GETTING REAL IN CYBERSPACE

Virtual reality is not in suspended animation. Lately researchers have made impressive advances in conveying the senses of smell and touch. **By David Pescovitz**

STANDING IN A CINEMA in a form-fitting black bodysuit and oversize spectacles, you are feeling a little foolish. But then the "projectionist" flips a switch, and suddenly a riotously colorful, panoramic view of a massive garden nearly overwhelms you. Giant, exotic flowers sway slowly under a rainbow sky, and the scent of fresh sunflowers and soil fills the air. You feel something rubbing gently against your leg and look down to find a two-headed purple hare staring up at you. Leaning down, you stroke its soft fur before it hops ahead in surreal slow motion. Moments later the hare pauses in midhop, turns to face you and, in a language you've never heard before but somehow understand, beckons you to follow it into the foliage.

A dream? Afraid so. But eventually that level of immersion during a moviegoing experience could become reality. Or at least virtual reality.

Born out of graphical information display and flight simulation experiments in the 1960s, the term "virtual reality" was coined in 1986 by Jaron Lanier, the dreadlocked young computer scientist who became the poster boy for the technology. Before long the media, futurists and various pundits were hyping it as a revolution in simulation, communications and entertainment much more advanced than it really was. "Virtual reality won't merely replace TV, it will eat it alive," science-fiction legend Arthur C. Clarke predicted in those days.

And it still may, someday, according to the engineers and scientists who are now quietly inventing the future of the technology. Today's state-of-the-art in virtual-reality entertainment can be found at Disney's DisneyQuest interactive theme parks and at the Universal Studios theme park in Orlando, Fla. Inside DisneyQuest, visitors fly through an Arabian cityscape on Aladdin's Magic Carpet, propelled by powerful Silicon Graphics Onyx2 computers. At Universal Studios Islands of Adventure, the Adventures of Spiderman ride takes visitors in a bucking and rocking vehicle through a high-speed, sensory-overloading three-dimensional cartoon.

Like Spiderman, it's amazing. And riding the Magic Carpet is quite a trip. But both have nothing to do with approximating reality.

"If I want to present someone with a virtual world that's believable, the first arbitrarily hard problem is that the computer-generated characters have to behave in a believable way," says Randy Pausch, co-director of the Entertainment Technology Center at Carnegie Mellon University and a consultant on DisneyQuest. "Walking around in a virtual ghost-town is doable. But for the characters in the world to respond to me in a meaningful way, you have to solve the entire artificial-intelligence problem. It'll be a real long time before I can talk to Yoda."

Artificially intelligent actors aside, the line between the virtual and real worlds has been progressively, albeit slowly, blurring. Interactive, real-time, three-dimensional graphics become more lifelike with each new generation of microprocessor. For example, the nauseating, herky-jerky motion of 1992's Dactyl Nightmare, the first breed of virtual-reality arcade games, is no match for the breathtaking scenes in the games that can be played at home on Sony's forthcoming PlayStation 2 console.

In the meantime, researchers are making impressive progress on the visual and spatial aspects of the virtual-reality experience. They are also starting to devise ways of incorporating into it the two other senses that could realistically be conveyed: smell and touch.

SEEING IS BELIEVING

In research laboratories, at least, the techniques to display virtual reality and control our avatars in virtual worlds have surpassed the joystick and cumbersome head-mounted display. Take the Vir-

JAMES KIRKLAND

Patrons of an entertainment fantasy will not only see a two-headed purple hare, they will also be able to stroke the creature's fur and smell the flowers and earthy scents of an imaginary garden.

Lasers in a head-mounted display will **project images** right onto the **retinas.**

tual Retinal Display, built by Microvision in Seattle, based on technology licensed from the University of Seattle Human Interface Technology Laboratory. Eliminating the middleman of a television screen, the device projects a color image right onto the retina using lasers. Once the size and power requirements of the laser components shrink, high-resolution, head-mounted displays won't be much more cumbersome than a pair of Ray-Bans.

"In a single-spectacle-type system, we'll provide a wide field-of-view stereoscopic display that also tracks the eyes as the image is being viewed, permitting us to alter the imagery based on the fixation point of the two eyes," says Microvision's principal scientist, Thomas M. Lippert.

Meanwhile scientists at the University of North Carolina at Chapel Hill have built a wide-area body tracker in an 8-by-5.5-meter (26-by-18-foot) space. As you walk around the room, optical sensors worn on your body provide a computer with your location relative to a series of infrared-light-emitting diodes mounted on the ceiling. Your motion inside the room is then mapped onto your computer-generated form in the virtual world. As Yogi Berra supposedly said, "Wherever you go, there you are."

So in the quest for the ultimate virtual-reality experience, where do we go from here?

Follow your nose. It always knows. That's the mantra of Myron Krueger, a virtual-reality pioneer whose Artificial Reality Corporation in Vernon, Conn., is one of the few facilities tackling this underrated but powerful element of human sensation.

M. J. SHARP

Like a sextant in cyberspace, the silver-and-transparent item on top of the wearer's head is a head-mounted tracking device that updates the head's position in relation to an array of infrared-light-emitting diodes in the ceiling. Updated 1,500 times a second, the positional data go into a virtual-reality scene generator, which computes a picture for the viewer to look at, based on where his or her head is at each instant. The tracking device was built by Gary Bishop and his colleagues at the University of North Carolina at Chapel Hill.

We don't have the sniffing power of a bloodhound, Krueger explains, but the human nose is capable of detecting odorants in up to one part per trillion concentration, depending on whether the smell is foul, fragrant or somewhere in between. And in many arenas, from food preparation to chemistry, odor is one of the most useful senses in the body's arsenal. Indeed, Krueger's research into olfactory virtual reality began with the long-promised notion of telepresence surgery, in which a physician miles away from the patient conducts an operation using remote-controlled robotic instruments and video cameras.

Supported by a grant from the Defense Advanced Research Projects Agency, Krueger is searching for ways to give surgeons the olfactory clues that occur when, for example, a bowel is perforated. And there isn't a stack of previous research he can stand on to see the answer. The only existing technology used for science, which has enabled psychologists to study the effects of odors on mood, employs passive evaporation. The most volatile components evaporate first, causing the smell's characteristics to change with time, much like the scent of a perfume changes during the course of the day. The system is problematic for anything beyond short-term laboratory use.

SAYONARA, SMELLY SENSORAMA

As far as olfactory entertainment goes, technology hasn't progressed much beyond the gimmicky Sensorama technology used in conjunction with a few limited-release, location-specific entertainment films starting in the 1960s. "Quite simply, olfactory displays are very easy to do badly," Krueger says.

To enjoy the Sensorama experience, the user sat on a motorcycle seat and watched a stereo film of a trip through New York City. Wind blew against the user's face, the handles vibrated, and big-city odors like bus exhaust and pizza added to the fun. But not only did the odor hit the player in one burst rather than gradually, each smell could not be removed before the next one was added, resulting in a malodorous mishmash at the end of the ride.

Krueger's current prototype resembles a headset microphone aimed at the nose. Ten odors are stored in liquid form in a pack worn on your back. The scents are generated by ultrasonic forced evaporation—the molecules of the liquid are literally shaken until they evaporate. The system is integrated into a wireless head-mounted display that tracks your motion and, via the computer, signals the olfactory display at the appropriate time. When you move your head, Krueger says, you can detect an odor with a lag of less than a tenth of a second.

"If the smell increases as I approach a graphic object, it not only makes the object seem a little more real, it also makes the action of moving my head and body more real," he says. "There's a synergy between the action and the odor."

Before Krueger's olfactory display system is ready for your local virtual-reality cineplex, more work will have to be done on the odors themselves. "The technology of odor simulation is very lim-

VIRTUAL TECHNOLOGIES

The feel of an object that does not exist can be conjured up with a haptic device, such as Virtual Technologies's CyberGrasp. Sensors on the glove indicate where each finger is relative to the virtual object, and computer-controlled tendons exert the appropriate forces on the fingers and hand to simulate the object's shape and texture.

"In the case of a joystick, you're really limited to simulating the few real-world activities that require a joystick—flying a plane, for example," Kramer says. "We want to immerse the entire hand and body into the computer, so you really can reach out and touch someone."

CyberGrasp is an exoskeleton for the hand that enables users to hold computer-generated objects and feel their shape. Worn like a glove, CyberGrasp fits over the company's CyberGlove hand-tracking system, which computes the location of the user's fingers as they relate to the virtual object. A network of six computer-controlled tendons, much like those inside the human hand, prevents the user from closing his or her hand beyond the form of the virtual object being held, while also pushing appropriately on the pads of each fingertip and the palm.

Originally funded by the U.S. Navy, which needs haptic technologies for telerobotic applications such as hazardous-waste removal and telesurgery, the CyberGrasp is a giant leap.

Still, holding someone's hand in a virtual world isn't the same as hugging them. What is needed, clearly, is a haptic suit. The difficulty in designing one, Kramer explains, is covering the entire body with the tremendous number of actuators necessary to make the sensory feedback high-fidelity. One possibility is to etch the actuators in silicon. These so-called microelectromechanical systems (MEMS) are inexpensively batch-produced using processes similar to those by which microchips are manufactured. But even many thousands of MEMS pushing and pinching your skin could not give you the sensation of tumbling down a hill.

"A suit with an array of actuators doesn't give you ground-reference forces," Kramer says. "You could feel a wave rippling across your body, but it's not going to knock you off your feet. We need a big breakthrough."

One possibility Kramer mentions is that of electromagnetics. He envisions a virtual-reality-equipped room that, like an MRI machine, is actually a giant magnet. Clad in a haptic suit with magnetic properties, the wearer would be buffeted like a paper clip under a refrigerator magnet.

When electromagnetic push comes to shove, totally immersive virtual reality that engages all your senses is many years away. But advances in raw technology, along with a better understanding of human psychology, will someday enable us to truly play inside our own science fictions.

"Hollywood paves the path and shows us the direction people want us to go in," Kramer says. "And we're trying to make good on those predictions."

Clad in a **haptic suit,** future moviegoers might be **buffeted like paper clips** under a refrigerator **magnet.**

ited beyond flowers and fruit," Krueger says. "And it's nonexistent for things like diesel fuel, explosives, all those things you might want for an action-adventure game."

FIRST-PERSON FUTURE

"Reach-out-and-grab-it" movies may very well be in our entertainment future, adds James F. Kramer, CEO of Virtual Technologies in Palo Alto, Calif. "In the future, Hollywood movies will be directed from a first-person perspective, so you'll see and feel the same things the main character does," Kramer insists. "You'll don a force-feedback glove, and when the actor reaches out and touches an object, you'll feel it, too."

Virtual reality that feels real? An elusive goal, to say the least, but one that Kramer is already reaching for with his CyberGrasp haptic feedback interface.

Current haptic devices—ranging from Microsoft's SideWinder Force Feedback Pro joystick to SensAble Technologies's Phantom, which enables a user to feel the scrape of a carving tool on a virtual sculpture, for example—all chain the user to a small workspace. They are fine for computer-aided design or "Fighter Ace" games but are simply too restricting for the free-form nature of most virtual-reality entertainment applications.

ABOUT THE AUTHOR

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