Subjective Evaluation of Stereoscopic View in Immersive Projection Display

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Abstract: We made a subjective evaluation of stereoscopic views in an immersive projection display. This kind of display has been used for exhibiting virtual reality content in learning facilities such as science museums and cultural centers. They require space and time that differ from those in daily life. The immersive projection display may provide us with the sense of presence by stereoscopic images with a wide field of view. We performed an experiment to compare stereoscopic images with normal images in moving around in the virtual world. The results of the subjective evaluation suggested that the virtual objects placed near a user looked three dimensional more in the stereoscopic views, and the sense of presence was provided sufficiently even in the normal views.

Keywords: Immersive projection display, stereoscopic view, evaluation, virtual reality

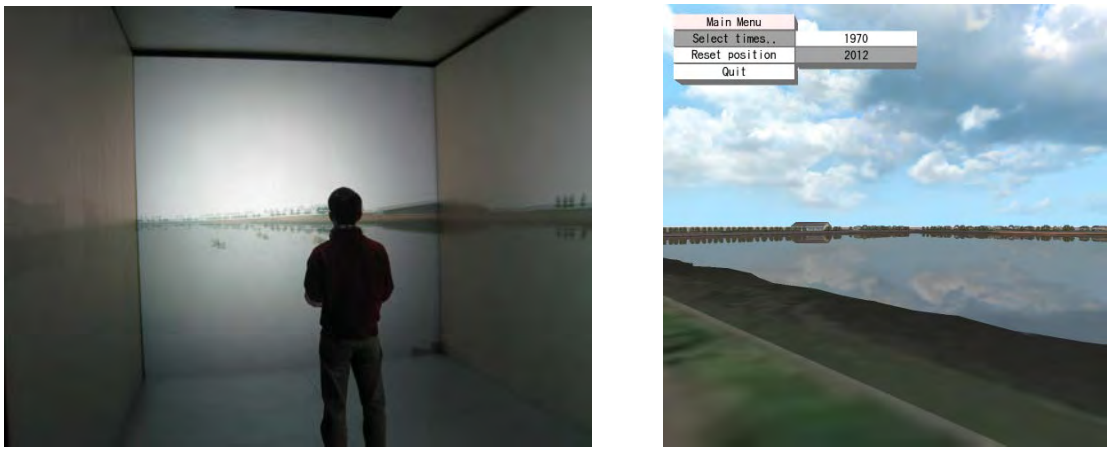
1. Introduction

Since an immersive projection display has been proposed as a CAVE system (Cruz-Neira, Sandin, & DeFanti, 1993), many systems have been applied as a virtual reality environment to learning facilities such as science museums and cultural centers. The typical CAVE system consists of four screens with three sided walls and a floor forming a cubic screen. Stereoscopic images are projected to each screen so as to be seamlessly seen from a user's point of view, achieving a wide viewing angle. It enables the user to be given the sense of presence at a high level.

When new media are used for learning, the performance gains in the initial period of time (Clark, 1983). It is called the novelty effect. The novelty effect is convenient for learning environments such as science museums and cultural centers, because those environments are required to have space and time that differed from those in daily life (Bell, 2002). We believe that the immersive projection display has potential to provide the space and time that differ from those in daily life. It is not clarified what elements of the immersive projection display affect the user's experiences, though there have been the researches on effects of large displays (e.g., Tan, et al., 2006) and stereoscopic displays (e.g., Willemsen, 2008) on task performance. Here, we investigate the effects of stereoscopic views on the sense of presence by a subjective evaluation in an immersive projection display.

2. System

Our immersive projection display was originally constructed as a CAVE-like system with a 5.5-surface cubic screen (Asai, Osawa, & Sugimoto, 1999). It was reconstructed with a PC cluster and freely available software (Asai & Takase, 2013). Only four out of five surfaces in the cubic screen were used as the projection display, as shown in Figure 1 (a). Stereoscopic images are projected by LCD projectors, and are separated to the left-eye and right-eye images through the circular polarization. The size of each square screen is 3 m by 3 m, and the projection resolution is 1000 by 1000 pixels. The stereoscopic images are generated by four PCs equipped with a GPU, which form a PC cluster through a gigabit Ethernet LAN. A wired game pad is used as a joystick for controlling the viewpoint in the virtual world. We developed an original application of moving around in the virtual tideland and observing various kinds of wild birds in the different period of year, as shown in Figure 1 (b).



(a) Overview of immersive projection display (b) Screenshot of virtual tideland world

Figure 1. Presentation by immersive projection display.

3. Experiment

We performed an experiment to compare stereoscopic images with normal (two dimensional) images in viewing scenes of the virtual tideland world. Both stereoscopic and normal images were projected to the four screens (three walls and one floor), and no sound was generated during their experiences.

3.1 Methods

Nine participants were the BA and BS students who gathered from different universities. The participants used the system for roughly 5 minutes in each condition on the stereoscopic and normal views. They were instructed to move around in the virtual tideland world. They were polled with a preference test after the use. The preference test includes 9 questions listed in Table 1. A five-point Likert scale was used in the preference test, ranging from 1=definitely disagree to 5=definitely agree. Open-ended comments were required to provide their opinions in using the immersive projection display for viewing the virtual tideland world.

Table 1: Questions in preference test in experiment.

No.	Question items
1	The system responded smoothly.
2	The objects close to you looked three dimensional.
3	You distinguished the objects placed near and far.
4	The scenes were viewed with the depth feeling.
5	You were immersed in the virtual world.
6	Viewing scenes was interesting.
7	You felt something uncomfortable in viewing scenes.
8	It was suitable for viewing scenes for a long time.
9	You were tired in viewing scenes.

3.2 Results and Discussion

Results of the preference test are shown in Figure 2. The number in the horizontal axis corresponds to each question item, and the symbols a and b indicate the conditions of stereoscopic and normal views, respectively. The thin bar on each black and white column is the standard deviation. The results from a paired t-test obtained the tendency toward significant differences between the conditions in the question items 2 ($t(8)=2.95$, $p<0.05$), 3 ($t(8)=2.53$, $p<0.05$), 4 ($t(8)=3.16$, $p<0.05$), and 8 ($t(8)=-2.68$, $p<0.05$). The question no. 2 and 8 had large differences between the conditions in the average scores, and each

score differs largely between the participants. The question no. 3 and 4 had the significant differences between the conditions, but the scores stayed between 3 and 5 in the both conditions.

The result of the question no. 2 suggested that the objects close to him/her looked three dimensional more in the stereoscopic views than in the normal views, though it depended on the participants. The result of the question no. 8 suggested that the stereoscopic views were not so suitable for the long time use. We guessed that this result was influenced from the high speed of moving around in the virtual world, because four participants reported in the open-ended comments that they had a feeling similar to motion sickness due to the high speed movement. Although the tendency toward the significant differences was found in the question no. 3 and 4, the high scores in the both conditions may lead to the importance of the other parameters such as wide views, rather than the stereoscopic views. The high scores in the question no. 5 and 6 also suggest that the both stereoscopic and normal views have given the participants the immersive and enjoyable feelings that may bring learning effectiveness.

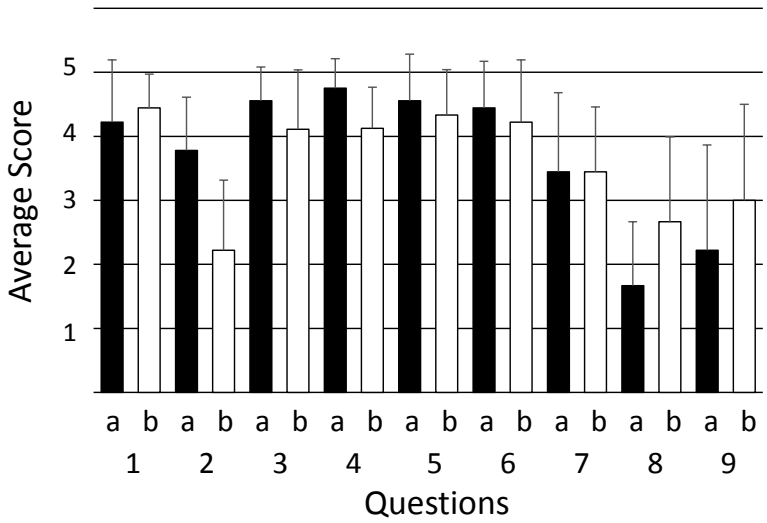


Figure 2. Results of preference test in experiment (a: stereoscopic, b: normal).

4. Summary

We made a subjective evaluation of stereoscopic views in an immersive projection display, comparing stereoscopic images with normal images in moving around in the virtual tideland world. The results of the subjective evaluation suggested that virtual objects placed near a user looked three dimensional more in the stereoscopic views, and the sense of presence was provided sufficiently even in the normal views.

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