A Comparison of Zoom-In Transition Methods for Multiscale VR

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Figure 1: The paths for three zoom-in transition techniques which animate the user's pose and scale are shown as colored lines and by four characteristic inset views. (a) OrbitThenZoom first orbits around the target position and then zooms in to it, (b) CurvilinearZoom simultaneously orbits and zooms-in to arrive at the target position and, (c) ZoomThenRotate first zooms to the target position and then rotates to the target direction. A cut-out view is overlaid on the third inset for (a).

ABSTRACT

When navigating within an unfamiliar virtual environment in VR, transitions between pre-defined viewpoints are known to facilitate spatial awareness of a user. Previously, different viewpoint transition techniques had been investigated, but mainly for single-scale environments. We present a comparative study of zoom-in transition techniques, where the viewpoint of a user is being smoothly transitioned from a large level of scale (LoS) to a smaller LoS in a multiscale virtual environment (MVE) with a nested structure. We identify that orbiting first before zooming in is preferred over other alternatives when transitioning to a viewpoint at a small LoS.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**.

KEYWORDS

navigation, viewpoint transition, multiscale virtual environments

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1 INTRODUCTION

A bookmark interface for 3D navigation in virtual environments affords easy re-visitation of important places, which reduces navigation costs. While there are clear benefits to using bookmarks in VR, teleporting to bookmarks can cause disorientation due to the instant change in view direction and peripheral spatial context. To mitigate disorientation, a visual indication of the viewpoint transition helps users maintain spatial orientation by illustrating the process of how to get to the destination from the initial position [Robertson et al. 1989]. Researchers have presented several transition techniques in 3D UI and VR research [Rahimi et al. 2018; Sukan et al. 2012]. However, previous transition techniques were targeted at simple single scale environments, where only the user's position and orientation are animated. An exception is Kooper et al. [Kopper et al. 2006], who presented a transitional target-based navigation interface that enables a user to get inside a smaller level of scale (LoS) nested by larger LoS. Still, the main focus of their work [Kopper et al. 2006] was the navigation interface, while the transition technique involved only a simple linear interpolation of position and scale but not the orientation of the user. We extend the idea of viewpoint transitions to multi-scale virtual environments (MVEs) and investigate how transition techniques affect the user experience and spatial awareness in MVEs where each LoS is nested within a larger LoS. As the first step towards understanding the effect of transition technique on user's spatial awareness in MVEs with nested structures, we study viewpoint transitions from a large LoS to a smaller LoS. While this seems similar to a zoom-in operation in 2D maps, both 3D motions and viewer orientation make this more complex. We thus use the term zoom-in transition for 3D MVEs. We conducted a user study where we evaluated three variations of zoom-in transition techniques in an MVE with a nested structure. Each technique was designed based on previous work but adapted to the nested MVE to ensure effectiveness.

2 USER STUDY

To evaluate the three zoom-in transition techniques in our user study, we recruited six participants. There were five females and the average age was 27.3 (SD = 5.89).

2.1 MVE Zoom-in Transition Techniques

We designed three zoom-in transition techniques that continuously change the translation, rotation, and scale of a user from the initial to the target viewpoint (Figure 1). When passing through opaque obstacles, e.g., walls or table cloth, we use a cut-out effect (Figure 1a) to make the destination visible, to prevent disorientation caused by being temporally blinded right before passing into/through the obstacle. The same effect was applied to all three techniques.

2.1.1 Orbit-then-Zoom. Inspired by a previous approach [Komiyama et al. 2017], we designed OrbitThenZoom to first orbit around the destination at a large LoS and then zoom in to the small (nested) LoS.

2.1.2 Curvilinear Zoom. Like approaches that interpolate the user's position and orientation simultaneously [Sukan et al. 2012], we designed CurvilinearZoom which interpolates position, orientation, and scale, so that the viewpoint is transitioned along a curvilinear path.

2.1.3 Zoom-then-Rotate. We also designed ZoomThenRotate to zoom in to the destination at a small LoS and then rotate the user towards the target orientation at the destination. This is in effect the opposite approach to OrbitThenZoom , as ZoomThenRotate rotates the user's orientation at the end of the transition while OrbitThenZoom rotates at the beginning through orbiting.

2.2 Apparatus and Environment

We conducted our user study with a HTC Vive Pro HMD and two Vive controllers for input. The participants performed the experimental tasks in a 3m × 3m empty area. To evaluate the techniques, we adapted a previous MVE design [Lee et al. 2020] to create an environment where each LoS is enclosed within a larger LoS (Figure 1): a caterpillar lair (level 5), inside a bench (level 4), inside a house (level 3), inside a rock (level 2), within a desert (level 1).

2.3 Procedure

Participants initially performed one practice trial for each transition technique and then moved on to the actual experimental tasks. The task was twofold: a) first, to visit the destination at the smallest LoS by selecting the bookmark icon with a controller to initiate the viewpoint transition. While being transitioned to the destination LoS, participants were asked to focus on the relative position of the female character, called "giant Alice", as seen from the destination (the first characteristic view in each of Figure 1a-c). b) second, once they finished observing the transition to the destination three times, we asked them to travel to the giant Alice from the destination, by using a MVE flying interface [Lee et al. 2020]. Once they finished the tasks for all conditions, they were asked to fill a questionnaire with subjective ratings for each transition technique.

2.4 Results and Discussions

OrbitThenZoom was preferred most while CurvilinearZoom scored highest in ease of use, efficiency, and accuracy. Three participants reported that OrbitThenZoom helped them to locate the destination from the overview which made it easy to understand the spatial context. CurvilinearZoom also received positive feedback in that it was relatively easy to maintain a sense of direction. However, two participants reported CurvilinearZoom caused more disorientation and dizziness, which aligns with a finding from previous work that transitions involving simultaneous translation and rotation cause more disorientation than transitions that separate them [Rahimi et al. 2018]. ZoomThenRotate was least preferred and scored the lowest ratings in all categories. Most participants experienced challenges with completing the task of tracking the relative position of giant Alice using ZoomThenRotate, since that task is challenging. Some even lost track of giant Alice during the rotation at the end of ZoomThenRotate. Thus, changing the orientation at a small LoS seems to be disorienting since the user can only see the directional change at the local level, but not at the global one.

3 CONCLUSION AND FUTURE WORK

We conducted a study to compare three transition techniques for MVEs with nested structures. We identified that the OrbitThenZoom technique with rotational and zoom-in transitions in two separate phases was preferred, while CurvilinearZoom with simultaneous rotational and zoom-in transition seems to support the user better in maintaining spatial orientation. In future work, we plan to compare these two techniques in a larger user study to identify which properties of each technique help users maintain spatial orientation, update their spatial knowledge, and cause less simulator sickness. Also, we will investigate how providing interactive controls for parameters of the zoom-in transition, such as the transition speed and timing, affect the usability of each technique.

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