits their expectations because we humans have a lot of experience with interacting in and navigating through the three-dimensional real world.

VR offers several advantages over 'traditional' multimedia. VR can be said to exceed multimedia in its ability to hold the user's attention and interest. An interesting application that takes advantage of this is distracting burn patient from their pain during wound care (Hoffman et al, 2000). Most importantly however, VR is known for the fact that use of this technology can generate a sense of presence (Schuemie et al. 2001). This means that, up to a point, the user perceives the virtual world as the real one. The virtual world can evoke similar responses from the user as the real world, making it possible for instance to treat people for phobias in VR.

Previously we have shown that phobia treatment can be effective even with the cheapest VR setup (Schuemie et al, 2000). For further research in this area a more elaborate system is needed that can facilitate quick prototyping of new ideas.

This paper investigates the requirements for a testbed that can be used to develop VR systems for treatment of phobias and proposes a possible configuration, using cheap off-the-shelve components, to meet these requirements. The resulting hardware and software configuration is of a generic nature and can possibly also be used for other VR research.

REQUIREMENTS

Many VR-based testbed systems have been developed and reported on in the virtual environment research community (Davidson, 1997) However, systems for treating phobias have unique requirements, the most prominent one being that these systems must be effective in treating phobias. An aspect that is commonly associated with this effectiveness is the sense of presence that the system can evoke.

*Presence is a psychological state or subjective perception in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience. Except in the most extreme cases, the individual can indicate correctly that s/he is using the technology, but at *some level* and to *some degree*, her/his perceptions overlook that knowledge and objects, events, entities, and environments are perceived as if the technology was not involved in the experience (Lombard, 2000)*

There are many factors that can contribute to a sense of presence (Schuemie et al, 2001), some of which, such as psychological characteristics of the user, are not controllable by the designer of the system. On the other hand, there are several key attributes of the VR-system that can be modified by the designer. These factors can roughly be divided into the interactivity of the system and the vividness of the displays.

Interactivity

Interactivity refers to the amount of user-interaction supported by the system as well as the naturalness of this interaction. In general, VR systems offer at least one type of interaction: headtracking. By using a tracking device the orientation and often also the position of the Head-Mounted Display (HMD) is determined and used to change the viewpoint in the Virtual Environment (VE).
It is important that the system responds to the user input in a timely fashion. The delay between change in user input (e.g. turning one's head) and change in the system output (e.g. rotation of the viewpoint displayed in the HMD) is called the 'latency'. The delay becomes complete invisible to the user when the latency is lower than 20msec. Few systems are able to achieve this however. Fortunately, to maintain a sense of presence latency need not be that low, although a negative correlation has been found between presence and higher latency (Welch et al., 1996).

Vividness

Vividness refers to quality and fidelity of the displays. The quality and fidelity of the visual display is determined for instance by the resolution and contrast of the screen, as well as the Field of View (FoV) of the display and the pictorial realism of the scene.
One important feature of most VR systems is stereoscopy, where each eye receives an image from a slightly different viewpoint, taking into account the distance between our eyes. Stereoscopy is found to enhance the sense of presence, also adding to the perception of the world's apparent depth and volume (Hendrix & Barfield, 1996).

Other requirements

To be useful in research, a VR-system furthermore also needs to be easy to adapt. It should be possible to use different input and output devices and easily change the functionality of the system. The system should be easy to maintain and, because there is always a limited budget, not too expensive. An optimum has to be found in terms of price and performance.
An ideal case would be to use off-the-shelve components, limiting cost and maintenance problems, without losing flexibility.

HARDWARE SOLUTIONS

HMDs

Although many different display systems such as projection screens are available for VR-systems, HMDs are often preferred because of their lower costs and their ability to shut the user of from the real world. Unfortunately, development in stereoscopic HMDs appears to have been standing still for the last ten years. Many new monoscopic HMDs have come on the market, which are intended to be used as personal movie-theaters. However, hardly any new models have been introduced that enable stereoscopic viewing of virtual environments. The models that do exist have low resolutions or are very expensive.
To provide an indication: three models in the mid-price range are the Visette Pro (Cybermind), the V8 (Virtual Research) and the I-Glasses Protec (I-O Display Systems). All three provide the user with a resolution of approximately 640 by 480 pixels. Prices range from $4000 to $9000.

	H	V	Contrast
Visette Pro	60	46.8	200:1
Virtual Research V8	48	36	200:1
I-Glasses Protec	27	20	100:1

Table 1: Three HMDs with their Horizontal (H) and Vertical (V) Field of View and their Contrast Ratio

These HMDs all require two separate VGA inputs, one for each screen in the HMD. It is important to know that these VGA inputs need to be synchronized, i.e. that a new image for one input is send at exactly the same time as the images for the second output. Some HMDs, like the I-Glasses Protec, will fail to display anything if this requirement is not met. Others, like the Visette Pro, will show distortions in the images.

Trackers

Trackers enable the computer to track the orientation and often the location of an object like the HMD or an input device. This can be achieved using several different technologies. One way is by using gyroscopes and additionally inertial detectors that can measure changes in orientation and location without an external reference point. Other technologies do require an external device that can function as a reference point. Ultrasonic trackers use sound at ultra-high frequencies for determining location and orientation. These have the disadvantage that a direct line of sight must exist between the tracker and the sound sources. Magnetic trackers use a magnetic field and have no such limitations. However, in today's world there are many possible sources of electromagnetic interference such as computer-monitors or power lines, often making this method of tracking somewhat noisy. In general, magnetic trackers such as the Flock of Birds (Ascension) and the Fasttrack (Polhemus) are cheapest, making them the most popular choice.

Graphic cards

The pace of development in hardware 3D acceleration has been enormous these last couple of years. Not too long ago, this market was dominated by Silicon Graphics, which had it's own platform and operating system. However, development of 3D accelerators for games on the PC platform made these cheap graphic cards strong competitors for the expensive Silicon Graphics systems.
For stereoscopic HMDs two synchronized VGA outputs are required. This synchronization can not be achieved by using a single card with two outputs such as the Matrox G450 and its predecessor, the G400. If using these or standard 3D cards, a separate device could perform this synchronization afterwards, but these devices are expensive.
Another solution is using cards that have a synchronization option. The Intense 3D Pro 2200 cards (Intergraph) can be linked using a GenLock connector to synchronize the output, but they also are expensive when compared to equivalent cards without synchronization option and have special requirements of the mainboard that should be taken into consideration.
Using two separate cards poses another problem related to controlling these cards with the software. With a single card with two outputs, the width of the desktop is simply doubled and each half of this virtual screen is send to a different output. This is also a standard option for the Intergraph cards. Other cards require for instance the Dualscreen option of Windows98.

SOFTWARE SOLUTIONS

Two Application Programmers Interfaces (API) have emerged over the years: OpenGL was originally introduced by Silicon Graphics and remains to be used more for professional application. Direct3D was develop by Microsoft and is used mainly for games. Direct3D is only supported on the Windows 9x family and not on the WindowsNT platform.
Even though it is possible to write an application by directly using the OpenGL or Direct3D APIs, this can be a cumbersome process. Often a higher level library or tool is used.

Libraries

Libraries contain pieces of code that can be envoked with a single command. These libraries can hide the specific implementation of for instance communication with input and output devices. Even though commercial libraries are available such as World ToolKit (Sense8), many researchers develop their own. While this does provide the highest level of flexibility, it is obvious that this is a very time-consuming endeavor.

High level tools

To speed up the development process, high level tools are available. The tools offer a graphical user interface for designing the VE and its attributes.
Several of these tools are complete packages and include a tool for modeling the geometry of a world as well as its dynamics. One such tools that was very popular until recently is Superscape VRT. Unfortunately, Superscape stopped all development on this product. Other manufacturers offer similar products, such as DVise (Division), Vream (VReam) and WorldUp (Sense8). This last tool was developed based on the World ToolKit library.
Because there are already many professional 3D geometry modelers available such as 3D Studio MAX (Discreet) and LightWave (Newtek) this functionality is not incorporated into tools such as EON (Eon) and Virtools (Virtools). These tools offer the possibility to assemble objects designed in other packages and add the dynamic behavior to make the VE interactive.
The high level tools all use some kind of scripting language to control at least part of the dynamics of the VE. However, not all functionality can be supported by these crude languages. Some of these tools, like WorldUp, do allow calls to Dynamic Link Libraries (DLLs) which can be written in professional software development tools such as Borland Delphi and Microsoft Visual Basic. Through these libraries for instance network communication and database access can be implemented.

VE DESIGN

Designing a VE is no sinecure. Modeling the objects requires special care for the complexity of the geometry. When there are too many details in a VE this will slow the rendering down and create unacceptable latency. In VR, objects are made of flat polygons, because it is quicker to render these than curved surfaces. The amount of polygons in a VE should be limited. To give the impression of detail, textures can be applied to the surface of an object.
The advantage of today's hardware 3D acceleration is that these textures are almost 'for free' when it comes to processing time.
When the user will not be moving much in the VE the appearance of objects far away will not change. It is therefore not necessary to model these objects at all; they

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can be drawn on a background. For higher realism photos of real surroundings can be used, as shown in figure 1.

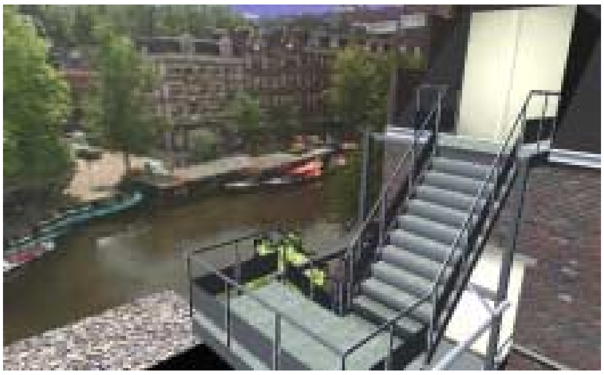

Figure 1: Fire-Stairs Scene Developed Using the Proposed Testbed. The Canal and Buildings in the Background are Photos Displayed in the VE

Several tools are available to merge the pictures into a seamless panorama, such as PhotoVista.

RESULT

Overview

The setup used in our laboratory for treatment of phobias consists of the following components: the Visette Pro HMD, an Ascension Flock of Birds tracker and a PC with two Intense 3D Pro 2200 cards that have been synchronized using a GenLock connector. A Logitech wireless trackball serves as input device for the patient.

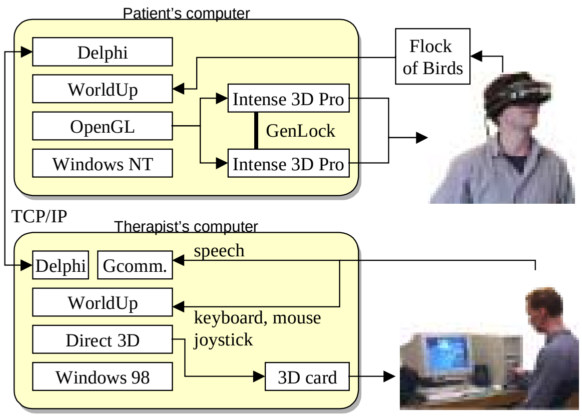

Figure 2: Overview of the Proposed Testbed, Showing How a Second Computer is Connected Using a Delphi DLL.

We use the WorldUp high level toolkit for modeling and displaying the VE and Delphi 5 (Borland) for creating DLLs that handle network communication and the graphical user interface for the therapist. Because both outputs of the first computer are completely dedicated to displaying the VE in the HMD, a second computer with a standard 3D card is used to control the VE over the network.
To support speech recognition, a tool called Game Commander (Game Commander) is used. This simple application, originally intended to be used for games, translates voice input into keyboard commands that are further handled by the WorldUp software.
The VEs used in the experiments consist of relatively few polygons, ranging from approximately 790 to 2000 per VE. Extensive use was made of textures and backgrounds.

Meeting requirements

One requirement concernes the effectiveness of the system in treating phobias. For this, the system should offer sufficient interactivity and vividness. In an extensive controlled experiment the only interactivity for the patient was the control of the viewpoint in the VE through the headtracking with a latency below 300ms. The vividness of the system was determined by the stereoscopic HMD with a resolution of about 640*480 pixels and a FoV of 60(h) by 46.8(v) degrees. The results showed that the effectiveness of treatment of fear of heights using the VR system is similar to the effectiveness of treatment in reality (Emmelkamp, Hulsbosch, Krijn, de Vries, Schuemie & van der Mast, 2001).
Other requirements concerned maintainability and flexibility. Because the system is built entirely by using off-the-shelve components, it is easy to maintain and adapt. WorldUp offers support for a wide variety of input and output devices. Furthermore, there is no need to use low level programming languages, all functionality can be programmed either by using the WorldUp software with it's high level scripting language or by using Borland Delphi, a high level programming environment. The VEs used for our research can be designed and constructed from scratch by an expert in less than three days work.

CONCLUSIONS

In this paper a configuration for a VR-system is described that can support a wide variety of research activities. The system is relatively cheap, costing around $16000 for a system with one computer, including all software. The most expensive parts are the HMD including the tracker at $9000 and the Intergraph 3D cards at around $2000. Hopefully prices of these will drop in the future.
Maintaining and expanding the system, such as creating a new VE or adding network support for a second computer is easy and can be done using high level tools, facilitating quick prototyping of new ideas while maintaining the high performance necessary for VR. This enable researchers to focus on the semantics of the system and not on the technical details.

In general, the attempt to construct a system meeting the requirements for VR research of, amongst others, phobia treatment is a success.

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