Gauntlet: Travel technique for immersive environments using non-dominant hand

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Gauntlet: Travel Technique for Immersive Environments Using Non-Dominant Hand

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Abstract

We present Gauntlet, a travel technique for immersive environments that uses non-dominant hand tracking and a fist gesture to translate and rotate the viewport. The technique allows for simultaneous use of the dominant hand for other spatial input tasks. Applications of Gauntlet include FPS games, and other application domains where navigation should be performed together with other tasks. We release the technique along with an example application, a VR horror game, as an open source project.

Index Terms: H.5.2 [Information interfaces]: Information Interfaces and Presentation—User Interfaces;

Figure 1: Travel task performed using non-dominant hand leaves the dominant hand free to perform other interactions, such as pointing. In our implementation the spatial input is captured with a Leap Motion mounted on the Oculus Rift DK2. To reduce gorilla arm effect, both elbows may be rested on the table.

1 Introduction

Aside from target selection and manipulation, navigation is one of the basic interactions undertaken by users of immersive environments. Travel, a subset of navigation, refers to moving the viewport's position within the virtual environment. In systems that use spatial input devices, such as optical or magnetic motion tracking, travel is performed sequentially rather than concurrently with other tasks, such as object selection and manipulation. In contrast, people commonly perform various tasks while changing the position and rotation of their head, that is, their viewport. Also, in many VR applications simultaneous object manipulation and navigation is an essential requirement. For example, in a fast-paced FPS game player may want to be able to move, while simultaneously aiming a weapon to attack.

We introduce Gauntlet, a travel technique that utilizes the non-dominant hand and an easy to perform and recognize hand pose, a closed-fist, to support continuous viewport translation and rotation. Although the technique is yet to be formally evaluated, we postulate that it may have two advantages over previously proposed techniques. First, it reduces user fatigue, because the travel task can be performed in a seated position, with elbows rested on a table. Second, it leaves the dominant hand free to simultaneously perform other interactions without causing bimanual interference.

2 Related Work

Previous work examined enabling travel by using locomotion input devices, such as an omnidirectional treadmill, and magnetic (www.neuronmocap.com) or optical motion tracking (www.vicon.com). Redirected walking[6] has also been proposed as a travel technique with high degree of immersion. These approaches leave the hands free to perform other tasks at the expense of complex system setups that require large physical space for interaction. Moreover, forcing users to physically move their body in order to reposition the viewport results in fatigue during prolonged interaction scenarios. Alternative approaches, such as *pointing-to-teleport* add the semantic of viewport movement to 3D pointing [1, 4], do not accommodate travel scenarios such as tunnel steering and eliminate the experience of the user's movement itself, negatively affecting immersion, and potentially resulting in spatial disorientation. Codd-Downey et al. [2] examine use of unimanual gestures for travel, using the Leap Motion as a spatial input device. However, while the gestures can be performed with a single hand, users may find it difficult to perform complex hand poses with non-dominant hand while at the same time using the dominant hand for other tasks due to bimanual interference. Finally, Nabiyouni et al.[5] introduce Leap Motion-based "airplane metaphor", where viewport translation and rotation are controlled by tracking an open hand. However, their technique does not use a delimiting gesture, which may result in unintentional travel when user's hand is rested in a neutral, opened position.

3 Gauntlet Technique

We implemented Gauntlet using Leap Motion's Orion SDK and Oculus Rift DK2 head-mounted display (HMD). However, in principle, the technique could be implemented using any spatial input device, and other immersive environments, such as CAVE systems.

3.1 Delimiting Gesture

Gauntlet technique is activated by closing the fist of the non-dominant hand. This gesture can be reliably recognized by Leap Motion. Once the user's fist is closed, its position and rotation is saved and marked as "neutral". Until the hand opens, fist displace-

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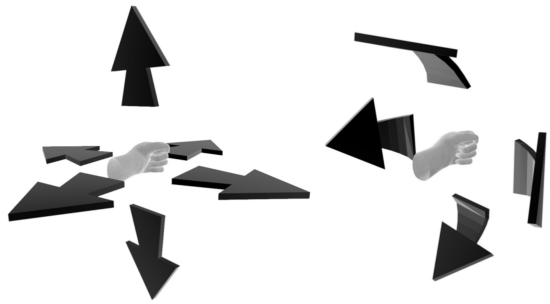

Figure 2: Non-dominant hand is tracked to determine the translation and rotation of the viewport as long as the hand is in a closed-fist pose.

Figure 3: In a student VR game "Haunted House", the player walks through a haunted mansion using Gauntlet technique, while defending themselves against hostile ghosts, searching for and picking up keys and flashlight batteries, and opening doors using their dominant hand.

ment is tracked relative to the position of the HMD. Opening and closing the fist again at a different location resets the neutral position.

3.2 Viewport Translation

The user traverses the immersive environment by moving their fist toward the intended direction of travel. The direction is calculated as a *displacement vector* describing the current position of the fist versus a "neutral" position. This mapping allows for 3 DoF translation. In applications where navigation happens along a plane or terrain (e.g. FPS games), and where movement of the viewport along the y-axis is determined by the shape of terrain, the y-axis component of the fist's displacement vector is ignored. To compute the speed of viewport translation, we map the magnitude of the displacement vector to speed using a linear function, which was preferred in our pilot studies, as compared to non-linear mappings. To avoid abrupt changes in velocity, we calculate the linear interpolation of the velocity vector over 0.5 seconds.

3.3 Viewport Rotation

In HMD-based immersive environments, viewport rotation is mapped to the user's head rotation, allowing the user to look around. However, requiring the user to physically turn around calls for more physical space and, over time, causes fatigue. Thus, Gauntlet technique allows for the rotation of the viewport in addition to the head rotation. The technique maps the fist's rotation to the viewport rotation (Figure 2). The angular velocity of the rotation is determined by measuring the displacement of the fist rotation from its original position. Similarly to the translation velocity, the rotation is mapped through a linear function and smoothed with linear interpolation over 0.5s.

4 Fatigue

One of the main goals of our design was to reduce user fatigue as compared to previously proposed travel techniques. While formal evaluation of the technique's ergonomics is in our future work plans, we hypothesize that the technique will reduce fatigue. In particular, we hope that the technique effectively addresses the *gorilla arm effect* [3], a consideration that is especially important in spatial user interfaces, yet rarely addressed by design. Due to gorilla arm effect, most spatial interaction techniques cannot be used for a prolonged period of time, for example, when playing a computer game continuously for a few hours. Considering this, we designed Gauntlet so that it can be performed in a seated position, with elbows rested on a desk or an armchair. If traveling on a plane or terrain, the entire forearm can be rested on a desk and moved along the desk surface itself, which reduces fatigue even further.

5 Example Application

As an example application for the Gauntlet technique, "Haunted House" VR game was developed as by a group of undergraduate game design and game development students. The game's premise is to find a way out of the haunted mansion by navigating through a labyrinth of rooms (Figure 3). The game uses spatial input (Leap Motion) and a head mounted display (Oculus Rift DK2). The game is a good candidate for using the Gauntlet technique, because its core mechanics require that the travel is performed simultaneously with the other tasks: picking up the keys, unlocking doors, and flashing a torch at ghosts. We release both the game and a Unity implementation of the Gauntlet technique as an open source project.[1]

6 Conclusion

The Gauntlet technique for travel in immersive environments allows users to perform travel while at the same time performing other interactions (pointing, manipulation). The technique utilities the non-dominant hand, leaving the dominant hand free to perform other tasks. The technique is designed to minimize bimanual interference, and to reduce overall user fatigue and gorilla arm effect. By introducing a delimiting gesture, a closed-fist, the technique allows to easily switch from bimanual interaction to unimanual interaction with simultaneous travel. In the future, we plan to evaluate Gauntlet technique in a formal experiment by comparing its performance and ergonomics to other travel techniques that use spatial input.

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[1] Code available at https://github.com/gameresearchlab/HauntedHouse