Navigation and Locomotion in Virtual Worlds via Flight into Hand-Held Miniatures

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ABSTRACT

This paper describes the use of a World-in-Miniature (WIM) as a navigation and locomotion device in immersive virtual environments. The WIM is a hand-held miniature graphical representation of the virtual environment, similar to a map cube. When the user moves an object in the WIM, the object simultaneously moves in the surrounding virtual environment. When the user moves an iconic representation of himself, he moves (flies) in the virtual environment. Flying the user in the full scale virtual world is confusing, because the user's focus of attention is in the miniature, not in the full scale virtual world. We present the novel technique of flying the user into the miniature, providing perceptual and cognitive constancy when updating the viewpoint.

1 INTRODUCTION

A World-in-Miniature (WIM) [1], as shown in Figure 1, is a hand-held miniature 3D map [2]. When the user manipulates objects in the map, the corresponding objects simultaneously update in the full scale virtual reality (VR). This is useful because it gives the user a manipulable *God's eye view* [3] in addition to the surrounding immersive view. We have observed that naive users readily use the multiple views of the WIM for tasks like object placement.

2 NAVIGATION TECHNIQUES USING THE WIM

The camera icon in the WIM represents the user's current position and orientation in the VR. We find that when the user grasps the camera icon and moves it, simultaneous real-time update of the viewpoint is disorienting. An alternative is to defer viewpoint update until after the user releases the camera icon, and use slow-in-slow-out [4] animation of the viewpoint in the full scale virtual world. This is similar to specifying a flight trajectory and then executing that flight through the environment

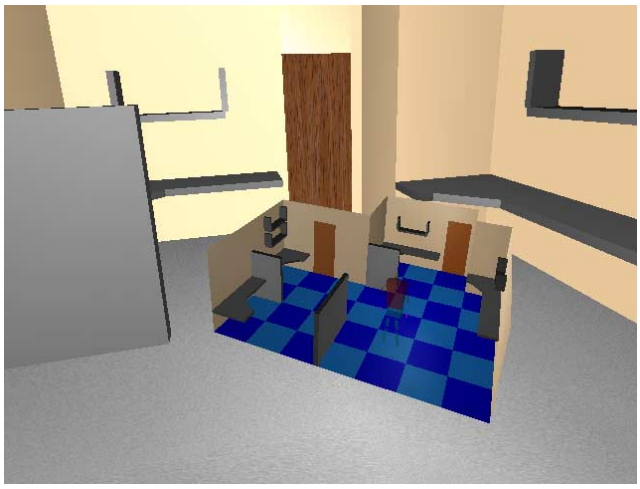

Figure 1: *The World In Miniature (*WIM*) viewed against the background of a life-sized virtual environment.*

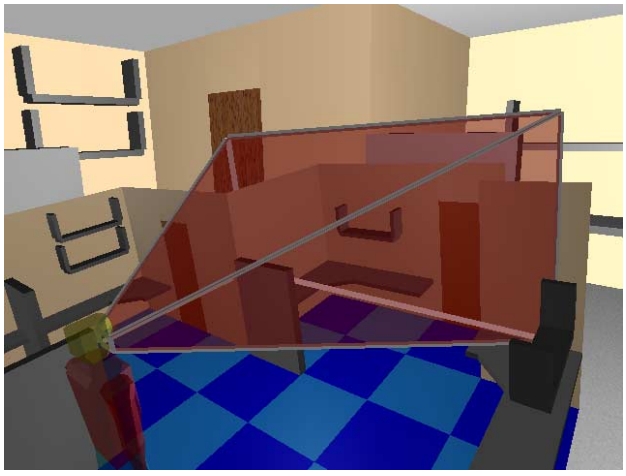

Figure 2: *A frustum which corresponds to the user's view.*

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This is still confusing to users, who react in one of two ways. Some users move the camera icon, and then "hunker down" during the animation; they keep their gaze fixed on the miniature world and wait until the animation around them stops, then look up to regain their bearings in the full scale virtual world. The second usage pattern is to move the camera icon and then lower the WIM quickly, attempting to reorient in the full scale virtual world before the flight begins. Some users requested addition of a delay, to allow them to re-assimilate their location in the full scale virtual world before the flight begins.

We speculate that when users focus on the camera icon, they *cognitively vest* themselves in the miniature. This theory is bolstered by the visceral positive reaction we received when changing the camera icon to an anthropomorphic doll icon. We speculate that users mentally envision themselves to be at the doll's vantage point, a much stronger association that merely using the miniature as a symbolic representation for viewpoint. Users also tend to align the WIM so that they are looking "over the shoulder" of the doll, similar to the way a automobile passenger might rotate a paper road map to align with the current direction of travel.

If the user is cognitively vested in the miniature, any animation between locations in the full scale virtual world requires the user to shift focus from the miniature back to full scale. Therefore, we now take a different approach: when the user releases the doll icon, the system animates the user *into* the miniature. The user *becomes* the doll. Geometrically, this operation involves either shrinking the user, or growing the WIM. In practice, users do not perceive a change in scale of either themselves or the WIM; they merely express a sense of *going to* the new location. As the animation completes, the user ends up in the new position and orientation in a full scale virtual world, which used to be the miniature. The graphics which formed the old full scale virtual world are then faded out, and a new WIM is presented to the user.

3 DISCUSSION

Instantaneously moving the viewpoint has many known disadvantages [5]. The use of smooth animation of viewpoint in the virtual world has two potential drawbacks:

1) the path to the new location may require planning to avoid obstacles, or in the worst case, traveling through obstacles

2) the distance to cover may be very large

When using a WIM-based doll icon, the user is very likely to have a clean line of sight to the doll icon, as he is currently manipulating it. The perceived distance to the new location is always at arm's length; changing scale during what is perceived as a fixed distance is an alternative to flying at great speed over what is perceived as a large distance.

Previous work [2,3,6] has implemented variations on allowing the user to scale the virtual world down to a miniature, select a new vantage point, and then re-scale the miniature world back up using the newly selected vantage point. Our work differs in that we deal with orientation, as well as position, and that our technique does not seem to be cognitively interpreted as scaling by our users.

There are numerous variations on how to display the doll icon in the WIM. One helpful variation is to show a view frustum which corresponds to the view possible from the doll's current location, as shown in Figure 2 We have also found it helpful to have the doll's head mirror the user's head motion in real time, especially when using the frustum.

Using a WIM as a locomotion tool becomes more powerful when using multiple WIMs in the same scene. With multiple WIMs, each WIM acts as a *portal* onto a different, perhaps distant, part of the surrounding immersive world, or to a different world altogether. By moving the doll icon from one WIM to another, the user can quickly transport his immersive viewpoint to another point in space, or to a completely different context.

As a final observation, consider the case where an external entity (e.g. the system or another user), aggressively forces a change in the user's viewpoint. The new location can first appear as a WIM in the current location, providing constancy for the forced navigation.

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4 CONCLUSIONS

Our early experiences with the world-in-miniature (WIM) paradigm led us to conclude that a WIM was useful for some common tasks in virtual environments. However, we found that manipulating the viewpoint and updating the viewpoint via smooth animation in the full scale virtual environment was confusing to many users. We claim that the perceptual and cognitive constancy provided by the technique of flying *into* a world-in-miniature is a useful alternative to smoothly animating the viewpoint in a 1-to-1 scale virtual environment.

We have presented an interaction technique that allows a user to navigate and travel via a miniature 3D map, but avoids the problem of shifting the user's cognitive focus back and forth from the map to the full scale VR. This effort is part of a larger research agenda that acknowledges that virtual reality (VR), like all new media, will eventually develop a set of standard idioms, much as film has evolved to use flashbacks, cross-cuts, dissolves, etc. We believe our technique of flying the user into the miniature may become one such idiom for VR.

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