Vertical Locomotion in VR Using Full Body Gestures

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ABSTRACT

Virtual Reality experiences today are majorly based on horizontal locomotion. In these experiences, movement in the virtual space is accomplished using teleportation, gaze input or tracking in physical space which is limited to a certain extent. Our work focuses on intuitive interactions for vertical locomotion involving both hands and feet. Such an instance of vertical locomotion is - ladder climbing. In this paper, we present an interaction technique for climbing a ladder in Virtual Reality (VR). This technique is derived from the natural motions of the limbs while climbing a ladder in reality, adhering to safe climbing practices. The developed interaction can be used in training experiences as well as gaming experiences. Preliminary evaluation of our interaction technique showed positive results across dimensions like - learnability, natural mapping, and intuitiveness.

CCS CONCEPTS

• **Human-centered computing~Virtual reality** • **Human-centered computing~Gestural input** • Human-centered computing~Graphical user interfaces • Human-centered computing~User sxtudies • Hardware~Haptic devices

KEYWORDS

Virtual Reality, Locomotion, Gestures, Interactions, Tracking, Ladder Climbing, Teleportation

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1 INTRODUCTION

Research has shown that full-body gestures that trigger kinaesthesia provide a more intuitive interface and also adds to the level of presence in virtual environments [4]. Current interventions for locomotion in virtual reality environments are using gaze input or handheld controllers which are very different from natural human movement. VR systems like HTC Vive and others allow the users to do natural movement to a limited extent along with other ways like teleportation. Physical and virtual treadmills [3] and motion platforms allow users to perform natural full-body gestures by walking in place to move in the virtual environments. Compared to the volume of work that has been done in horizontal locomotion in VR, explorations in vertical locomotion in virtual environments is relatively less. Often the same input mechanisms and interaction that are used for horizontal locomotion is also implemented to accomplish vertical locomotion. Although these interactions may give an illusion of climbing, they are rather unnatural as the gestures performed lack natural mapping to the actions performed in real life and also, they do not utilize full-body gestures. Just like walking, climbing is also accomplished by repetitive cycling of certain movements which includes movement of all four limbs. In this paper, we present a novel interaction technique for climbing a ladder in virtual reality using full-body gestures utilizing readily available hardware. Slater et al. [4] proposed a method of climbing stairs and ladders in virtual reality by a technique they called "walking in place", which detected collision between the user's foot and the virtual stairs/ladder rungs. By using Microsoft Kinect user's hands and feet were detected and tracked. Takala and

Matveinen [5] developed a technique which allowed the user to reach out and grab the rungs of a virtual ladder using handheld controllers to grab and release the rungs. Once the rung is grabbed, the user can pull and push the ladder up or down to climb the ladder up or down respectively. Lai et al. [2, 1] proposed another technique for climbing a ladder in VR which used both hands and foot to simulate climbing. The hardware comprised of 2 handheld controllers (Nintendo Wii Remotes) and optical tracking system to track head, hands, and foot of the user, therefore using all for limbs to climb a ladder.

2 INTERACTION DESIGN

The hardware setup consists of a VR system comprising of a head-mounted display (HMD), two hand controllers and one Leap Motion module attached to the HMD. The Leap Motion module is used to track the user's hands, recognize gestures and render a real-time feed of the hand movements in VR. To track the feet, we tied the two Vive controllers, one on each foot

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[Figure 1]. We designed the VR experience targeting two core activities - climbing up and climbing down the ladder. Activities like reaching out to the target rung, grabbing and holding the target rung, place the first foot on the first rung from the bottom, etc. are repeated in an order to climb the ladder. Rendering of virtual hands and the gestures of grabbing and holding created a natural sensation of reaching out, grabbing and holding a rung, while the Vive controllers tied to the foot allowed the user to raise his/her leg to place it on a rung. The placement of the foot on a rung was accompanied by an audio cue and haptic feedback from the controllers to inform the user that he/she has placed the foot on a rung.

Figure 1: (Left) Depiction of hand and foot interaction while climbing the ladder. (Right) Output in VR

Our VR experience consists of a ladder comprising of 18 rungs and upon successfully climbing up 12 rungs, the user reaches the terrace of the building. After reaching the terrace, the user can initiate the climbing down the process. The user falls from the virtual ladder if, at any point, the user loses 3 points of contact, the user moves both the feet at the same time or releases both the hands in the middle of the climb. To climb up the ladder, the user needs to perform 4 actions in a particular order and repeat them in a cyclic pattern. An orange highlight band on the rung acts as a cue for the user to initiate the climb [Figure 2]. Once the user grabs the highlighted rung using a grab gesture, the orange band shifts on to the rung near to the user's feet, indicating the user to place his/her foot. To place the foot on the rung, the user needs to make a gesture of lifting the foot and keeping it on the rung. Once the foot collides with the rung the virtual shoe is placed on the rung and the orange band moves back to upper rung. The user repeats the same cycle using the other two limbs to climb up the ladder. For climbing down the ladder, the user follows the orange bands in a similar way as climbing up, using similar grab gesture with hands, but the foot gesture changes from lifting the foot to stepping back a little. The designed interaction was tested with a small set of users to find out how intuitive the interactions are, how natural are they in nature, how well is the learnability and if the interaction gives physical fatigue.

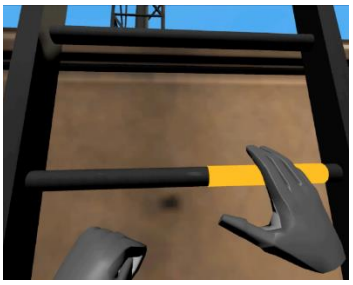

Figure 2: User's hands interacting with the ladder in VR. The Orange bar on the rung is for visual cue.

3 CONCLUSION

The work was aimed at experimenting on interaction techniques for vertical locomotion in virtual reality. The preliminary evaluation findings indicate that by utilizing full-body motion accompanied by audio-visual cues and haptic feedback, we can not only enable users to quickly learn the principles of safe ladder climbing but also fairly replicate the real sensations of climbing a ladder in a virtual environment. In comparison to the previous work done in this domain, our setup was affordable, easily portable and the designed interactions and gestures were intuitive and natural. This kind of setup can be used not only for trainings and simulations, as well as in VR games to increase presence in the virtual environment by enhancing proprioception.

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