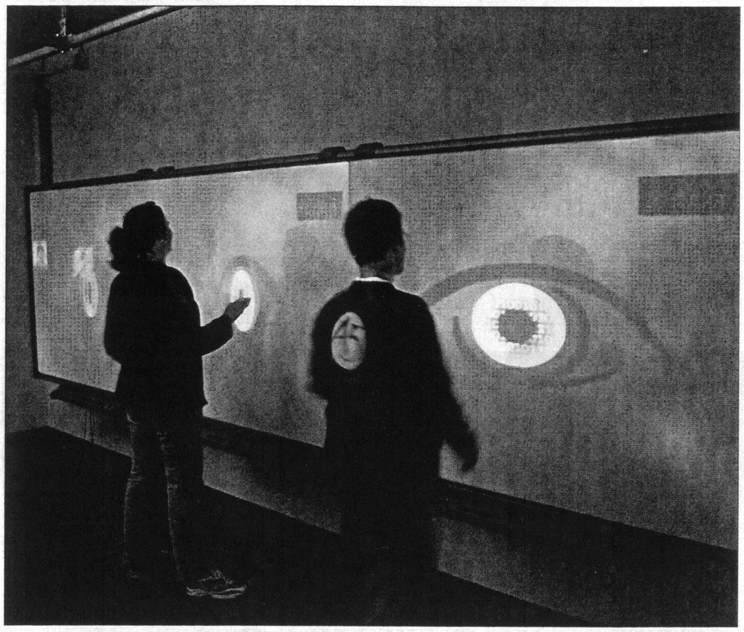
PROJECTING A GOOD IMAGE

Shadows are the bane of projector users. They're also a barrier to interactivity.



The first of its kind, a custom 18-foot-long by 5-foot-tall interactive whiteboard from Smart Technologies serves as an innovative educational tool for students in the College of Computing at the Georgia Institute of Technology in Atlanta.

by Tim Kridel

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IT'S A problem as old as projectors themselves: Somebody is in the way. It's even worse if the image is projected onto an interactive surface, such as an electronic whiteboard. That combination of problems prompted Gregory Abowd, an associate professor in the College of Computing at the Georgia Institute of Technology in Atlanta, to call Smart Technologies, which makes interactive whiteboards. But Abowd and his colleagues wanted to tackle more than just shadows.

"He said, 'I want to put a Smart Board without any seams at the front of a classroom,'" says Dave Martin, chairman and co-CEO of Smart, based in Calgary, Alberta. "We said, 'Gee, could you come back in a couple of years?' He was quite insistent and said, 'No, no, we've got people who need this type of thing sooner than that.'"

Roughly one year later, the group got what it wanted — or at least the genesis of their concept: an interactive whiteboard nearly 18 feet long and almost 5 feet tall. The prototype is based on Smart's Digital Vision Touch (DViT) technology, a camera-based system that enables touch on any part of the surface. "The lens is quite unique in allowing us to build a view at a 90-degree angle," Martin says.

A standard Smart Board features a set of four cameras that look across the 84-inch surface. That arrangement lets the system calculate X, Y, and Z axis information as the user interacts with the surface. Georgia Tech's system uses three side-by-side Smart Boards and a total of 12 cameras — that's enough real estate for at least three people to use the board simultaneously and still have ample elbow room.

"We're trying to figure out a way to create a world in which you could project some computer-generated imagery on any surface," says Abowd, who's been working on classroom technologies since the mid-1990s. "We've been doing this with a lot of electronic whiteboards, but we've been limited by the size of the interactive surface. I wanted to break away from that constraint."

challenge. "People prefer rear-projected displays, but the current technologies we have for providing this don't scale particularly well," Abowd says. "There are some deployment difficulties with certain versions of rear projection. You need a certain amount of space either above or behind the display that's often not available or costly to get, and once installed, it's not easy to move the display to other locations. Those deployment difficulties are largely avoided when you work with front projection."

Although the obvious downside to front projection is shadowing, this approach had enough benefits that researchers decided to figure out a way to deliver a user experience on par with rear projection. The result: virtual rear projection (VRP). "It basically amounts to suppressing the light that hits someone standing in front of the projector, while also removing or at least minimizing the shadows," Abowd says.

There are a couple of ways to do that. One is to warp the image by projecting it at an oblique angle, effectively pushing the shadow at least partly out of the way so it's not falling in the spot where the user is interacting with the surface. "A simple version of this is available today in projectors that provide keystone correction for one axis of error," Abowd says.

Adding a second projector, also at an oblique but different angle, and with the pixels aligned, produces a half-shadow effect. "So even though you see the artifact, the audience can see through the shadow to what's behind it," Abowd says.

The researchers conducted a study to see if users preferred one over the others. "The passive VRP was significantly preferred over the easier-to-deploy and cheaper front and warped versions, but not as good as rear-projected," Abowd says. "This means that there's value in exploring dual-projection modes to minimize the impact of shadows, but if you want to get to the satisfaction level of rear projection, you need to do something more."

Passive and proactive

If a camera trained on the projected surface knows what the image should be, it can detect where the shadows are being cast. The system then can determine which pixels are affected and which projector can reach that portion of the screen. "If you do that for both of them, then you can remove most of the artifacts of the shadow," Abowd says.

That kind of setup can correct at a maximum of about 8 to 10 frames per second, but the shadow removal is still detectable, Abowd says. More sophisticated algorithms, a faster processor, or both could speed up the correction, but the approach is ultimately limited by two factors. For one, it's a reactive approach: Look at the display, see the shadows, and then correct them. For another, it's only as fast at the projector. So if it projects, say, 30 times per second, the system can't correct any faster.

Another approach is proactive: Use a camera to detect obstructions, and then correct the image before it's projected, eliminating any

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projector-induced delay. "This is similar to how iSkia from iMatte works," Abowd says. The Georgia Tech system demoed in conjunction with Smart Technologies at InfoComm 2004 flooded the field around the display with infrared light so that the camera, equipped with an IrDA filter, could pick out the obstruction. (A video of another demo is available at www.cc.gatech.edu/~summetj/movies/ WAgame.AVI.)

To make the surface interactive, input must be coupled with output. One way is with a camera trained on the display, which provides a coarse level of interaction, such as the ability to press large virtual buttons. "But if you want to do something like write on the surface, you need a much higher-resolution input technology," Abowd says. "A year ago, I wasn't aware of any technology that would scale to the size that our virtual rear projector could scale and would provide the level of input capability. That's when I found out about DViT."

Abowd asked Smart to engineer a version roughly three times the size of its commercial product. "The way the whiteboard works right now is as three independent input surfaces," Abowd says. "In software, we have to bridge that seam."

That's one challenge Abowd and his colleagues are working on. Another is making VRP good enough to work in real time across all three surfaces. Based on research so far, "a combination of occluder light suppression with just the half shadow that we got from passive VRP will be good enough to provide an interactive surface for the user and the audience," Abowd says.

A modular approach

Abowd hopes to have a system ready for a classroom demo within six months to one year. There are a couple of ways a commercial version might evolve. One is to add a camera, an IrDA floodlight, and graphics warping to a WiFi-enabled projector. "It would look very much like a current projector, but with a second lens for the camera," says Jay Summet, one of Abowd's graduate students. "It works like a standard wireless projector, but if you buy two or more and point them at the same screen, the extra projector(s) will slave themselves to the first, giving added illumination power and VRP capabilities."

For now, they're focused more on research than on commercializing the product, but Summet estimates adding the functionality to a high-end projector would run about $150 to $300. The system also requires two projectors, doubling the total price tag. Is that too steep for anything except niche applications such as automotive design, where the premium is outweighed by having a huge interactive surface? Not necessarily.

"People could use these projectors independently in small conference rooms or their offices, but have the freedom to bring a few together into a larger conference room as needed," Summet says. "Fixed installations could be built up over time as funds became available, at first providing standard projection, and then adding extra illumination and VRP capabilities."

For vendors, the business case depends partly on whether selling the initial projector sets up future sales. "Manufacturers would like this feature because as soon as somebody bought their brand of projector, they would have a large incentive to buy a second or third of the same brand," Summet says. "Hopefully a standard would eventually be developed to allow projectors from different manufacturers to work together."

Other Georgia Tech researchers are equally optimistic. "I think this technology is ready for commercialization," says Jim Rehg, who worked on the system with Rahul Sukthankar and Tat-Jen Cham at the Compaq Research Lab before joining Georgia Tech. "I don't see a major cost barrier. Certainly the comparison to conventional rear-projection systems is quite favorable."

In the meantime, Smart is working on its own set of issues. For example, although one limit on the number of simultaneous users is sheer elbow room, so is the ability of the operating systems such as Apple, Linux, and Windows to support multiple input devices, whether they're styli or fingers.

"We're not rushing this to commercial market," Martin says. "We've found people who realize that this is an issue, and we hope to do more with Microsoft to understand what the OS should have in it." AV