ReverseCAVE Experience: Providing Reverse Perspectives for Sharing VR Experience

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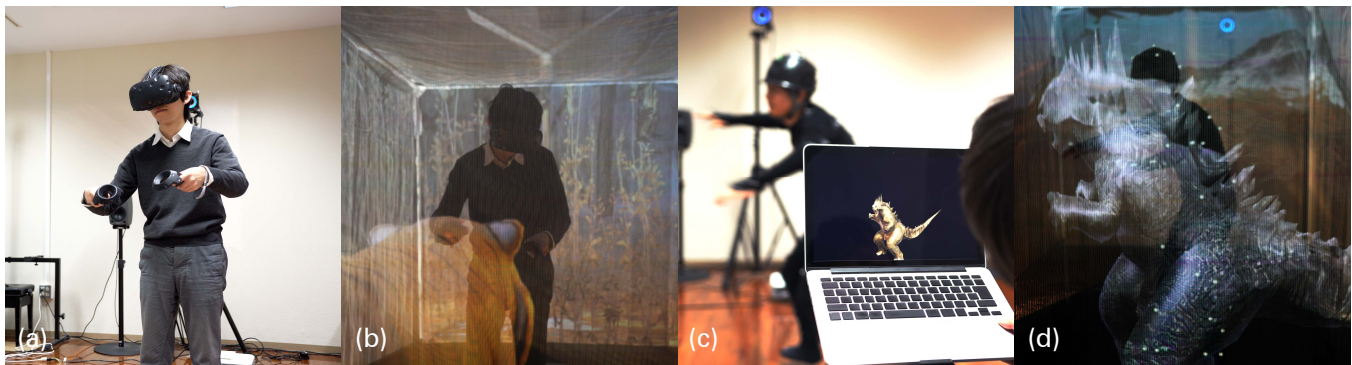
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Figure 1: Overview of ReverseCAVE. Conventional situation (a, c) and result of our method applied (b, d). a, b) He is playing the VR game and interacting with an animal. c, d) He is an actor acting as a creature using a motion capture system. In (a) and (c), it is difficult to understand what he is doing, however, in (b) and (d), we can understand what he is doing in the physical space. ReverseCAVE covers "*perspective gap*."

ABSTRACT

VR games are currently becoming part of the public-space entertainment (e.g., VR amusement parks). Therefore, VR games should be attractive for not only players but also observers. However, VR with HMD is a closed experience among those who are wearing HMD, and can only be individually experienced by the specific person. We call this "*perspective gap*." These perspective gaps exist in many situations. To address these problems, we present "*ReverseCAVE*", a system for sharing the experiences of people in VR with others (observers). As another application, it is possible to visually recognize the actual appearance of the person performing the act at the motion capture studio and the superimposed character at the same time. ReverseCAVE has four translucent screens surrounding the player. The VR environment is projected onto the screens. By this, the observer can see both the physical player and the VR environment experienced by the player simultaneously. Also, in the motion capture system, when viewing the actor from the observer outside of ReverseCAVE, the character is superimposed to the actor. This makes it look as if the actor is the actual character from the observer. We enhance the observers' experience by ReverseCAVE.

CCS CONCEPTS

• **Human-centered computing → Mixed / augmented reality**;

KEYWORDS

Virtual Reality, environmental VR, mixed reality (MR), sharing experience, CAVE, visualization

*Both authors contributed equally to the work.

1 INTRODUCTION

Head mounted display (HMD) is rapidly spreading as a device for experiencing virtual reality (VR). It is important to be able to share VR experience with others [Biocca and Levy 1995]. However, VR with HMD is a closed experience among those who are wearing HMD, and can only be individually experienced by the specific person. In many cases, people without HMD cannot share the experiences with the people wearing HMD. We call this problem "*perspective gap.*" As a method to solve this problem, for example, SAVE [Zhu et al. 2016] superimposes the image of the VR player onto the VR environment using chroma key, and displays this to the LCD monitor. For another example, ShareVR [Gugenheimer et al. 2017] uses floor projection and mobile displays in combination with position tracking to visualize the VR environment for Non-HMD users.

We focus on these perspective gaps in VR and computer graphics applications. These perspective gaps exist in many situations (e.g., VR games in game shows, actors and observers in the motion capture studio, telepresence situation in conference). To address such problems, we present "ReverseCAVE" [Ishii et al. 2017], a system for sharing the experiences of people in VR environment (player) with others (observers), as shown in Figure 1ab. As another application, it is possible to visually recognize the actual appearance of the person performing the act at the motion capture studio and the superimposed character at the same time, as shown in Figure 1cd. Similar to CAVE, ReverseCAVE has four screens surrounding the player. The screen's material in our study, which is a translucent fabric, is different from CAVE. Then the VR environment is projected onto the screens. By this, the observer can see both the physical player and the VR environment experienced by the player.

2 IMPLEMENTATION OVERVIEW

ReverseCAVE consists of a motion capture system, a cubic translucent screen, and projectors, as shown in Figure 2. The motion capture system is used to acquire the position of the observer to calculate the projection position. The VR environment that the player is experiencing is projected onto the screen. By this, the observer can see both the physical player and the VR environment. Also, in the motion capture studio, when viewing the actor from the observer's side, the character is superimposed to the actor. This makes it look as if the actor is the character from the observer. The character's position is changed corresponding to the position of the actor and observer. In other words, the character is superimposed on the intersection point of the eye-line (between the observer and actor) and the projecting plane of ReverseCAVE.

3 FUTURE VISION: VR TO EVERYONE

We investigated whether users would want to share their VR experiences with others when using our system with eight participants (all males) aged between 19 and 23 years (mean: 21.6). There were two experimental conditions, *with ReverseCAVE* and *without ReverseCAVE*. We showed the participants a video of a player experiencing VR (the video version of Figure 1ab), and asked if they would like to share a video or a photo with others if they were the player in the video. "*Sharing*" here implies both sharing in closed forums such as Facebook messenger, and sharing on open forums
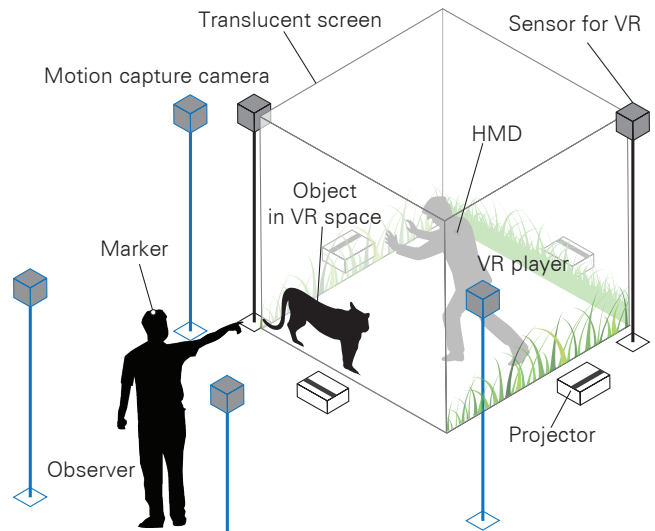

Figure 2: System components of ReverseCAVE.

such as Instagram. We recorded the participants' responses using a 5-point Likert scale.

Based on the result, *without ReverseCAVE*, the average score was 3.1 (SD = 1.27); however, *with ReverseCAVE*, the average score was 4.4 (SD = 0.70). We conjecture that the users were more inclined towards sharing their experience with others when using ReverseCAVE. Applying the paired t-test, there was a significant difference between *with ReverseCAVE* and *without ReverseCAVE* cases (t = -3.99, df = 7, p < 0.01). For *without ReverseCAVE* condition, the participant with a score of 2 commented, *"I don't want to share something which other people can't understand what I am doing, and looks weird."* For *with ReverseCAVE* condition, the participant with a score of 5 commented, *"I felt it would be fun and easy for others to understand by posting it because you can see me play the VR and the actual VR which I'm seeing at the same time."* As described earlier, by using ReverseCAVE, it is possible to share with others what the VR player is experiencing; therefore, the possibility of sharing the experience with others can be enhanced.

Till today, VR experience was only for the the player. However, by using ReverseCAVE, VR experience can be shared to everyone. We envision that VR experience is for *everyone*.

REFERENCES

Frank Biocca and Mark R. Levy. 1995. *Communication in the Age of Virtual Reality.* Routledge.

Jan Gugenheimer, Evgeny Stemasov, Julian Frommel, and Enrico Rukzio. 2017. ShareVR: Enabling Co-Located Experiences for Virtual Reality Between HMD and Non-HMD Users. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 4021–4033.

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Yu Zhu, Kang Zhu, Qiang Fu, Xilin Chen, Huixing Gong, and Jingyi Yu. 2016. SAVE: Shared Augmented Virtual Environment for Real-time Mixed Reality Applications. In *Proceedings of the 15th ACM SIGGRAPH Conference on Virtual-Reality Continuum and Its Applications in Industry - Volume 1 (VRCAI '16)*. ACM, New York, NY, USA, 13–21.