# Building (Disney) Castles in the Air

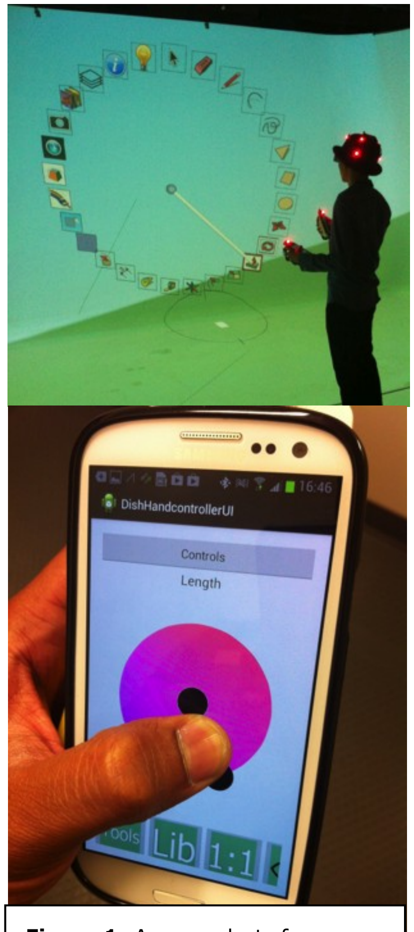


**Figure 1**: A user selects from a floating 3D menu inside the virtual world via a touch screen interface

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## Abstract
Our goal is to create an immersive modeling application that enables users to create complex real-world models comfortably and efficiently. To do this, we augment the power and richness of a commercial off-the-shelf modeling application (SketchUp) with natural and intuitive virtual-reality interaction techniques. We provide two hybrid 2D-3D input devices that combine 6-DoF bimanual interaction, tangible physical buttons, and dual touchscreens for precision and control. Our goal is to leverage the strengths of both 2D and 3D interfaces while avoiding their weaknesses.

## Author Keywords
Context aware, 3D touch, mobile interaction, bimanual interaction

## ACM Classification Keywords
H.5.2 [INFORMATION INTERFACES AND PRESENTATION]: User Interfaces –GUI, Input devices and strategies, Interaction styles;


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## Introduction & Motivation
In spite of a large body of compelling research and demos that indicate that immersive modeling is an effective way to create 3D digital assets, no one has built a VR-based system that can create real-world models more effectively than commercial off-the-shelf (COTS) modeling applications like Maya and SketchUp. Real-world production environments demand intricate 3D models with high levels of detail that are difficult to create in existing immersive modeling applications due to limited feature sets, awkward system control, and unfamiliar and sometimes physically draining interaction techniques that lack precision and control.

Our goal is to develop a system that:

- Supports creation of both rough 3D blocking models as well as detailed 3D design models
- Combines the natural and intuitive power of VR interaction with the precision and control afforded by 2D touch screen interfaces
- Distributes interactions across these input modalities based on their affordances and streamlines the transition between modalities
- Minimizes energy expended in interactions and maximizes comfort in order to support working for extended periods of time (e.g. interaction at a distance, working while sitting, etc.)

We share our experiences in adapting the popular SketchUp application for use in a CAVE. We describe

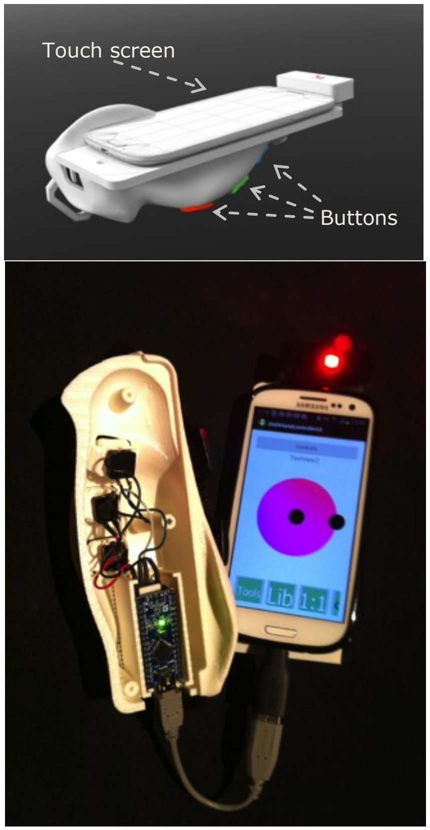


**Figure 2**: Top: A 3D rendering of the handcontroller design. Bottom: The components and internals that make up the hybrid controller

the development and use of the handcontroller (HC) – a hybrid device that collocates 3D tracking, tangible physical input, and touch screen interactions all in one compact package. We also demonstrate how using these hybrid input devices in unison with bimanual interaction and floating 3D GUIs helps to compensate for the absence of the traditional WIMP interface, enables powerful new multi-dimensional interaction techniques, and makes real-world work possible in the virtual world.

## Related work

In the past decade, there has been great interest in using 2D touch inside VEs. Kim et al. [1] investigated walking with fingers on a touch surface to manipulate viewpoint in a VE. Palm pilots were used as an interaction device for 2D tasks in VEs by [2]. Wang et al. [3] utilized a tablet strapped to the arm for operations inside a VE like texture, terrain and viewpoint manipulation. Combining 2D touch with 3D tracking was explored by [4] with the definition of a continuous interaction space and by [5] with their work on anchored multi-touch. Takala et al. [6] incorporated 3D interactions into Blender – an open source CAD application. Two Handed Interactions were successfully used in a 3D modeling application by [7].

## System

*Hardware*

The display of choice is the DISH, a CAVE environment that features 5 stereo projection surfaces – 4 walls and a floor that seamlessly blend into each other. We use Phasespace Inc.'s optical and sensor fusion tracking systems to provide 6 DoF tracking of the head and hands. The hybrid input devices known as the HCs (Fig2) were designed and developed in-house. They make use of both tangible buttons for quick and reliable access to frequently used functions (object and viewpoint manipulation and menu activation) and 2D touch screens for interactions requiring greater precision, expressiveness, or control. The HCs were designed to minimize stress on the user's hands and maximize comfort during long-term use.

*Software*

We use TechViz, an openGL intercept application, to adapt SketchUp for VR viewing in the DISH. A custom SketchUp plugin was developed to communicate with the HC units, simulate mouse and keyboard inputs, update view transforms via the Techviz API, update 3D visual representations of hands, and generate a host of floating 3D GUIs that enable rich interactions in the VE. User interaction with the smartphones was achieved by a custom Android application.

## Interaction

In order to accomplish real world tasks, we use a combination of 6-DoF bimanual interaction and 2D touchscreen interfaces.

*View and object manipulation*

View navigation and object manipulation are primarily achieved via the Two Handed Interface (THI) [8], which enables free form translation, rotation and scaling of the world about the user and objects in the world. We include several other forms of viewpoint manipulation such as Two-handed Fly and Scaled World Grab [9].

More complex forms of object manipulation are accomplished using SketchUp's rich suite of modeling tools. The relatively closed nature of SketchUp's API, however, requires interactions with native SketchUp tools to happen via mouse emulation. This fact,

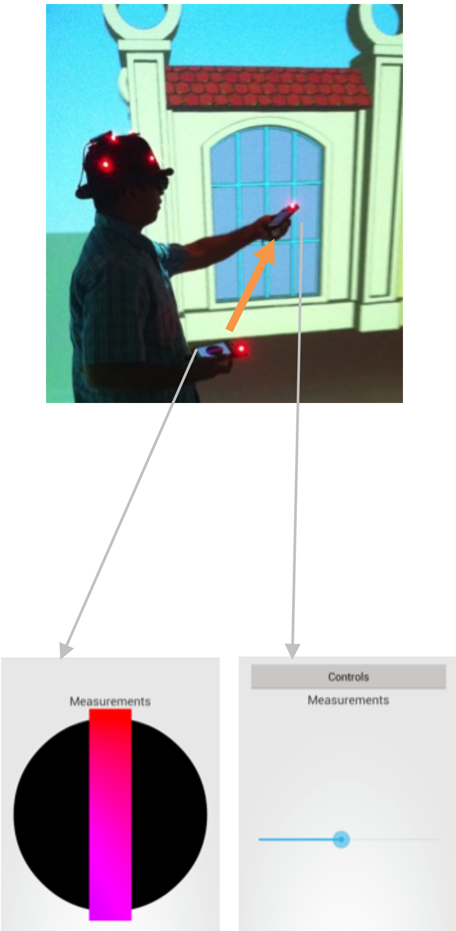


**Figure 3**: A user performs two handed fly using the vector between the hands and simultaneously adjusts the rotation angle and traversal throttle through touch screen interfaces

combined with our desire to enable interaction at a distance, prescribes our use of image plane interaction techniques [10] for interaction with SketchUp native tools. Custom or open SketchUp tools, on the other hand, can take advantage of full 6-DoF interactions.

*Touchscreens in Virtual Environments*

We provide dual touchscreens, one for each hand, to augment the direct bimanual interaction. We believe there are several benefits to this approach. Most importantly, one can use 2D touchscreens to provide context sensitive 2D interfaces that are rich, expressive, and easy to use. Using 3D interactions for purely 2D tasks, on the other hand, results in cumbersome experiences and wasted effort. Touchscreens can serve as both input and output devices and can provide stabilizing haptic surfaces for more precise interaction. Finally, using touchscreens instead of immersive menus means that users can keep their hands comfortably by their side and make selections with a minimum of effort (moving thumbs not arms).

*Dual Touchscreen Interaction*

With dual touchscreens users can interact and input data simultaneously on both devices. An example is the paint tool, where the left screen allows control of Hue and the right screen allows control of both Saturation and Value, thereby allowing simultaneous control of 3 dimensional variables.

Spatially aware 2D touch can be used to augment 3D interaction. When using two-handed flying for view navigation, for example, the vector between two tracked hands defines the fly direction and its magnitude the speed. GUIs are activated on the touch screens to simultaneously define the throttle multiplier on the leading hand and direction of rotation (yaw) on the trailing hand (Fig3).

Dividing touch interactions between two such screens helps to clearly distinguish and allocate interactions based on their nature and context. The non-dominant hand (NDH) primarily drives menu selection using simple interactions. Touch interactions on the NDH are designed to depend on proprioception and we represent the effects of those interactions using floating 3D GUIs (Fig1). This design reduces the need to look down at the HC and helps preserve immersion.

The dominant hand (DH) is reserved for context specific input and interactions that require fine or precise input. For example, when using the texture tool, the GUI on the DH switches to a gallery of texture options. Users can then touch the texture of interest and apply them to any surface in the VE. The touchscreens are then used to perform multi-touch interactions at a distance to translate, rotate or scale the applied texture with respect to the face.

*Precise input and feedback*

Although 3D interaction provides a very natural way to create shapes or content, noisy tracking data often results in imprecise models. Touchscreens alleviate this problem by enabling precise alphanumeric input. Touchscreens can also stream and display context information, thereby providing real-time feedback to the user about the dimensions of the objects as they are creating them. This allows for the user to focus first on the form and then fine tune to fit to specifications using alphanumeric input (Fig4).

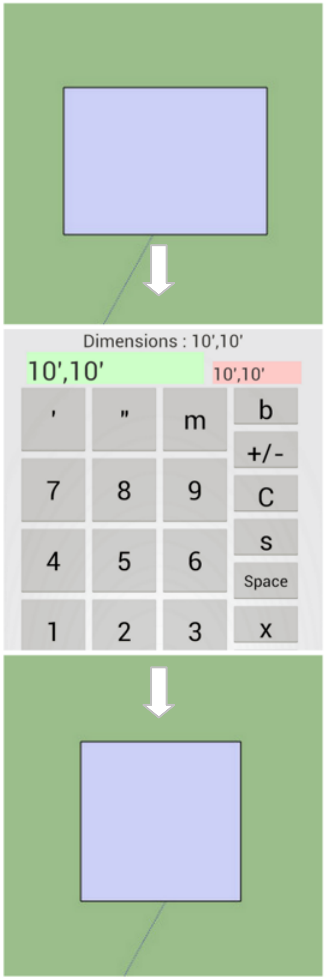


**Figure 4**: A user starts with a coarse shape and then fine tunes it to precise values

## Conclusions and Future Work

The goal of our research is to create a real-world modeling application in a virtual world. To this end, we use 6-DoF bimanual interaction techniques combined with 2D touchscreen based interfaces. Our philosophy is to use the interaction modality that makes the most sense for the task at hand rather than applying a one-size-fits-all approach.

We introduce the handcontroller, a hybrid device that collocates 3D tracking, tangible physical input, and touch screen interactions all in one compact package. We demonstrate how the touchscreens on the two HCs and the floating 3D GUI form a triangle of interaction, allowing users to easily transition between 2D and 3D tasks.

In the future we will continue to explore the rich possibilities afforded by this hybrid approach. Areas of opportunity include developing support for complex hierarchical menus, leveraging touchscreens for spatially aware specification of constraints during direct object manipulation, using touchscreens for fine grain object manipulation through vernier control and the ability to nudge objects, and the exploration of new dual screen multi-touch input techniques.

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