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3Design - Holographic Telecollaboration Interface

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Introduction

For Senior Design, Fall 2012, our class was tasked with one of two goals: either improve upon an existing product in a significant, quantifiable way, or develop a new piece of technology that solves a feasible, clearly articulated problem.

Our team consisted of two Computer Science majors (Scott Freemon and myself), one Computer Engineering major (Preston Garland), and one Electrical Engineering major (Mark Gill). All interested in new forms of media, we looked for a project that would combine custom hardware with the larger-scale programming resources at hand. Multiple members of our group had been recently investigating the topics of motion tracking and three-dimensional display, so we eventually decided to attempt combining the two (citing the CAD interface from the *Iron Man* films as solid enough evidence that, should such a thing be able to be constructed, it would be well worth whatever investment it took to do so). We scaled back to simply attempting to create an interface that would appear three-dimensional, be viewable from all angles, and allow intuitive touch- or gesture-based control for natural user interaction.

Eventually, a potential need for such a system was stumbled upon, and we elected to orient our project to the common scenario in which a team of designers is geographically scattered. Encountering the difficulty in describing a three-dimensional form as we attempted to discuss the project over the phone and videoconferencing, we realized that our project could be beneficial to architects, product designers, and other individuals looking for a way to get the hands-on experience from around the world. We thus created a second model and connected the two together, with the idea that when one person manipulates the object, it would produce the same effect at the other end: as though all connected were sitting around a table.

Development Cycle

The first prototype was constructed out of cardboard as a means to test the "holography" technique. Deciding that a goggles-based system would lose the primary advantage of providing vision to an entire conference room and finding other means of three-dimensional display to be either limited in viewing angle or significantly out of our financial reach, we decided to go with a classic technique called "Pepper's Ghost" that had been used to great effect during the Coachella 2012 music festival. Displaying four images (front, back, top, side) on a horizontal, high-brightness screen such that each view is reflected in a pyramid, the illusion of a floating, volumetric object is created. By raising the pyramid onto stilts but keeping the screen at eye- (or desk-) level, we allowed for a user to reach under the device and attempt to touch the image.

Our main setback was the lack of proper motion tracking equipment: we had intended to use the high-resolution finger tracking sensor *Leap* by upstart Leap Motion. However, the product – initially announced to be released in October – was delayed until February, leaving us with the need to improvise.

We attempted to use a Microsoft *Kinect* depth camera, which had served as our original inspiration, but found that the minimum distance required was too large to be used in a hand-focused mounted application (such cameras being intended for room-scale body-tracking rather than desk-scale finger-tracking). Eventually, we resorted to using a normal webcam and designed the structure to allow localization of fingers placed vertically under it; we also simply decided to place more emphasis on gesture controls. Fine motor control was thus significantly more difficult to achieve, though using a brand of fairly common webcams did substantially reduce the project's cost.

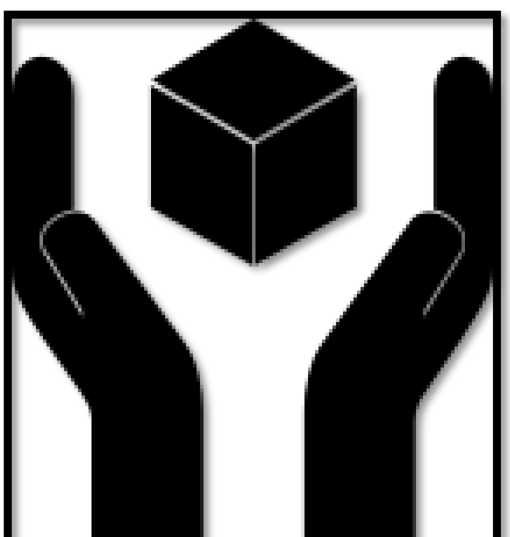
While the first prototype was cardboard, the second was built largely out of industrial-grade materials (polycarbonate, zinc-plated steel) in an effort to be robust. Our final model was constructed out of wood; while the Mark III did indeed look more like a prototype than its predecessor, it was a cheaper, more user-friendly, and ultimately a more refined system (as well as one that boasted a much improved bulk-to-viewable ratio). Though improved, our second device was still serviceably functional, so the end product consisted of connecting Mark II to Mark III; this development ended up working to our favor, as it made us realize that more options were open for the project's use. An artist on an airplane, for example, could design a 3D model on a normal laptop and get immediate feedback from a team sitting around a *3Design* unit somewhere on the ground. The non-homogeneity ended up being an unexpected positive outcome.

Implementation

The driver software for the devices was developed using the C++ package *openFrameworks*, which allows for high-speed rendering while also sporting cross-platform support (out of our four team members, only two used the same operating system, and they used different versions). The framework also incorporated the *Asset Import Library*, which allowed us to load objects from a variety of sources including animation tools and certain drafting packages.

A California-based display company was used to obtain panel-mount industrial displays so as to provide the brightness necessary to make the images daytime-viewable.

Media



3Design Logo,
Adopted from Public Domain
via *The Noun Project*
http://thenounproject.com/

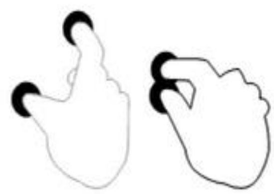
Logo on Lid (Laser-Etched)
3Design Mark III

Right to Left: *3Design* Mark I, II, and III

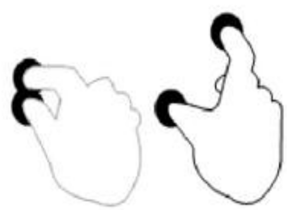
Mark III In-Use

(Off-Camera: Mark II, across the table, displaying the home being rotated)

Use a pointing gesture to highlight a portion of the image. The pointing gesture is used to focus other users' attention on a specific area for discussion. Execute the pointing gesture by holding one finger out underneath the object.



Use a pinching inwards gesture to zoom out allowing more of the object to be viewable. This is executed simply starting your fingers a few inches apart and bringing them together.



The reverse pinching gesture zooms in towards the object. Execute the reverse pinch by starting your fingers together and moving them away from each other.

Snippet from the *3Design User Manual*
(written by Preston Garland and Mark Gill)

Conclusion

While a laptop overheated during the demonstration that hindered the presentation, the project – though falling short of its *Iron Man* inspiration – was still a functional proof-of-concept that incorporated programming, woodworking, circuitry, and a bit of mathematics. "Finding a need and filling it" within a semester's timeframe while still exploring a project that involved our group's particular set of skills and interests took some solid discussion to get rolling, but the thought process and development cycle were a fantastic exercise. I was exposed to a variety of skills and knowledge from my teammates that I would otherwise have never encountered, and I was able to pitch in with my own set as well. On both a technical level (implementing the finger tracking and display scaling) and an interpersonal level (coordinating among a loosely-organized team of students), the project was ultimately a thoroughly rewarding experience.