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Demo

Moving Interaction by Controlling Yourself in Virtual Space

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Abstract

In this demonstration, we propose a method of movement in virtual space. The user becomes a ball that can roll through the virtual space and is operated from a first-person perspective. There are several objects in virtual space, which correspond to miniature objects in real space that match their appearance and movement. Users could manipulate these real space objects themselves, lifting and moving themselves in virtual space to break through some of the barriers that exist in virtual space. In this method, we observed that users experienced less motion sickness, even though they were standing still in the real space and only the images were moving. This system enables users to interact themselves from real space to virtual space, and is expected to become a new method of interaction in a society where digital twins have become widespread.

CCS Concepts
• ***Human-centered computing*** → *Interaction techniques;*

1. Introduction

In recent years, improvements in computer graphics technology and the availability of lower-cost head mounted displays (HMD) have made it easier to access virtual spaces. In 2021, virtual space became a widely known concept with Meta's announcement of the Metaverse. In virtual spaces, users are generally given visual information through a HMD and interact with the virtual space using a controller. However, interaction with the controller may differ from the sensation of actually grasping and moving objects with hands or moving around in the VR space by themselves. Movement methods within virtual spaces usually involves using joystick attached to the controller, and therefore scenes change in VR while the user in reality is not moving. These mismatches between input sensation and the corresponding visual stimulus is a cause of motion sickness [RB75, Tre77], and it is considered that the same mechanisms work for sickness caused by VR images.

As a method of interaction between users in real and virtual space, projects such as ShareVR, which enables users in the real space to interact with the virtual space using a controller while viewing an overview image of the virtual space projected on the floor, and Dollhouse VR, which allows multiple people to observe the space from different perspectives and work cooperatively, have been developed [GSFR17, ISS*15]. However, it is difficult to synchronize the timing of interaction between multiple users in the virtual space. Therefore, we developed a system to place objects in real space that match the appearance and movement in virtual space that users can manipulate by themselves. The purpose of this demonstration is to explore the possibilities this system has in virtual space of self-induced lifting and moving of the user through objects in real space, and to provide basic insights into the relationship between self-induced motion and VR sickness.

2. System Design

The user was presented a virtual space generated by a computer (FRONTIER FRGA Series, Windows 10, Intel(R) Core i7-11700KF, 32 GB RAM, NVIDIA GeForce RTX 3060) through a HMD (Oculus Rift S, 1280 x 1440 pixels, 110 deg, 80 Hz refresh)(Figure 1). The user became a first-person perspective ball in this virtual space and moved using a controller (Oculus Touch). The virtual space was created using Unity, and normal physics was applied to the ball, inertia and gravity calculations included. Several 3D modeled objects were placed in the virtual space. Objects were rendered as real space objects using a 3D printer: a cup, a staircase, and a container on which the ball could be placed.

In order to represent the movement of objects from real to virtual space, retroreflective markers were attached to them and their positions were tracked with a motion capture system (OptiTrack Trio, 640 x 480 pixels, 120 fps, focal length 3.5 mm, F-number 2.0, angle of view 47 x 43 deg).

The user used the joystick on the controller to move, and pressed buttons to jump, while trying to reach the goal. There were gaps and obstacles set up in some parts of the course that could not be broken through by movement or jumping alone. In order to break through these, the user needed to manipulate the corresponding real-world object and move around themselves. A cup-like object was placed

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in the virtual space. Firstly, the user entered the object while moved the corresponding real object (Figure 2). This made it possible for the user to move the container they themselves are inside in the virtual world. Through this method, they were able to move through gaps that could not be reached by joystick movement or jumping alone. Secondly, a field with large elevation difference was presented. Here, the user was asked to move the virtual staircase to the appropriate position so that they could climb up the virtual steps. Finally, the goal was reached by riding in virtual space on a container on which the ball could be placed and moving the corresponding object in real space.

Generally, in VR-based content, the mismatch between vision and movement causes sickness, one of which being the huge virtual scene changes while the user is not physically moving. In this system, the size of the objects that can be moved is larger than the size of the user in the virtual space, so the change of the scene are very large although the user does not have to move. Even though changes were huge, it was observed that this method caused less user sickness.

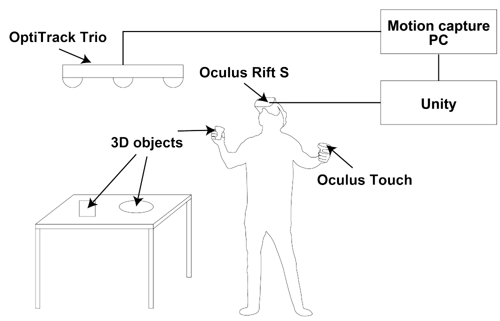

Figure 1: *System design. The 3D printed objects were attached with retroreflective markers to apply the captured motion to the corresponding objects in the virtual space.*

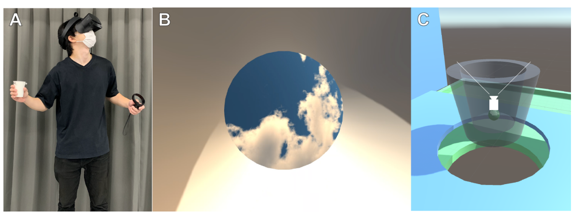

Figure 2: *Demonstration. (A) The user manipulates objects in real space while observing images from a first-person perspective through the HMD. (B) User view in virtual space. The user becomes a ball in a cup and looks up. (C) Overhead view of virtual space.*

3. User Feedback

All Users (N = 6) were familiar with VR content. Before the actual experience, they were provided with the location of the miniature objects in reality, and were allowed to manipulate the objects while wearing the HMD. The objects could be seen through the gap between the HMD and the user's face.

At the start of the experience, users first practiced moving and jumping with the controller. Then, they were instructed to proceed to the course in virtual space. The users attempted the course by manipulating objects in the real space which have reflections in the virtual space, and breaking through gaps and elevation differences in the course. We conducted a semi-structured interview after the experience. Here we list three comments for further discussion:

- I was able to move it by myself and was not as sick as I thought I would be.
- There was a sense that the small self in the cup was being moved by the larger self.
- I found it difficult to climb steps and to get on a container on which I could put a ball.

Notably, despite of the large amount of the scene changes during the experience, several users reported less motion sickness than usual VR experiences. On the other hand, because the player became a ball, it was found difficult to control their movement by manipulating miniature objects, because it required a different movement strategy than when manipulating a virtual avatar. Since such movements that are different from the user's intention may cause not only motion sickness, but also a reduction in the quality of the experience in the virtual space, we will improve the controls of the system in the future.

4. Conclusion

We developed a system that enables users to manipulate their environment in the virtual space by arranging miniature objects in the real space, which has their corresponding representations of larger objects in the virtual space (stairs, giant cup, etc.). For example, by manipulating the miniature cup, users can bring themselves into the virtual giant cup. The user is a ball following normal physics, so manipulating the miniatures directly caused users' motion in the virtual space. Comments suggest that this system caused less VR sickness, comparing to the standard VR experience. In the future, we aim to provide new interactions between virtual and real space, and have applications of improved user experience with movement.

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