Chapter 6
World-in-Miniature Interaction for Complex Virtual Environments

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ABSTRACT

Object occlusion is a major handicap for efficient interaction with 3D virtual environments. The well-known World in Miniature (WIM) metaphor partially solves this problem by providing an additional dynamic viewpoint through a hand-held miniature copy of the scene. However, letting the miniature show a replica of the whole scene makes the WIM metaphor suitable for only relatively simple scenes due to occlusion and level of scale issues. In this paper, the authors propose several algorithms to extend the idea behind the WIM to arbitrarily complex scenes. The main idea is to automatically decompose indoor scenes into a collection of cells that define potential extents of the miniature replica. This cell decomposition works well for general indoor scenes and allows for simple and efficient algorithms for preserving the visibility of potential targets inside the cell. The authors also discuss how to support interaction at multiple levels of scale by allowing the user to select the WIM size according to the accuracy required for accomplishing the task.

INTRODUCTION

During the last few decades much research has been devoted to develop new strategies for facilitating user interaction with complex, densely-occluded virtual environments. Among the different approaches that have been proposed for measuring scene complexity, the most relevant one, from the point of view of 3D user interfaces, is *depth complexity*, which depends on the number of occluding objects. Occlusion is a big handicap for the efficient accomplishment of 3D interaction tasks, including selection and manipulation, as most interaction techniques for these tasks require

DOI: 10.4018/978-1-4666-0285-4.ch006

the object, along with relevant context information, to be visible. Navigating to a location where potential targets are visible is a common solution to this problem, but requiring the user to navigate every time an occluded object must be selected hinders performance in manipulation-intensive applications.

In this paper we address the problem of facilitating the interaction with highly-occluded, indoor scenes, focusing on applications running on spatially-immersive displays such as CAVEs. This work is based on the World in Miniature (WIM) (Stoakley, Conway, & Pausch, 1995), which is particularly appropriate for performing tasks requiring relevant context information to be visible. The WIM complements the first-person perspective offered by typical Virtual Reality applications with a second dynamic view of a miniature copy of the virtual world (Figure 1). This second exocentric view of the world helps users to understand the spatial relationships of the objects and themselves inside the virtual world. Objects in the miniature replica of the scene are referred to as *proxies*. Typically the miniature is hand-held, the non-dominant hand being used for rotating the WIM, thus establishing the frame of reference for further interaction tasks, and the dominant hand is used for selection, manipulation, and navigation tasks. Its hand-held feature also allows it to be quickly explored from different viewpoints without modifying the immersive point of view.

The WIM metaphor supports most 3D user interaction tasks, including selection, manipulation and navigation. Objects can be selected either by pointing directly at them or by pointing at their WIM proxy. For simple scenes, a rotation of the non-dominant hand is enough to view and pick objects that are occluded from the immersive viewpoint. Likewise, objects can be manipulated either at the one-to-one scale offered by the immersive viewpoint, or at the WIM scale. By representing the virtual camera with a 3D avatar, the WIM provides a convenient way to quickly change its location inside the virtual environment.

Unfortunately, the WIM metaphor has two important limitations regarding its scalability which have prevented its widespread use. The first one is concerned with the level-of-scale at which different interaction tasks have to be accomplished. Different interaction tasks require, broadly speaking, different levels of accuracy. Since the WIM covers the whole scene, it is appropriate only for rough, coarse-level interaction tasks. For example, a WIM showing a full house might be suitable for quickly moving the camera from a room to another, but it lacks accuracy for finer tasks, such as laying out furniture pieces. Most extensions to the WIM are concerned with this problem. A second major limitation of the WIM is occlusion management, i.e. how to keep relevant objects simultaneously visible while preserving important context information.

A key observation is that many user interaction tasks are *local*, i.e. they can be accomplished with a minimum amount of context information. For instance, adjusting the position of a piece of equipment in a room might be accomplished disregarding the contents of other rooms. This suggests that the part of the scene covered by the miniature replica should be adapted according to the user task. Therefore two key problems have to be addressed. On the one hand, decide which part of the virtual environment must be included in the replica. As stated above, using a replica of the whole environment is only feasible for simple scenes like a single room. Some authors have extended the WIM metaphor to cope with complex models (Chittaro, Gatla, & Venkataraman, 2005; LaViola et al., 2001; Wingrave, Haciahmetoglu, & Bowman, 2006). These approaches define a region of interest (ROI) and put in the miniature copy only those objects inside this ROI. The user is allowed to scale and move the ROI, either automatically or manually. Although these techniques allow the accomplishment of user tasks at different levels of scale, the solutions