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Is Walking Necessary for Effective Locomotion and Interaction in VR?

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Abstract—This paper reports on a work-in-progress study to investigate if/how leaning-based interfaces affect simultaneous locomotion and interaction. We compare **physical walking** and **Controller** with a seated (i.e., **HeadJoystick**) and standing (i.e., **Naviboard**) leaning-based interface. We disambiguated performance in locomotion versus interaction using a novel experimental paradigm, where participants should point toward moving targets using their virtual light-saber while actively following a moving platform.

Index Terms—3D User Interface, Motion Sickness, Cybersickness, Locomotion, Travel Techniques, Dual-Task, Virtual Reality

1 Introduction

Many real-world scenarios require users to physically walk while interacting with the environment. However when simulating these scenarios in VR, physical walking might not be possible beyond a limited tracked free-space walking area. Therefore, many VR applications use other locomotion interfaces, such as handheld controllers, to reach those areas past the tracked area. But as handheld controllers do not provide any vestibular and proprioceptive sensory data about the travel direction or distance, using them reduces the believability and naturalism of locomotion experience and can contribute to the motion sickness.

Several locomotion interfaces have been designed to address these challenges by providing limited motion cues toward the travel direction, such as leaning-based interfaces, which control the simulated velocity by the user-powered leaning toward the target direction. However, prior studies often showed lower effectiveness of leaning-based interfaces compared to handheld interfaces for simultaneous locomotion and interaction tasks [1], [2], [3].

Recently, we introduced effective seated and standing leaning-based interfaces called HeadJoystick [4], [5] and Naviboard [6], respectively, where the user moves their head toward the target direction to control their simulated velocity. Compared to handheld controllers, HeadJoystick improved almost all performance, user experience, and usability aspects [5], while Naviboard improved task completion time and reduced motion sickness to levels almost comparable to physical walking [6]. However, as far as the authors know, none of these more effective leaning-based interfaces (i.e., HeadJoystick and Naviboard) have been investigated for simultaneous dual-task scenarios that combine locomotion and interaction.

To address this gap in the literature, this work reports on a work-in-progress study to investigate if leaning-based interfaces (such as HeadJoystick and Naviboard) can improve the effectiveness of simultaneous locomotion and interaction compared to handheld controllers, and to approach performance levels of the gold-standard of physical walking. To do so, we designed a new experimental paradigm of gamified locomotion + interaction that allows to disambiguate performance in locomotion versus interaction by defining similar performance measures of effectiveness for both locomotion and interaction tasks.

2 User Study

2.1 Task and Environment

To provide a fast-paced gamified task, we took inspiration from *Beat Saber* [7] (a top-selling VR game) and turned it into a task where users need to actively follow and stay in the center of a slowly moving platform, while at the same time using their light saber to continuously point toward the center of upwards moving targets (mimicking rising balloons) in blue as shown in Figure 2. Each participant used four interface for this task: physical walking, controller (thumbstick), and two leaning-based interfaces, HeadJoystick [5] and Naviboard [6] as depicted in Figure 1. To investigate the effect of seated vs standing body posture on overall performance and user experience, Controller and HeadJoystick users were seated, while Naviboard and walking users were standing. In all our conditions, participants rotated physically either while standing or seated on an office swivel chair. Using this task, we assessed how the interface affects the user experience, usability, and performance.

Figure 2 depicts the study environment and the blue targets, which appeared every second matching the music beats (similar to the Beat Saber VR game). To increase predictability of the platform's/targets' motion, their paths were shown as red/white lines. To increase predictability

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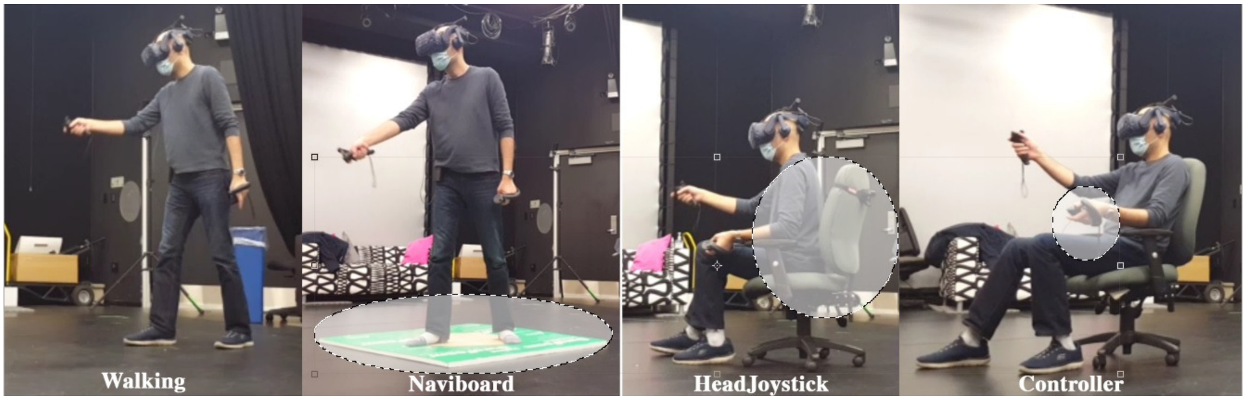

Fig. 1. All four locomotion conditions from left to right: Physical walking; Naviboard, where the user stands on a circular wooden plate surrounded by Styrofoam and moves their head (leaning/stepping) toward the target direction; HeadJoystick, where a seated user moves their head toward the target direction; and Controller, where the user uses Controller's thumbstick to move.

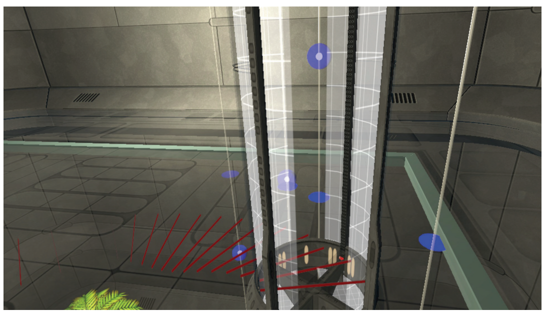

Fig. 2. Virtual environment for this study: Participants were asked to follow the moving platform and stay as close as possible to its center while using their light saber to point toward the center of blue targets to pop them.

of the interaction task, each target was shown below the semi-transparent floor two seconds before they rise above the floor level. Participants were asked to pop targets (confirmed by a popping sound) if the light saber touched their center (shown by a small white sphere) for 0.33s, which could increase linearly based on distance of the light saber from their center.

2.2 Experimental Design and Dependent Variables

This within-subject study design used a factorial combination of 4 interface conditions {Walking, Naviboard, HeadJoystick, and Controller} $\times$ 4 trials $\times$ 6 translational and rotational velocities {0m/s with 0deg/s, 0.3m/s with 30deg/s, 0.6m/s with 30deg/s, 0.6m/s with 45deg/s, 0.8m/s with 45deg/s, 0.8m/s with 60deg/s}. Each trial took 2 minutes to complete consisting of six levels of difficulty with different translational and rotational velocities. Interface conditions were counterbalanced across participants using a Latin-square design. After using each interface, participants evaluated different user experience aspects (i.e., motion sickness, task load, spatial presence, immersion, vection intensity, enjoyment, and overall preference) and usability aspects (i.e., ease of use, ease of learning, task load, potential for daily use, potential for long-term use, and overall usability) similar to our prior studies [4], [5]. After finishing all four interfaces, the experimenter explored the reasons behind participant's answers in a semi-structured interview.

Performance measures were including the overall performance, accuracy, and precision. We defined the interaction/navigation score as the accuracy of interaction/navigation. To motivate participants to spend similar efforts for both interaction and navigation tasks, we defined the overall score as the minimum of interaction and navigation scores at each moment, summed up over the trial duration. Interaction/navigation precision was assessed by the percentage of time participants missed the targets/platform.

3 Conclusion

This paper reports a novel experimental paradigm to investigate if two leaning-based locomotion interfaces (HeadJoystick and NaviBoard) that had demonstrated performance improvements over controller usage in a locomotion task [5], [6], would show similar benefits in a dual-task that requires simultaneous locomotion and interaction. We designed a new paradigm of gamified locomotion + interaction that allows to disambiguate performance in locomotion versus interaction. Running this study was delayed due to Covid-19 restrictions.

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