# HOG on a WIM

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## ABSTRACT

This paper presents a new interaction metaphor for mixed space collaboration: HOG on a WIM. *Hand of God* (HOG) on a *World in Miniature* (WIM) is the first collaborative WIM. It enables a tabletop display user to collaborate with a Virtual Reality (VR) user. The tabletop display user has a god's eye view of the virtual world and communicates with the VR user through natural gestures and speech. The VR user controls a WIM to navigate and manipulate the virtual world with the aid of the tabletop display user's guidance.

**Index Terms:** I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction techniques; I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual reality; H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces—Collaborative computing

## 1 INTRODUCTION

God-like interaction [10] is a metaphor for communication of situational and navigational information between outdoor Augmented Reality (AR) users and indoor tabletop display users. Indoor tabletop display users (see Figure 1) see a god's eye view of the area in which the outdoor AR user is present. Objects on or above the tabletop surface are captured and sent to outdoor AR users. For example, if the indoor tabletop display user points to an area of interest, the outdoor user will see a giant hand—the "Hand of God" (HOG)—come out of the sky and point to the real-world location.

Virtual worlds are good for prototyping and modeling real world places and events that may otherwise be too dangerous or too expensive to experience in real life. They are typically a safe way to explore and understand large worlds or representations of large data sets. Virtual worlds can be extremely large and complex, leading to difficulties in manipulation and navigation. Interaction techniques for manipulation of virtual objects and navigation of virtual worlds is a widely researched field [1, 2, 3, 5, 6, 7, 8, 9, 12]. One technique that supports both manipulation of virtual objects and navigation is the Worlds in Miniature (WIM) [11] technique. The WIM technique enables Virtual Reality (VR) users to gain a god's eye view of the world they are immersed in. This interaction technique gives VR users the ability to manipulate and navigate complex worlds by representing the world as a small manageable representation.

We have combined god-like interaction with a WIM to create the HOG on a WIM, the first collaborative WIM (see Figure 2). It enables tabletop display users to use their hands to assist VR users with navigation and manipulation tasks on their WIM. As the HOG is a complete 3D reconstruction the VR users can orientate the WIM to view the interaction from different viewpoints.

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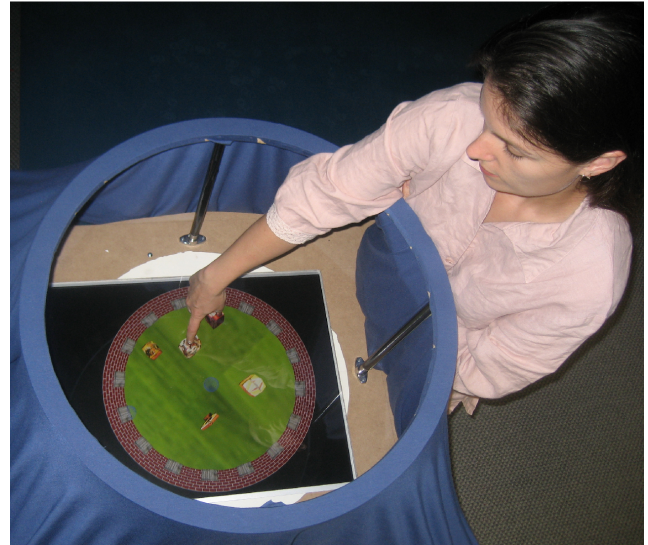†e-mail: wayne.piekarski@unisa.edu.au

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Figure 1: A tabletop display user pointing to an object in the VR user's world. The tabletop display shows a god's eye view of the VR user's world, which includes the position and orientation of the VR user and the virtual objects. The tabletop display user can assist the VR user with navigation and manipulation on the WIM by using natural hand gestures and speech.



Figure 2: The VR user sees a WIM which is registered to their non-dominant hand. Objects from the virtual world can also be seen on the WIM. The VR user sees the hand of the tabletop display user pointing to one of the virtual objects. The VR user navigates and manipulates the objects in the virtual world based on the tabletop display user's gestures and voice communication.

## 2 IMPLEMENTATION

To explore the benefits and limitations of the HOG on a WIM metaphor, we built a VR system in which immersed users are provided with a WIM. The VR user wears an i-glasses Head Mounted Display (HMD) and their head and hand orientations and positions are tracked using a Polhemus 3space Fastrack 6-DOF tracking system. Overlaid on the user's non-dominant hand is a WIM. Most prominent on the WIM are the larger physical landmarks from the virtual world.

We use a similar tabletop display system as presented in Stafford et al. [10]. With a projector based display, objects such as hands and props will be illuminated with imagery from the display image and cast shadows onto the display surface. Instead of a ceiling mounted projector, we use a 30" Apple Cinema HD Display as the display surface thereby eliminating these problems. The display shows a god's eye view of the virtual world as seen in Figure 1.

The table is comparable to a miniature movie set: it has 4 Point Grey Dragonfly cameras to capture the action on or above the table surface. A blue screen around the perimeter of the table affords simple segmentation of the camera images. The cameras are synchronized by a custom MSP430 microcontroller. The textured geometry is sent over a network to the VR rendering station and we use Li et al's[4] algorithm to render the captured object in a single rendering pass. The combination of the VR world and the 3D reconstruction rendering can be seen in Figure 2.

## 3 COLLABORATIVE NAVIGATION

There are a number of ways for the tabletop display user to assist the VR user with navigation:

**Point to landmarks:** virtual objects can act as landmarks to be navigated to. As virtual objects are visible on the tabletop display the tabletop display user can point to an existing object and say "go here". The VR user sees which object is being pointed to; verbal communication assists the VR user in interpreting the meaning correctly.

**Act as landmark:** virtual worlds maybe sparsely populated with landmarks. For navigation to places with no obvious landmarks the tabletop display user can point to an area and say "go here". In this case the hand acts as a landmark for the VR user to navigate to.

**Trace out path:** navigation directly to a final destination may not be appropriate in some case. Instead, a path may need to be followed to reach the final end point. As the hand is updated in real-time the tabletop display can trace out a path. The VR user can follow the hand as it moves around the virtual world.

## 4 COLLABORATIVE OBJECT MANIPULATION

The tabletop display user is also able to provide manipulation assistance in the following ways:

**Show how to rotate:** a tabletop display user is able to point to an object in the virtual world and say "rotate it this way" at the same time as performing a rotation action with their hand in the direction of suggested rotation. The VR user will be able rotate the object in the direction indicated by the tabletop display user. The tabletop display user can see the result of the VR user's rotation as it happens and provide feedback as appropriate.

**Show where to relocate:** a tabletop display user can assist with the relocation of a virtual object with a two step approach:

1. point to an object and say "put this",

2. point to the second location and say "here".

The VR user can pick up the object that was first pointed to and place it at the second location that was pointed to.

## 5 LIMITATIONS AND FUTURE WORK

As with a WIM, scaling issues can occur for the tabletop display user. It is difficult to accurately point to objects that are too small. The solution is to maintain a reasonable scale and scroll the virtual world into view as required.

For the tabletop display user, reaching over the perimeter of the table for an extended period of time produces strain on the user's shoulders, arms, and back. It would be possible to eliminate the screen by using stereo imaging to determine the depth of geometry but this is not currently being considered.

Verbal communication is a critical cue for conveying information about the manipulation or navigation task to perform. A pointing gesture can be ambiguous if it is not accompanied by an action to perform. In our setup, the VR user and tabletop display user are co-located and can communicate without technological assistance. If the two users were not co-located, it would be necessary to use technology such as a phone or Voice over IP to facilitate verbal communication.

The reconstruction approach we use does not generate an explicit mesh. Using a technique that did, the tabletop display user could interact with virtual objects. However, as there would be no haptic feedback, it would be very difficult for the tabletop display user to accurately interact in this way.

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