Chapter 8

Conclusions

8. Conclusions

A virtual environment produces quite benefit in many areas, nevertheless the construction of virtual environments is a complex work because it involves many tasks. This document focuses on different tasks involved in the construction of virtual environments, which were separated by modules.

- The first module was referent to the display of Virtual Environments on multiple screens. In this module frustum is an important term, a study about frustum was done and several scenarios were created to explain its behavior according to different conditions. Furthermore, a set of equations were presented, which were successfully validated in a system. An evaluation of usability was carried out, the results of this evaluation demonstrate that our system display coherent and continuous virtual worlds on coplanar and non-coplanar screens.

- The second module was focused on different distributions and configurations of a virtual environment. The study case was a CAVE because this environment is one of the most comprehensive. Four configurations and three alternatives were analyzed to reduce the physical requirements. The techniques reviewed were: "the technique of the mirror and the projector", "different ways of distributing the devices involved in the environment" and the rotation of some degree between the CAVE and the room walls. Analyzing the designs, the fourth has a considerable reduction of space with respect of the first attempt; it only uses the 28.48% of space used in the first design. The fourth design involved the three techniques. Finally the development of a system was carried out to validate the methodology shown in this section.

- The third module was referent to three contributions to stereoscopy- Three antique techniques were adapted and constructed with digital resources.
    - The design of a Cazes-type computer-based stereoscope was presented in this document, furthermore some equations to determine the size of four mirrors used in this stereoscope and a code to display correctly the stereo pair was shown. This stereoscope was evaluated and the results of the evaluation confirm that Cazes-type digital stereoscope shows 3D images in high quality. All users perceived depth during the evaluation, the majority of the users (90%) had no difficulty in merging both images.

    - Wheatstone-type digital stereoscope can be built in different sizes using monitors and projectors. The Wheatstone-type stereoscope was analyzed and it is considered as a new virtual environment due to the characteristics that it has. In this stereoscope the number of viewers depends on the environment size, furthermore, this stereoscope can be used in many applications for its size and its feasibility. This stereoscope was evaluated with excellent results; the users confirm that this stereoscope allows real-size, high-resolution images without difficulty to merge the stereo pair.

- In this work was also presented a boxed-type digital stereoscope, which was built with a monitor and special lens, the design of these lens is shown in this document, the stereoscope allow seeing small stereo pairs. This stereoscope is easy to build because only uses a computer. This design can be useful in stereoscopic tests and projects. Boxed-type digital stereoscope was also evaluated and the results of the evaluation indicate that this stereoscope produce a small 3D image in high quality.

All these three stereoscopes have some characteristics in common, they allow showing of high quality stereo virtual worlds, which can be static or in movement.

- We have also reviewed the different sound techniques and we decided to work with 3D sound because it behaves more realistically. We incorporated sound in four virtual worlds and shown the behavior of navigation when 3D sound is used. Upon combining a 3D virtual world, stereoscopy, multi-screen techniques, different input devices and 3D sound we could build dynamic and more complete virtual environments. The 3D sound was used in two ways:
  - As supplement to visual information through spatial information and spoken explanation
  - As a background sound in two galleries of art.

  On incorporating 3D sound in the virtual environments two problems were found and solved.
  - When different sound sources were placed in small virtual worlds interference and confusion between sounds was produced. The solution to this problem was to do an adjustment in the volume of the objects, limiting the maximum volume reached in the virtual world; the equation to adjust the volume was shown in this document.
  - The second problem was detected on incorporating 3D sound in the Wheatstone-type digital stereoscope, because it produces a laterally inverted virtual world, the solution was to invert the world beforehand so that it could be seen correctly and coincide with the sounds.

  The sound module was evaluated and the results demonstrate that 3D sound produces a better interaction, location, provides extra information and feedback

- In addition, we have incorporated a chapter that discusses three different ways to manipulate virtual environments, which include:
  - Use a remote control.
  - Use the viewer position and his orientation.
  - Use a Head-Tracker for navigating hands-free virtual worlds in a function of time.

  Every one of these manipulations is useful, and its use depends on the environment size.

- We had the idea of using a system which could be adaptable to different situations and that allowed for the construction of a great variety of virtual environments. We tested our contributions using this system. Furthermore, this project has been developed using one or two Laptops.

With the results produced in this project different configurations of environments can be done, some of them very simple and others more complex ones.

Finally, the contributions presented in this document will be the basis to begin doing research in the domain of Virtual Reality in the Universidad Autónoma de Tlaxcala, in the Bachelor and Master's program in Computer Engineering.

Future Work

Analysis and studies:

- This project cover 3D objects and sound, a future work could present an analysis of latency between 3D objects and sound.

- This project involves different devices; a future work could present a study of prediction algorithms to compensate the latency among the different devices.

- This project offers the building of virtual environment with multi-screen system, motion tracking technology and 3D sound. A future work could present the evaluation and effects of multimodal feedback on a set of tasks.

- To analyze the behavior of the Wheatstone-type digital stereoscope using the re-engineering according to (Kollin, et al., 2007) and (Kollin, et al., 2007-2).

Implementations:

- In this work, the objects of the virtual worlds are static; a future work could present the incorporation of algorithms that allow containing dynamic objects in the virtual worlds.

- Incorporation of the techniques of Artificial intelligence in new virtual worlds

- To include algorithms of collision in the navigation and between objects contained in the virtual worlds.

- Due to the fact this system was programmed on a client-server configuration, on some occasions there are problems of delay and synchronizing. A future work could present the incorporation of solutions to problems occasioned by the network.

- The development of formulae and systems to generate flexible designs and maps of virtual environment built with multiple screens.

- The implantation of mobile viewports, which allow improving the mobility in the Wheatstone-type digital stereoscope

- The sound effects produce a realistic experience and improve the location of audio sources. A future work could present the incorporation of different sound effect in this project.