DIY World Builder: An Immersive Level-Editing System

Jia Wang* Owen Leach** Robert W. Lindeman†
HIVE Lab
Worcester Polytechnic Institute

(a) (b) (c) (d) (e)

Figure 1. (a) The physical interaction space, with motion-capture cameras, fans, and the passive floor surface, (b) terrain editing with the wand, (c) object creation and manipulation using the wand+tablet, (d) text input on the tablet, (e) lighting control on the tablet.

ABSTRACT

This paper presents an immersive system for building virtual worlds from within the worlds themselves. The system incorporates solutions for editing and texturing terrain, adding foliage, water, structures, and text, adding and controlling lights, including the time of day, and texturing objects in the scene. In a tracked head-mounted display environment, the user controls movement using a hybrid solution combining real walking and pointing-directed flying, and selects and manipulates objects using a hybrid wand and forearm-mounted interaction tablet interface. The user receives immersive cues such as wind from fans mounted around the physical space and audio from headphones. Feedback through a vibrotactile belt and a novel passive floor technique are used to indicate to the user when she is approaching the edge of the tracked space. Preliminary user testing showed positive user experience and suggestions for future improvements.

Keywords: Immersive world building, virtual reality, tablet, wind feedback.

Index Terms: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Input Devices and Strategies.

1 INTRODUCTION

We present an immersive authoring system which provides solutions to many of the required tasks users carry out in virtual environments, including navigation through the environment, creation, selection, and manipulation of objects, symbolic input, and system control [1]. In addition, our system supports terrain (height map) editing, tree- and grass-brushes, ground-texture painting, object texture editing, directional- and spot-light editing, and placement of water bodies (e.g., ponds and rivers). The entire system uses a head-mounted display (HMD), with support from handheld and body-worn input devices.

2 MOTIVATION

Our design was heavily influenced by the short concept film *World Builder* by Bruce Branit [2]. The film centers around a man who builds a virtual world for his partner who is in a coma. The hospital where she is staying supports neuro-holographic input which allows patients to experience full-sensory virtual worlds. The building process begins with the man standing in an empty space, and building up a rich city scene by combining primitive geometric objects, positioning, scaling, and rotating them, applying textures, cutting and pasting objects, applying lighting effects, and more, all from within the world itself. During the world building process, the man uses many interaction techniques, such as hand gestures, image-based group selection, hand- and forearm-based bimanual interaction, and hybrid hand+tablet selection techniques.

3 SYSTEM COMPONENTS

Our system is based around the Unity3D game engine [10], and we have chosen a rich set of input devices to support the user task of immersive level editing.

3.1 Navigation Using CloudWalker

Navigation is accomplished using a technique we call "CloudWalker", a hybrid solution combining pointing-directed flying with a wand and real walking. The wand allows a cloud the user is standing on to be efficiently moved over large distances, while real walking on top of the cloud promotes small scale, precise movement [3]. Indication of proximity to the boundary of the tracked space is provided using a vibrotactile belt with eight tactors arrayed around the waist [6]. In addition, we have implemented a "passive floor" control mechanism for letting the user know where she is within the physical space. The user's footfalls sound and feel different in the center area of the space, as opposed to near the edges. Finally, directional wind feedback is provided to the user during travel to give a deeper sense of motion [11]. The complete system setup is illustrated in Figure 1a. Another method to travel, Worldlets [4], is described below.

3.2 Wand+Tablet-based Level Editing

A novel combination of direct, wand-based interaction with support from a forearm-mounted tablet is used for the main level editing operations of the system. User performance for selecting and manipulating widgets in immersive environments has been shown to be significantly better when a 2D surface is provided, compared to free manipulation in 3D [5]. Because mobile devices such as tablets and smartphones have significant computing power, good connectivity, and rich displays, these devices now provide an ideal platform for tablet-based interaction. We take advantage of the small field of view of the eMagin Z800 HMD to allow the user to view the virtual world straight ahead, and the

*e-mail: wangjia@wpi.edu
**e-mail: oleach@wpi.edu
†e-mail: gogo@wpi.edu

physical tablet with a slight look down at the forearm where the tablet is mounted, as shown in Figure 1b.

Interaction within the world involves setting parameters, changing modes, and selecting properties on the tablet, and applying those changes using direct interaction with the wand. The tablet is running Unity on Android, and the HMD is driven by a desktop also running Unity. Both systems are synchronized, so any changes to the world made on one device are immediately reflected on the other. Similarly, when the user changes between modes, say, from terrain editing to object manipulation, both the tablet and desktop switch together. As an example, if the user wants to apply a texture to an object, the texture is selected from a texture palette displayed on the tablet, and then the wand is used to select the object. Using a Worlds In Miniature (WIM) approach [8], the tablet can also be used to create and select Worldlets which are user-specified viewpoint positions and orientations. The orientation of the Worldlet is set using a single-finger panning motion on a window on the tablet. This technique is also used to point spotlights added to the scene. Users can select a Worldlet to move to by using a Worldlet palette on the tablet. One of the main benefits of our hybrid Wand+Tablet approach is how the WIM and first-person perspectives complement each other, allowing large- and small-scale operations of the same task, such as object positioning and terrain editing [7].

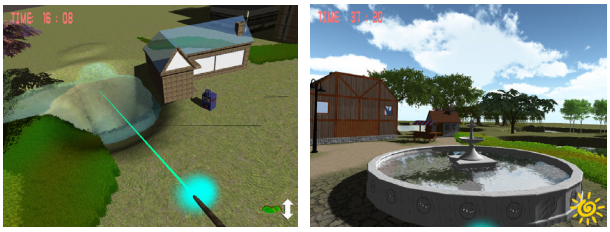
Terrain editing is one of the main subtasks involved when defining levels. Our system provides a terrain height editing brush for lifting, lowering, and aligning areas of the terrain surface, as well as a texture painting brush for applying various ground textures, such as sand, grass, or stone. In addition, various foliage brushes, such as different kinds of grass and species of trees, can be used to place billboard objects, as shown in Figure 1b. Each mode (e.g., grass or trees) also has a "broom" tool, which interactively removes the grass or trees from the scene.

As shown in Figure 1c, objects can be added to the scene using the tablet to select from a palette of existing objects (both primitives and custom-built models) and placing them using the wand. Positioning, rotating, and scaling can be accomplished either using the tablet WIM or the wand, thereby supporting both large-scale movement and fine positioning. Textures can be selected from a texture palette, and applied using the wand. In addition, as shown in Figure 1d, text can be entered on the tablet using the Android keyboard (with support for all Android text-entry methods including Swype [9]), and effects such as font type and color can be applied. The text can then be attached to any object, and will automatically be rotated to be "flat" on the surface intersected by the wand pick ray.

The user can also interactively place and adjust lights in the scene, using the tablet to select light properties, and the wand to place the light in the scene. Adjustment of the light properties, for example the object of focus for a spotlight, can be done either on the tablet or with the wand. Time-of-day presets (e.g., dawn, noon, afternoon) are available for selection on the tablet. This manipulates a directional light and the skybox. The skybox can also be manually selected from a pre-defined gallery. The user can also indicate using the wand the direction they would like to define as "East," and use a rotation gesture on the tablet surface to "dial" the time of day, similar to the *World Builder* movie, as shown in Figure 1e.

4 User Feedback and Future Work

Four users, including one expert, were asked to try our system. After an introduction, each user started with a blank, flat terrain, and was asked to build a level of their choosing. They were free to ask questions and give comments during the exercise. Two sample worlds built by the users are shown in Figure 2. The duration of immersion ranged from 45 to 90 minutes, and feedback was generally positive. All of the users said they would have liked to continue, and that the system was fun to use. Interestingly, fatigue was not mentioned as an issue during the sessions.



(a) (b)

Figure 2. Worlds created by novice (a) and expert (b) users.

We can separate user comments into two categories: feature requests and system improvements. In terms of feature requests, the ability to undo and redo actions, and save and load created worlds were the most common system control features that were requested. One user asked for a way to smooth the terrain better, and the ability to resize trees was requested by three users. Two users asked for more objects, such as leaves, rain, and fish, and the ability to change the water color. Several important system improvements were also suggested. Two users commented that changing the focus from the tablet to the HMD breaks presence and interrupts the flow of interaction. Two users suggested using a larger tablet. Several of the users requested a "sample" tool, whereby objects, colors, or textures currently used in the scene could be sampled, and then applied, which would speed creation of similar objects. Two users mentioned difficulty in judging scale in the absence of any baseline objects. They both started out creating elaborate terrain features, only to find out when they started placing objects (e.g., houses) that the terrain features were very small. One solution would be to display a scale model of a human near the intersection of the wand and the terrain. In future, we plan to extend our system to collaborative world building by adding support for users with different interfaces and roles.

References

[1] D. A. Bowman, E. Kruijff, J. J. LaViola, I. Poupyrev. *3D User Interfaces: Theory and Practice*. Addison-Wesley, 2004.

[2] B. Branit. World Builder. 2009. http://www.youtube.com/watch?v=VzFpg271sm8

[3] G. Cirio. P. Vangorp, E. Chapoulie, M. Marchal, A. Lecuyer, G. Drettakis. Walking in a Cube: Novel Metaphors for Safely Navigating Large Virtual Environments in Restricted Real Workspaces. *IEEE Trans. on Vis. and Comp. Graphics*, vol. 18(4), pp. 546-554, 2012.

[4] T. T. Elvins, D. R. Nadeau, D. Kirsh, R. Schul. Worldlets: 3D Thumbnails for 3D Browsing. *Proc. of ACM CHI'98*, pp. 163-170,.

[5] R. W. Lindeman, J. L. Sibert, J. K. Hahn. Hand-Held Windows: Towards Effective 2D Interaction in Immersive Virtual Environments. *Proc. of IEEE VR'99*, pp. 205-212, 1999.

[6] R. W. Lindeman, J. L. Sibert, E. Mendez-Mendez, S. Patil, S. Phifer. Effectiveness of Directional Vibrotactile Cuing on a Building-Clearing Task. *Proc. of ACM CHI'05*, pp. 271-280, 2005.

[7] W. A. Shafer, D. A. Bowman. Evaluating the Effects of Frame of Reference on Spatial Collaboration Using Desktop Collaborative Virtual Environments. *Virtual Reality*, vol. 7(3), pp. 164-174, 2004.

[8] R. Stoakley, M. J. Conway, R. Pausch. Virtual Reality on a WIM: Interactive Worlds in Miniature. *Proc. of ACM CHI'95*, pp. 265-272.

[9] Swype text input. http://www.swype.com/

[10] Unity Game Engine. http://www.unity3d.com/

[11] J. Wang and R. W. Lindeman. Comparing Isometric and Elastic Surfboard Interfaces for Leaning-Based Travel in 3D Virtual Environments. *Proc. of IEEE 3DUI'12*, pp. 31-38, 2012.