I-DRIVE: Inserting Dynamic Real Objects into Immersive Virtual Environments

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The Challenge

Virtual environments (VEs) are usually static models with which the user has little or no interaction. Why is that? Standard input devices—joysticks, keyboards, etc.—do not closely mimic natural motions, such as grabbing and pushing. While VE researchers have made significant advances in rendering, tracking, and hardware, we look to address two areas that are currently done poorly: visually faithful user representations, *avatars*, and natural interactions with the environment. When users move their arms into the field of view, we want to show accurately lit, pigmented, and clothed arms. When they carry real objects into the environment, we want those objects to affect the virtual environment. We want a *hybrid reality*, where real and virtual objects can dynamically interact.

The user is reconstructed and inserted into the virtual environment in real time with properly resolved visibility. The system provides the user with a visually faithful avatar that can naturally interact with the virtual environment. *Top:* The user manipulates blocks, while he sees a reconstruction of his hands and the blocks in the HMD. *Above:* The visibility of the user's avatar is correctly resolved with the virtual teapot.

Highlights

- **We are building *hybrid realities*, a new *type* of Virtual Environment (VE) that uses new rendering and interaction algorithms to incorporate real objects into virtual environments.**
- **Hybrid realities allow real objects to *affect* the virtual environment (simulations, lighting, shadows, collision detection/ response).**
- **We are investigating the effect of rendering and interacting with real objects on task performance and presence in virtual environments.**

The Approach

The core questions are, "How do we generate models of dynamic real objects in real-time?" and "How can we use these representations of real objects, such as tools and the user's hands, as dynamic input devices in the virtual environment?" Our research involves real-time reconstruction algorithms to: (1) render avatars and (2) enable natural interactions in VEs. We have built a prototype system for generating approximate models of the user and other real objects in real time.

Reconstruction Algorithm. We use a set of outside-looking-in cameras and a novel *visual hull* technique that leverages recent advances in graphics hardware. Images from each camera are examined and the pixels that make up the real objects are extracted. Next, a volume querying technique asks, "Which 3D points are within the visual hull of real objects?" We accelerate this computation by using projected textures of camera images. Our system bypasses an explicit 3D modeling stage. It generates results in real time. We detect collisions with the reconstructed object by testing for intersections between the real object's visual hull and the virtual object geometry. In an example VE, the user can reach out and interact with a virtual cloth system. The system renders the user within the scene and the cloth dynamically responds to it.

Avatars and Natural Interactions. The system allows us to investigate whether interacting with real objects and visually faithful avatars improve task performance and presence in virtual environments. For example, if someone is training on a real piece of machinery, things look right (he sees himself and the real equipment within the virtual environment), feel

A NASA engineer uses real parts and tools to interact with a satellite payload model. In this demo application, he is evaluating different payload layouts to determine whether there is enough space to mount the white tube and then to attach the connector to the center of the assembly. The real-time reconstruction system flags collisions between the real objects (user, parts, tools) and virtual payload models.

right (haptic feedback of handling the real equipment), and interact naturally. Further, since the real objects have corresponding real-time-generated virtual models, a simulation running within the virtual environment can *react* to them.

Applications. We are collaborating with the NASA Langley Research Center on applying our system to a payload design evaluation to flag possible assembly, integration, and testing problems early in the project development cycle. With the critical time constraints that payload development is under, the ability to test multiple design alternatives quickly would be valuable. Further, any potential difficulties that can be recognized early would result in a substantial savings in time, personnel, and money.

Project Leaders

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Key Words

Virtual environments; avatars; rendering; human computer interaction

First person view. A user pulls apart virtual curtains to look outside a window. The reconstruction system is generating real-time models of the user, and the cloth simulation reacts to the collision with the virtual avatar of the user's hand.

Third person view. A user wears a head-mounted display and is interacting naturally with a virtual curtain simulation. The user is not carrying any specialized tracked devices.

Selected Publications

Lok, B. "Online Model Reconstruction for Interactive Virtual Environments," *Proc. 2001 Symposium on Interactive 3D Graphics*, Chapel Hill, N.C., 18–21 March 2001, 69–72, 248.

Lok, B. "Avatar Advances," *Computer Graphics World*, 24(2), February 2001, 17–20.

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