Recording Video in the CAVE

Mohamed Mediouni

Abstract—Evaluating the performance of a simulator in the CAVE has to be confirmed by encouraging people to live the experience of virtual reality. In this paper, a detailed procedure of recording video is presented. Limitations of the experimental device are firstly exposed. Then, solutions for improving this idea are finally described.

Keywords—Virtual reality, CAVE, stereoscopic, camera.

I. INTRODUCTION

THE concept of virtual reality has been used since 1970 which covers many fields. Until now, the definition is not yet clearly specified. According to [1] virtual reality is a virtual world in which the person can live the experience of reality. This discipline is essentially based on three basic concepts: immersion, imagination, and interaction.
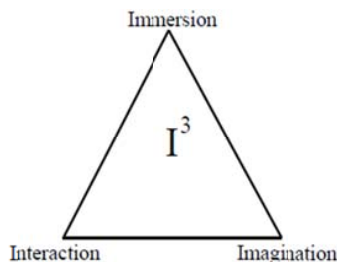

Fig. 1 The tree I

Immersion [2] is a psychological state that leads to a physical sensation. Immersion depends on the virtual environment and moral presence of the participant according to different stimuli. The interaction [3] is defined as an action or exchange between the user and the environment (subject, body, etc.). There are two types of interactions: sensory interactions (HMD, speakers, etc.) and motor interactions (joystick, mouse, etc.). Fig. 2 shows the relationship between the two instructors and the user in a virtual environment. The phenomenon of interaction is related to three main parts: navigation, selection and manipulation. The designers or the authors of science fiction need their imagination to create new immersion and interaction. In literature, there are many virtual environments such as a workbench [4] and HMD (Head Mounted Display) [5]. The use of the CAVE [6] is to overcome some limitations in terms of challenging applications and the immersion of the user. Inviting people to try the simulator in the CAVE is a difficult task. For that purpose, the recording in 3D simulation becomes a necessity. The article will be organized as follows: Section II will give

Mohamed mediouni is with Université de Sherbrooke, Quebec,Canada e-mail: mohamed.mediouni@Usherbrooke.ca).

an overview of the applications of the CAVE. In Section III, we will mention the notion of stereo and its categories. In Section IV, we will discuss about the problems of the recording video in the CAVE. In Section V, some solutions will be proposed to resolve the problem.
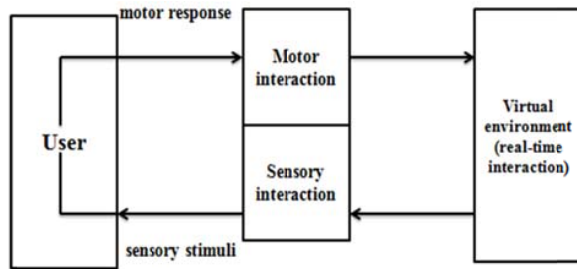

Fig. 2 The interaction between user and virtual environment

II. THE CAVE

The CAVE is the acronym of Cave Automatic Virtual Environment. It was developed by the Electronic Visualization Laboratory [7]. It's a virtual environment that is composed of four screens, four mirrors, and four projectors to display stereoscopic images. To see 3D objects, the user needs stereoscopic glasses. The user uses a joystick to interact with images. In literature, there are several types of CAVE with the same device configuration and operational information. There are many API (Application Programming Interface) for the CAVE such as CAVELib [8], IRIS Performer [9], and OpenGL [10]. The choice of these programming tools reflects the simplicity of the development.

Fig. 3 The CAVE

The CAVE plays a very important role for tourism because it provides to the user the opportunity to visit historic towns. The North Carolina State University uses the CAVE as a tool to study the interactions between molecules such as protein and drug. Therefore, the researchers have a system of 6

degrees of freedom called MRA to feel the force between two molecules [11].

Fig. 4 Interaction with molecules

Researchers of the NASA use terrestrial robot prototype to visualize movements, to track the path, to change directions, etc. It takes into account several factors such as obstacles, the speed, and the nature of the ground. They use the CAVE to test the remote space mission, i.e. simulate the communication gap between the earth and moon. The cosmic explorer remains an important research tool to understand the phenomenon of evolution of the universe. In the CAVE, each galaxy is represented by a colored dot (e.g. red for the Milky Way) [12]. In the industrial and commercial field, the VIRTUAL project of the University of Geneva aims to develop a virtual platform, including the steering wheel to test the performance of a vehicle [13]. Fig. 5 illustrates this phenomenon.

Fig. 5 Controlling a virtual car

III. The Stereo in the CAVE

Stereo [14] is an important concept in the virtual environment which can be classified into two categories: active or passive. A stereoscopic image is composed of two images, one for each eye. Using stereoscopic glasses, the user can merge two images and see the relief. The basis of the stereoscopic vision is the ability to calculate the disparity between two dimensional images to construct a three-dimensional perception. The images in the video are composed of complementary colors (red, green, blue). The figure shows some stereoscopic glasses used in a virtual environment.

In the case of an active stereo, left and right eye images are displayed alternately. When the projector displays the image of the right eye, the left eye shutter is closed and vice versa.
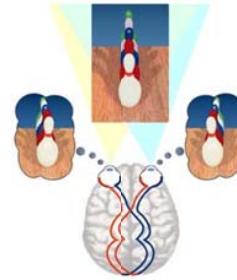

Fig. 6 Stereo vision

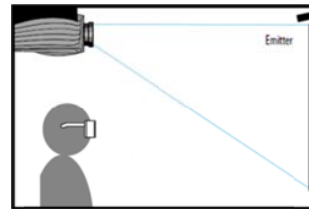Fig. 7 Stereoscopic glasses

Fig. 8 Active stereo

In the case of a passive stereo, left and right eye images are displayed concurrently by two projectors. A polarizing filter of each projector ensures that the information is correct.
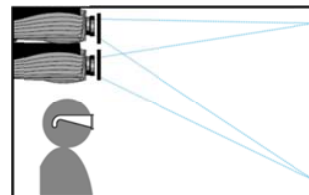

Fig. 9 Passive stereo

IV. Common Problem

On one hand, the display on the screens of the CAVE is stereoscopic (see Fig. 12). On the other hand the CAVE is single-user [15] that is to say; only one user can see and interact with 3D objects correctly. The user's position is computed with a tracking device. Fig. 11 shows that the field of view of each user is limited. However, the other viewers don't see the same 3D objects.

If the viewer's position was exchanged, the information shown would be wrong.
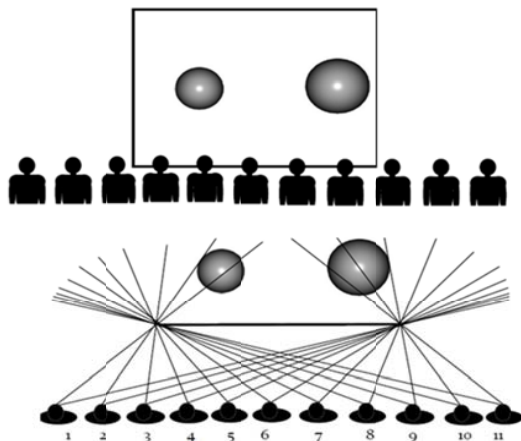
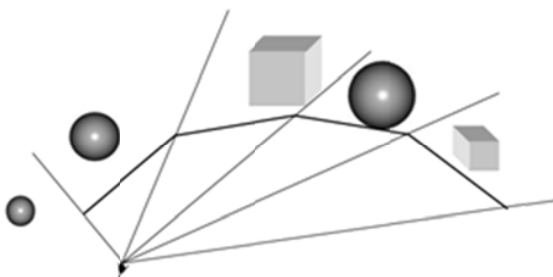Fig. 10 A 3D objects see from eleven person positions

Fig. 11 Incorrect computation of the user's position

Fig. 12 Stereoscopic image

V. SOLUTION

The obvious solution is the use of stereo video camera (with two lenses). The basic principle behind recording 3D objects is to capture and present two slightly different points of the viewer's visual system. The objective is to determine the stereoscopic depth. A stereo camera is composed of more than one lens, each with their own separate image sensor or frame. The right depth depends on three factors: foreground, background and zero parallax. To record a video in the CAVE, the user puts the polarizing glasses in front of the lenses while maintaining the orientation.

The non availability of this type of camera in the laboratory and the difficulty of installation limit this technology. The idea is to use a camera and find a solution for the two types of stereo: passive and active. With a camera, we have two choices: the user needs to put the tracker on the camera itself

or on a tripod. The cameraman can wear the tracker on his head as illustrated in the Fig. 14.

Fig. 13 Stereo camera: interaxial separation

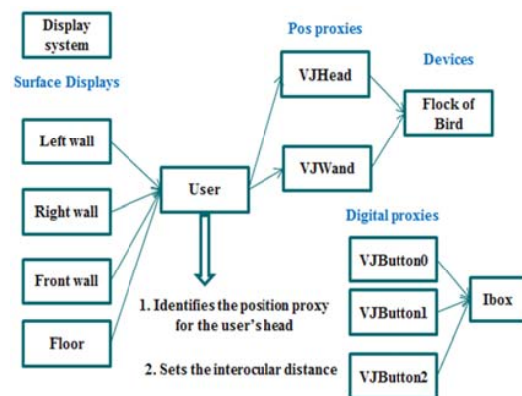Fig. 14 Recording video in the CAVE with a camera

Fig. 15 The user configuration

In the next step, the user can turn the stereo, e.g. turn off the interocular distance in the software used in the CAVE. In our case, the software used is VR-Juggler [16]. It is a flexible and dynamic middleware which has a specific configuration. Each element in the configuration properties and identified by name. VR-Juggler is very used in applications of virtual reality because it facilitates the transition of simulation from the desktop to the CAVE. Figure 15 explains the role of the interocular distance in the user's configuration. If the software will not support this modification, the user needs to record the video through the shutter glasses, which means the lens needs to be fairly small. The user cannot work due to synchronization issues between the camera and the glasses, but modifying the switching rate on the glasses might help the user who needs to experiment, assuming that the VR software

supports this type of modification.

VI. Conclusion

Recording video in the CAVE is not a trivial task. We need a background for technology and configuration of software. Thinking of solving the problems of recording a 3D video motivates researchers to go even further and treat other types of problems such as the interaction between the user and 3D objects.

Acknowledgment

The author would like to thank Tom Defanti for explaining some concepts of visualization in the CAVE.

References

[1] J. Tisseau. Réalité virtuelle - autonomie in virtuo -. ENIB laboratoire d'ingénierie informatique, Habilitation à Diriger des Recherches, 2001.
[2] M. Slater. Measuring presence: a response to the witmer and singer presence questionnaire. Presence: Teleoperators and Virtual Environments, 8:560–565, 1999.
[3] M. R. Mine, F. P. Brooks, and C. H. Sequin. Moving objects in space: exploiting proprioception in virtual-environment interaction. SIGGRAPH '97 Proceedings of the 24th annual conference on Computer graphics and interactive techniques, page 19-26.
[4] B. Fröhlich; B. Kirsch; W. Krüger; G. Wesche. Further development of the responsive workbench. Eurographics, pages 237– 246, 1995.
[5] The Effects of Head-Mounted Display Mechanics on Distance Judgments in Virtual Environments. ACM Symposium on Applied Perception in Graphics and Visualization, 2004.
[6] C. Cruz-Neira, D.J. Sandin, T.A. DeFanti. Surround-screen projection based virtual reality: The design and implementation of the CAVE. Proceedings of ACM SIGGRAPH, 135-142, 1993.
[7] H. Creagh. Cave Automatic Virtual Environment. Electrical Insulation Conference and Electrical Manufacturing & Coil Winding Technology Conference, 2003, 499 - 504.
[8] CAVELib. User and reference guide. Mechdyne corporation, April 2010 Edition.
[9] J. Rohlf and J. Helman. IRIS performer: a high performance multiprocessing toolkit for real-time 3D graphics. SIGGRAPH '94 Proceedings of the 21st annual conference on Computer graphics and interactive techniques. Pages 381-394.
[10] OpenGL architecture review board (ARB). https://www.opengl.org
[11] A. Craig, W. Sherman, and J. Will. Developing Virtual Reality Application. ELSEVIER, 2009.
[12] J. Goldman and T. Roy. Cosmic Worm. IEEE Computer Graphics & Applications. To be published. July 1994.
[13] A. Frisoli, C. A. Avizzano, and M. Bergamasco. Simulation of a manual gearshift with a 2 DOF force-feedback joystick. ICRA – International Conference on Robotics and Automation, Seoul, Korea, 2001.
[14] B. Raffin and L. Soares. PC Clusters for Virtual Reality. Proceedings of the IEEE Virtual Reality Conference, 2006.
[15] T. A. DeFanti R. V. Kenyon C. Cruz-Neira, D. J. Sandin and John C. Hart. The cave: audio visual experience automatic virtual environment. Magazine Communications of the ACM, 35:64–72, 1992.
[16] P. Hartling A. Bierbaum Christopher, C. Just and C. Cruzneira. Flexible application design using vr juggler. In In Conference Abstracts and Applications. SIGGRAPH, 2000.

Mohamed Mediouni is a PhD student in the faculté des sciences, Université de Sherbrooke Canada. He received his master's degree in robotics from the National School of Engineers of Tunis Tunisia. His research interests focus on computer graphics, physics simulation, artificial life, immersion, virtual reality, augmented reality, medical imaging, haptic, and robotics. He is interested in the behavior of the next generation of scientists. He is concerned with the development and the unhealthy state of education of his country.