

# ShadowLight: A Flexible Architecture for Immersive Rapid Prototyping and Design

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## 1 Introduction

ShadowLight™ is a virtual reality application that provides a spatially immersive environment for rapid prototyping and design. Rather than restricting users to the fixed toolkit of artistic or construction-centric manipulators of traditional systems, it provides a novel degree of flexibility by supporting a plugin architecture that allows the designer to utilize high-level components as the design media. Through this architecture, developers can create new functionality that integrates seamlessly with other elements in the ShadowLight framework. Each plugin provides its own interaction and simulation logic, allowing plugins that support static brush strokes to coexist with animated objects and complex physical simulations. Once a plugin is created, it may be used as an element on the designer's palette to be freely utilized as the media for creation. A given design created in ShadowLight may consist of interactively drawn static brush strokes and polygonal elements side-by-side with interactively placed intelligent agents and physical simulations. ShadowLight provides a consistent and intuitive interface to this functionality, seamlessly integrating the differing media into a single design environment.

## 2 Background

Conventional media do not provide an intuitive environment for the expression and refinement of spatially oriented design. Traditional computer modeling software systems present a three-dimensional medium, but partially negate the effectiveness of that medium by constraining the user with a two-dimensional interface both during creation and in experiencing the resulting world. Physical models provide that three-dimensional interface, but often impede the iterative refinement process by making modifications more difficult. Design evaluation at full-scale is usually impossible due to technical and cost constraints. Virtual prototyping applications seek to address these issues and provide a more natural environment for design by exploiting immersive virtual reality. However, current virtual prototyping applications are mostly relegated to highly specialized industry-specific tools with limited interactive manipulation capabilities.

## 3 Experience

ShadowLight provides a loosely defined environment capable of sustaining interactive schematic design using a variety of virtual media types. Rather than providing a built-in set of manipulators keyed to a particular set of design tasks, ShadowLight instead defines a basic set of interfaces against which third party plugin authors develop. These plugins are self-contained applications, with their own interaction, processing, and simulation logic. ShadowLight dispatches user interaction events to plugins, but each plugin is responsible for taking its own actions based on that input. This allows for a very diverse spectrum of possible plugins, ranging from simple drawing tools to complete embedded simulations. The ShadowLight environment provides more services to the developer than traditional VR libraries. For example, a plugin to create freeform ribbons or tubes may have a

very simple click-and-drag interface to draw a new shape in space, while a sculpting tool may have significantly more complex interface needs. A physical simulation, such as a fluid flow, might have any number of input and interactive control parameters. The plugin architecture allows that fluid flow to integrate with other plugin elements in the same virtual world. In each case, the plugin developer is entirely free to leverage devices ranging from floating palettes and popup menus to proprietary widgets and gestural interfaces. The output of each plugin is a set of objects added to the space. In the case of sketching or sculpting tools, these objects may be static polygonal meshes, while in the case of more advanced tools, the result might be dynamic bodies with highly evolved behaviors.

Design in ShadowLight is based around the notion of a "world", defined as an infinitely bounded space that serves as the medium in which the designer composes. To interact with this world, a six-degree of freedom "wand" is used which provides three buttons and a joystick. The wand is tracked over a certain physical space in front of a stereo-projected surface, such as a CAVE™ or ImmersaDesk™. The user may navigate about the world by pointing the wand in the desired direction of travel and pushing forward on the joystick. No global collision detection is performed, so the user is free to travel to any location in the world through any path, to freely explore the space from locations not possible in real life.

## 4 Conclusion

ShadowLight has been actively used by University of Illinois architectural design students, local middle school students and the United States Army. Over its three years of continual use, ShadowLight has evolved considerably to better fit the needs of its users. The plugin model of the latest version was designed specifically to allow the application to mediate among these widely varied needs. To an architect, ShadowLight is a virtual prototyping tool, while to a middle school student, it is an educational platform, and to a military researcher it is a rapid evaluation environment. In short, ShadowLight becomes a different tool to different people, based on the available plugins that are created for their needs, providing an atmosphere in which an idea may be intuitively created, explored, evaluated, and refined, using whatever combination of instruments, interaction, and media makes the most sense.

