A BODILY USER INTERFACE FOR VR-CAVE

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Abstract. The main purpose of this research is to explore how body movement can increase a user's sense of presence in the virtual reality cave (VR-CAVE). Traditionally, in architectural applications, there is no interaction between users and VR-CAVE. Visual perception is the major way of presentation. The users feel a new sense of presence. Therefore, in order to increase user's sense of presence, we designed a bodily user interface as our controller which utilized user's body movement to interact with VR. The contribution is that not only can a user easily or effortlessly control and navigate VR space but also VR navigation will directly link to the experience of walking in a physical space, which provides a strong sense of presence to user.

1. Introduction

The evolution of design media from 2D drawing since ancient Egypt to modern 3D models serves many purposes in solving complex problems of architectural design. The emergence of digital media extends architects' imagination furthermore. In recently years, the development of virtual reality (VR) makes the digital model have seem more real.

However, one of the known issues of VR is the sense of presence. VR is defined as a particular type of experience that includes sense of presence—a sense of being in a place even when he/she is physically located in another. And the bodily and cognitive activity of the user—the level of his interaction with the virtual world—is the source of sense of presence (Steuer, 1992).

The efficacy of a VR has often linked to the sense of presence reported by its users and comparing VR systems based on user's sense of presence that screen-based projections can make better sense of presence to non-experienced users than HMDs and monitors, and then the more control a user has over their actions in VR, the higher the ensuing sense of presence (Kay and Gavriel, 1997). With the screen-based projections input device for interaction such as keyboard, mouse, joystick, data glove or sensor floor provide a certain level of sense of presence. However, if we can utilize our body or body parts as an input device to interact with VR environment, we may obtain a greater sense of presence (Thomas and Frank, 1998).

VR-CAVE in NCTU (National Chiao Tung University), we usually use it to play animation of presentation and users can't navigate by themselves. In order to enhance sense of presence and advance user' spatial experiences that we use bodily user interface as control device.

2. Media Review

2.1. SENSE OF PRESENCE IN VR

When we are in VR, we often experience a sense of presence—the user sense of being in the virtual place (Thomas and Frank, 1998). "Sense of presence" is an important element of VR that is also as a part of definition (Steuer, 1992; Thomas and Frank, 1998) and directly influences the efficacy of VR (Kay and Gavriel, 1997). Important research questions about the sense of presence in VR include: how it should be defined and be measured, and the "control" factors that it is influenced (Kay and Gavriel, 1997).

2.1.1. Sense of Presence

There is currently no clear conclusion on how to define sense of presence. It may be described as a perceptual flow requiring directed attention and based on the interaction of sensory stimulation, environmental factors, and internal tendencies (Kay and Gavriel, 1997). For VR, it means experiencing oneself as being in a computer-generated environment rather than in one's actual physical location—humans experience varying degrees of presence in a physical locale and their attention is divided between the physical world and the mental world (Kay and Gavriel, 1997). Sense of presence may be driven by a rich sensorial experience and the level of interactivity to which a user can manipulate objects and move in a virtual world (Steuer, 1992).

2.1.2. Measuring Sense of Presence

Sense of presence is observable (Thomas and Frank, 1998). He/she is in there if He/she can grasp virtual objects or develop fear from virtual cliffs. The greater understanding of the factors that "drive" this phenomenon may result and measures of it should be repeatable and sensibly correlated with measurable characteristics of VR (Kay and Gavriel, 1997). We need to be aware that it may be a "situation awareness" or "emotion" which only tells us "how much" or may never be achieved (Kay and Gavriel, 1997). Nevertheless, there are two general means of measuring the sense of presence in VR: "subjective" reporting and "objective" measurement. Subjective measures are the methods of paired comparisons ("Which of these two VR has the greater amount sense of presence for you?). Objective measures are users' experience that they report all or none sense of presence (Kay and Gavriel, 1997).

2.1.3. The Influential "Control" Factors

Sense of presence will be enhanced when bodily action is possible in the virtual world and this interaction is developed form body or body parts to interact with VR (Thomas, Frank, Holger, 1999). It develops from the mental representation of bodily actions as possible actions in the virtual world. When movements of our body (or body parts) in VR are represented mentally as possible actions, it emerges (Thomas, Frank, Holger, 1999). In addition, designing an easy interaction VR is most predictive of the sense of presence, and it is higher for VR users who are in control of their own actions in VR as compared to passive users (Kay and Gavriel, 1997). The more control a user can perform, the higher level of sense of presence can be reached (Kay and Gavriel, 1997).

2.2. BODILY USER INTERFACE

There are many input devices utilized in computer or games, such as mouse, keyboard and joystick. In addition to those devices, there are many relying on body movements, which is named bodily user interface.

Bodily user interface was the main control device in the "Virku" project (Mokka, et al. 2003) in which an exercise bicycle was used to navigate a virtual hill. The bodily user interface was selected because it seems to add to users' sense of presence. It is a combination of an exercise bicycle, a computer and a screen. A user can go forward in the virtual world by riding the bicycle. The aim of this project was to integrate features of exercise and the playing of computer games to create immersive and motivating training sessions. The environment of the game affects the pedalling effort, e.g., riding uphill increases the required effort and downhill decreases it. The pedalling speed affects player's propagation speed in the virtual training environment.

The commercialized personal transporter "Segway" utilizes human body balance as control device: The Segway balances the way humans do—lean forward and backward—which responds to changes in your body's centre of weight. Lean forward and you move forward. Straighten up and you stop. Lean back and you move back (Dean, 2001).

In the area of entertainment, there are many games utilizing bodily user interface as controller. In "Dance Dance Revolution Gateway" (Konami Inc.) the player dances in rhythm on a carpet according to the directions on screen. The player controls his/her agent on the screen. In another game "Eye Toy" (Sony Company Environment Japan), a camera is used to take the bodily movement of the player to control the game. The player doesn't need any hand-held controller, because the player himself is the controller (Figure 1). In addition, there are many games that using similar technology to be their

Figure 1. Eye Toy.

controllers, such as “Para Para Paradise” (Konami Inc.) and “Percussion Freaks 10th Mix” (Konami Inc.)

3. Exploration

In VR-CAVE for architectural applications, designers present their designs usually using fixed-path pre-rendered animations. The spatial context is conveyed only by visual perception. Users can’t navigate space by themselves. It has no interaction between users and VR-CAVE. Although visual perception is the major way of presentation, there are still many possibilities to enhance the sense of presence in VR. And it was the same issue in NCTU. If a user utilized his body as a control device, he will obtain a strong sense of presence in VR (Thomas and Frank, 1998). Therefore, the main purpose of this research was to explore how body movement can increase user’s sense of presence in VR-CAVE, and then utilize it to obtain better efficacy of VR to let the spatial context become more understandable.

4. Research Processes

There were three steps in this reach: one, study of the body movement: body leaning. Two, implementing a prototype of the controller. Three, designing a test VR scene and controller refinement. Each step is described in detail as follows.

4.1. STUDY OF THE BODY MOVEMENT: BODY LEANING

In this research we selected body leaning to navigate VR-CAVE: lean forward, lean backward, left-leaning and right-leaning. These actions were used because of their likeness to the transition of the centre of weight in human walking: when human goes ahead or moves back, his body will naturally be forward or backward; when human turns right or left, his body will naturally be right-leaning or left-leaning. And human body leaning represents him to want toward the direction, such as while riding bicycle, his body will move right when one wants to turn right.

4.2. IMPLEMENT A PROTOTYPE OF THE CONTROLLER

Implement a prototype of bodily user interface that a user can navigate virtual environment by using body leaning. When his/her body leans forward, he/she will go forward in virtual environment; when his/her body leans left, he will turn left in virtual, and so on.

Our device was refitted by numeric keypad which was linked to a VR-CAVE server. We used cables to extend the arrow keys combined it with mercury-switch.

And then we set those components into a sleeveless jacket in three directions: right shoulder, left shoulder and back. This was our prototype controller.

The VR-CAVE is composed of three projection screens and six projectors, and is controlled by seven computers. The software that we used was Director 8.5 and Multiuser Server. The signal will convey form user to server while user's body leaning triggers mercury-switch. After the server receives this signal will send to six clients and the VR scene will respond (Figure 2).

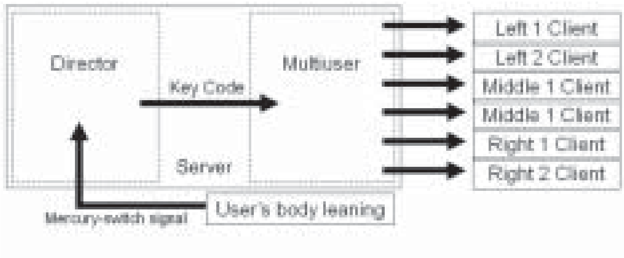

Figure 2. VR-CAVR software construction

4.3. DESIGN A TEST VR SCENE AND CONTROLLER REFINEMENT

A narrow corridor was designed where users can move and obtain better efficacy of stereoscopic navigation in VR-CAVE. The scene (Figure 3) was "Architecture Workshop Taiwan New Landscape Movement" by NCTU in National Taiwan Science Education Center. After the tested VR scene was designed and tested, we will refined the prototype of controller to adjust this virtual environment.

Figure 3. Architecture Workshop.

The whole system is including VR-Cave and a wearable controller. We will use this system to make controller refinement. We plan that one user will put on our device and adjust the mercury-switches in right place where the mercury-switches are off while the user is no action. And in order to make user action easily that we will adjust all cables.

In order to explore how body movement can increase user's sense of presence in VR, we will use the same digital model to test. A user will wear goggles and our controller to experience space, and he will use other devices (joystick, keyboard and sensor floor) to experience the same space in the VR Cave. Finally, an evaluation will be conducted base on the user's experiences.

5. Conclusion

Users thought that they became more involved and felt they were in the virtual environment while testing the VR. Using their bodies to navigate virtual environment was made them feel intuition and effortlessly to control, unless he/she tilted his/her body. However, some of them felt that non-sensitive between VR system and controller. After their bodies leaned forward for a few seconds, the VR scene went forward. Furthermore, the cables behind their back limited them to move. Other users reported they were very tried after they used controller for a few minutes, but it was a special spatial experience. Some of them felt that they were a part of virtual environment and were a joystick arrow key while they used controller. And their foot unconscious followed their bodies' movements and were linked walking experience while their bodies leaning. It was very real while using this way to navigate virtual environment and the space context was presented very clearly. Nevertheless, the cables reminded them that they were in the physical world. It would be better to navigate if the controller had a head tracker.

This research is an ongoing project and we will tackle the aforementioned issues to overcome these shortcomings to increase users' sense of presence.

6. Limitation and future study

The VR-CAVE tools are very difficult to obtain and develop. So we use easy way which doesn't require too much money to proceed this research. And because the software "Multiuser Server" has some limitation, some signal which server sends to clients will loose and then the VR scene will lag. The controller has cables in order to assure signal won't lose to server. But both of them will decrease users' sense of presence and these will be future study in our research.

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