Exploring Large Virtual Environments with an HMD on Foot

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1 Introduction

Virtual Environments presented through head-mounted displays (HMDs) are often explored on foot. Exploration on foot is useful since the inertial cues of physical locomotion aid spatial awareness. However, the size of the virtual environment that can be explored on foot is limited to the dimensions of the tracking space of the HMD, unless gain is scaled [Williams et al. 2006]. This work explores methods of remedying this limitation by changing the location of a user in physical space while maintaining their spatial awareness of their virtual space, a technique we call "resetting". Resetting involves physical locomotion with optical manipulated flow in such a way that the user's sense of where they are relative to objects in their virtual environment is not changed. We assess three plausible methods of resetting.

2 Resetting Methods

Freeze - Backup. In this method, the computer indicates to the user that he has reached the boundaries of the tracking system and needs to reset. The tracking system is then turned off, so that the user's position in virtual space is no longer updated with movement in physical space. The user is then instructed to take steps backwards in physical space while user's position in virtual space remains fixed or frozen. When enough steps are taken, the computer indicates for the user to stop, unfreezes the screen, and updates the tracking system, allowing the user to continue along the same path that the user was walking before the reset. During the backward walking, orientation tracking is active so that the user can look around.

Freeze - Turn. In this method, when the tracking device finds that the subject is close to a boundary, the computer indicates to the participant that he needs to reset by turning around. The display of the HMD is frozen, freezing the participant's position and yaw angle in virtual space, and the participant turns 180 degrees. The display is unfrozen, tracking is updated, and the subject is able to continue traveling along his route.

2:1 - Turn. In this method, when the subject reaches the boundaries of the tracker, the computer indicates that he should turn around until his spatial orientation is the same as before the turn. The rotation gain of the yaw angle during this turn is scaled by two, such that the user rotates 180° in the physical environment, but rotates 360° in the virtual environment.

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Figure 1: The virtual environment of the pilot study.

3 Pilot Study

Six lab members participated in the pilot study. The virtual world was viewed through a full color stereo Virtual Research Systems V8 Head Mounted Display with 640 x 480 resolution per eye, and a field of view of 60° diagonally. The size of the physical room in which the experiments were performed was approximately 5m by 6m, and within the room the limits of the video position tracking system was approximately 5m by 5m. The virtual room was 10m by 10m, twice the size of the physical limits of the tracking system, and is shown in Figure 1. In this pilot study, every participant freely explored the virtual environment under each resetting condition so that they underwent a number of resets. At the end of piloting all three conditions, they were asked to indicate which resetting condition was most natural.

4 Results and Discussion

Six out of six participants found the 2:1-Turn resetting condition most natural. The Freeze-Turn and 2:1-Turn resets are quicker than the Freeze-Backup method as it takes less time to simply turn 180° than to physically take steps backwards. The Freeze-Backup condition might also cause an interference between biomechanical information and visual field, making this method less natural. The same is true for the Freeze-Turn, biomechanical information does not match the visual information requiring the user to disregard the biomechanical information. However, lab members seem less aware of the 2:1 rotational gain change. Our next step is to rigorously test this hypothesis.

References

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