3-D Visualization

OFFICE OF THE FUTURE

BY CAMERON CROUCH

Imagine walking into your office to find a 3-D virtual model of your latest architectural design hovering above your desk. You flip a switch and in front of the desk appears a window through which you can see your colleague, in his office in Tokyo. You are able to collaborate in real time, with your colleague simply turning his head to see the other side of the model, as if he were in the office with you.

This is a vision of the "Office of the Future" proposed by a group of computer scientists who use digital projection as the building block for new 3-D display and communications technology. The project is being conducted at the University of North Carolina at Chapel Hill by research associates Greg Welch and Herman Towles, under the direction of Prof. Henry Fuchs, along with Prof. Andy van Dam of Brown University, Prof. Kostas Daniilidis of the University of Pennsylvania, and Gwendolyn Huntoon at the Pittsburgh Supercomputing Center.

OFFICE OF THE FUTURE SKETCH BY ANDREI STATE

Office of the Future has two main components: one is the display of computer imagery in designated areas of the office; and the other, called "tele-immersion," strives to capture the office and its contents and display it elsewhere for the purposes of real-time, 3-D collaboration. Central to the project is the idea that, in the future, we will interact with projected computer imagery displayed all around the office rather than sit in front of a computer monitor.

"With projectors, the computer imagery becomes part of the office, not just displayed on it," Welch explains. "Spatially, it's a much more natural interaction, especially if you want to collaborate."

Although challenges remain, this display turnover may lurk just around the corner. Welch and Associate Professor Gary Bishop before him have already set up a simplified version, dubbed the "Office of Real Soon Now," in their own offices. They replaced their traditional cathode-ray tube (CRT) computer monitors with three DLP™ (Digital Light Processing) projectors that display imagery on the walls. "I have two projectors on top of a bookshelf which project images abutted on a whiteboard on the wall," Welch says. "The third projector hangs below the shelf and projects images onto a whiteboard within a shelving unit on a side wall."

An advantage to the ample display is that images can be viewed from many angles and at a more comfortable distance than traditional monitors. Rather than sit at a desk, Welch now sometimes sits on a recliner and types on a keyboard perched on his lap.

With his PowerMac and video cards Welch can configure the dual projectors to create one large work area. He uses the large abutted images of the two projectors for collaboration with students or other visitors, keeping the third projector for more private work. Office of Real Soon Now employs standard, off-the-shelf equipment. To reduce the heat and noise generated by the projectors, Welch has his vented into the ceiling.

In the envisioned Office of the Future, imagery won't be restricted to projections on flat, square, whiteboard surfaces. "Today we have to mechanically align projectors, which is difficult," Welch explains. "We're working on software that would automatically align the imagery based on closed-loop feedback from cameras that continually look at the results of the projected imagery," allowing users to "wrap images around a wall or project them over bumps."

"We want the system to adapt to the structure of the office, not have the structure of the office have to be adapted to fit the projector," he said.

FUTURE COLLABORATION

The Office of the Future vision also includes cameras for capturing the office — and what's being projected in it — and displaying it remotely in 3-D. "We envision units that look like track lights that are both cameras and projectors," Welch said. "When you want to collaborate, your colleague could view your office in some sort of 3-D window and see around as if they were there."

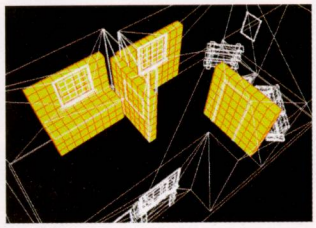
Barriers to tele-immersion today include the vast network capacity real-time rendering requires and the computational algorithms and speed needed. Despite the complexity, Welch's team has worked with the University of Pennsylvania and the Pittsburgh Supercomputing Center to achieve a real-time reconstruction of a room. "We're doing reconstructions

of rooms at a speed and quality we'd hope to have in normal computers in five to ten years," he said.

Welch doesn't foresee the tele-immersion component of the Office of the Future as something people will use all the time — just about five percent of the time, for collaboration.

LIFE-SIZE PROJECTION

At the heart of the Office of the Future is the notion of complete and immersive 3-D-display technology. "Today, people call 3-D-computer stuff '3-D,'" Welch said. "Internally, within the computer, it is. But the real visual aspect is usually only two-dimensional." Welch and his team are also working with projectors to display three-dimensional models that overcome the need for stereoscopic, head-mounted displays or goggles.



"BEING THERE" BLOCK MODEL

Called "Being There," the project consists of simulating architectural elements, such as a brick façade, a window, a painting, or a doorway, by projecting their images onto life-size physical models. "You take large Styrofoam blocks and build a rough approximation of a room," Welch said, then project images of the room onto them, simulating the appearance of the room. "We did it with Thomas Jefferson's library at Monticello."

The effect is a virtual environment that is both visually and spatially realistic. More than one person can view and move around the virtual space simultaneously. "Projector-based displays are fixed to the environment not your head," Welch explains. "It's difficult to walk around a room with a head-mounted display since two channels of video are fed to your head at all times, and there's a limited field of view."

While museums trying to recreate historical settings are likely to be the main adopters of the technique, Welch has been discussing the project with a person who wants to use it for architecture — to teach the structure and layers of a classic European cathedral.

'VISIONSTATION'

A North Carolina company, Elumens, has developed an approach to 3-D visualization that uses projectors within an immersive workstation. Its VisionStation consists of a standard projector, specially designed lens, and a 10-ft.-wide hemispherical display — large enough to cover the viewer's entire peripheral vision. When a 3-D image is projected onto it, the viewer or viewers feel like they're walking into the building or space — even without wearing a head-mounted display or 3-D goggles.

"The nut of our approach is to provide a wide field of view and a good sense of 3-D and immersion with a single projector and lens," said Eric Knisley, technical coordinator at Elumens. While similar systems use multiple projectors to stitch together images, Knisley said the VisionStation uses a single projector, making it easier to use and also cheaper. "But the trade-off is that you're limited to the resolution of the single projector. With three projectors, you get a combined resolution of all three."

The standard VisionStation costs about $20,000 and includes video encoding software that lets one create high-resolution 3-D animations on a mid-range computer. While Elumens first targeted the architectural market with VisionStation, Knisley said most architects have found it too expensive. "We've had more success at schools doing architectural visualization work like Kansas State University's School of Architecture and North Carolina State's School of Design."

VisionStation supports any of the high-end 3-D modelers like 3-D Studio Max, Knisley said. Once the 3-D image is rendered with one of these tools, Elumens software is available to correct the image so it will display properly on a dome, rather than a flat surface. At Kansas State, the system has been used for animated presentations, viewable on the VisionStation dome. Knisley said movies can be created using editing software such as Adobe Premiere, and played using Elumens' video encoder.

VisionStation has also been used for simulation and training. "The Department of Energy uses it to do walk-throughs of its new buildings," Knisley said, to visualize any problems with occupancy such as "if there's room in the hallway to pass" or "if you can see the exits from a certain spot." Although Elumens does offer models with stereoscopic goggles, their philosophy is to not require them.

Knisley said while the focus of the product has been 3-D display, its real future lies in design. Teams can collaborate on 3-D CAD or animation projects using Virtual Reality Modeling Language (VRML), he said, but image quality is lost due to slow network speeds. Collaborative 3-D design, like the 3-D display communications of the Office of the Future, is still waiting for the required network capacity. ●

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