TeleSteer: Combining Discrete and Continuous Locomotion Techniques in Virtual Reality

Ziyue Zhao
School of Advanced Technology
Xi'an Jiaotong-Liverpool University
Suzhou, China

Yue Li*
Department of Computing, School of Advanced Technology
Xi'an Jiaotong-Liverpool University
Suzhou, China

Lingyun Yu
Department of Computing, School of Advanced Technology
Xi'an Jiaotong-Liverpool University
Suzhou, China

Hai-Ning Liang
Department of Computing, School of Advanced Technology
Xi'an Jiaotong-Liverpool University
Suzhou, China

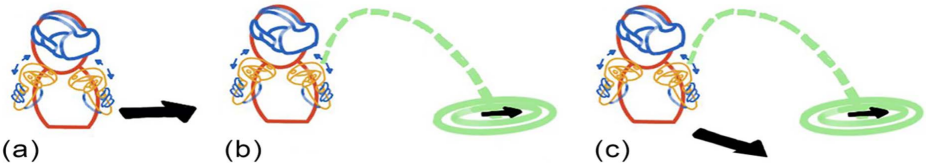

Figure 1: Illustrations of the (a) joystick steering, (b) AngleSelect teleport [3], and (c) TeleSteer locomotion techniques.

Abstract

Steering and teleporting are two common locomotion techniques in virtual reality (VR). Steering generates a great sense of spatial awareness and immersion but tends to lead to cybersickness; teleporting performs better in mitigating cybersickness but may lead to the loss of spatial awareness. Hence, we combined these two techniques and designed *TeleSteer*. This technique allows users to perform both steering and teleporting and customize the control. We discuss that a combined use of discrete (e.g. teleporting) and continuous (e.g. steering) locomotion techniques is necessary for scenarios that require both free explorations and close-range interaction tasks, making TeleSteer a suitable alternative.

Index Terms: Human-centered computing - Human computer interaction (HCI) - Interaction paradigms - Virtual reality

1 Introduction

Locomotion, one of the most critical components of virtual reality (VR) interaction, determines how users travel in virtual environments (VEs). Locomotion has been a popular topic in VR interaction for the past two decades, and many related works have already researched the performance of different locomotion techniques. Since the performance of different locomotion techniques in the virtual world affects users' perceived presence, spatial awareness, and the severity of cybersickness [6], choosing a suitable locomotion technique in different VEs is an important design decision to make.

Steering and teleporting are two commonly used non-natural locomotion techniques. The main difference is the continuity of movements. Joystick steering allows users to move towards their facing direction continuously by pushing the joystick on the controller. Teleporting, on the other hand, transfers users to the pointed destination instantly. Compared to teleporting, steering is more likely to lead to cybersickness, a phenomenon due to the conflicts between the self-motion perceived by the visual system and the physically stationary state perceived by the vestibular system [4]. Its main negative effects include nausea, headache, vertigo, disorientation, sweating, and eyestrain [5]. Previous work has proven that teleporting performs better in reducing cybersickness than steering [1], but the lack of spatial awareness due to the discontinuity of movement makes it easier for users to get lost in the virtual environment and can lead to a worse task performance [2]. In our previous studies, we learned from our observations and interviews with participants that it is difficult to control the locomotion accurately at a close range using teleporting. However, steering makes the journey boring and inefficient if the VE is large.

Considering the advantages and disadvantages of steering and teleporting, we combined the two locomotion techniques and designed *TeleSteer*. This locomotion technique attaches both steering and teleporting methods, allowing users to customize the control in two hand-held controllers, and choose the more appropriate method on the go. Our research contributes to the current locomotion research by 1) combining two of the most used locomotion techniques, 2) illustrating the need to combine discrete and continuous locomotion techniques, and 3) discussing the potential value and suitable scenarios for TeleSteer.

*Corresponding author: yue.li@xjtlu.edu.cn

2 Design Motivation

This work is inspired by our observations in previous VR user studies and the review of related work [7]. We observed that

- Users encountered difficulties when attempting to interact with objects at a close range using teleporting, mainly because users had to repeatedly point, aim, and confirm to teleport to move themselves around an object. On the contrary, steering better affords fine-tuning of positions under such circumstances.
- In large virtual environments that require users to explore freely, long-distance travel using steering was perceived inefficient and boring. In contrast, teleporting was more efficient.

Considering the strength and limitations of steering and teleporting, we designed *TeleSteer*, a combined discrete and continuous locomotion technique that allows users to customize the controls and select the appropriate locomotion technique on the go.

3 Implemented Locomotion Techniques

We implemented the locomotion techniques in Unity (version 2020.3.21f1) and deployed them on a Meta Quest 2 VR head-mounted display (HMD) with two controllers (see Figure 2).

Steering allows users to move towards their facing direction by pushing the joystick on the controller and to stop by releasing the joystick (see Figure 1a and Figure 2, left). Two orientation techniques are allowed: rotating heads directly or pushing the thumbstick left or

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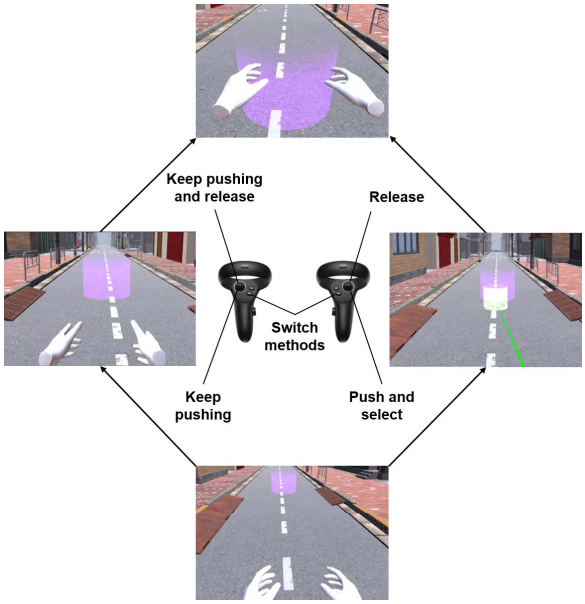

Figure 2: Demonstration of *TeleSteer*. Users could steer (left) or teleport to the destination (right), and switch methods at any time. The purple area indicates the destination.

right with the trigger button pressed. The rotation controlled by the thumbstick is discrete to avoid the effect of continuous orientation on cybersickness.

AngleSelect teleport (see Figure 1b and Figure 2, right) allows users to select a target point to translate and determine their facing direction after teleportation [3]. A parabola metaphor is used to visualize the path to the destination when the thumbstick is pushed forward. Additionally, an arrow is presented at the destination point to indicate the facing direction after teleporting. Users will be teleported to the target point once they release the thumbstick.

Both locomotion techniques were deployed to the two controllers, allowing users to perform different locomotion techniques and switch between them. For example, they can use the left controller to steer and use the right controller to teleport. Alternatively, users can switch between the two techniques on a controller by pressing the button "A" (on the right controller) or "X" (on the left controller).

4 Discussions

As a technique that combines both continuous and discrete locomotion, TeleSteer provides users with more choices for different situations. We see TeleSteer as a suitable choice for scenarios that require both long-distance travel in free exploration scenarios and close-range interactions with objects. The technique is highly reproducible and could benefit a wide range of immersive VR systems. In this section, we discuss some application areas and scenarios.

4.1 Cultural Heritage: Virtual Museums and Exhibitions

Most virtual museums have a large space and the exhibits are placed sparsely. To travel from one exhibit to another, teleporting is an efficient choice thanks to its capacity for long-distance travels. In addition, a continuous locomotion technique could contribute to the natural flow of an exhibition. It also allows visitors to slightly adjust their positions so that they can find the best view to observe and interact with virtual exhibits.

4.2 Education: Exploratory Virtual Classrooms

Virtual reality can bring education into contexts, such as simulating landforms in geography class, visualizing species in biology class, and taking students back in time in history class. These will engage students in both long-distance travels and close-range interactions.

Given the need and preference for locomotion techniques may differ among situations and users, TeleSteer combining discrete and continuous locomotion is likely to increase the usability of a system.

4.3 Entertainment: Virtual Shopping and Games

Locomotion technique is a significant factor affecting customers' VR shopping experience. Users has complained that it was difficult to control motions in VR [8]. With the high learnability of steering and the great efficiency of teleport, TeleSteer allows customers with different levels of experience to select the most comfortable one to travel in the virtual shopping mall. It saves time to travel from one commodity to another by using teleporting and makes it easier to get closer to the commodity by using steering. Similarly, TeleSteer could contribute to game experiences in exploring the play area, searching and collecting game items, and approaching other player avatars for social interactions.

5 Conclusion and Future Work

In this paper, we presented *TeleSteer*, a locomotion technique that allows discrete and continuous movements in virtual reality (VR). Combining steering and teleport, TeleSteer allows efficient long-distance travel and close-range continuous translation. It can be easily reproduced and integrated to existing VR systems.

Three potential application areas of TeleSteer are discussed. Other scenarios that need long-distance travel and close-range interaction are also suitable for using TeleSteer. In the future, we plan to conduct user studies to evaluate the effect of combined discrete and continuous locomotion techniques on users' task performance, perceived cybersickness, and spatial awareness in locomotion tasks.

Acknowledgment

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