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New haptic display technology creates 3D graphics you can see and feel

Researchers at UC Santa Barbara have invented a display technology for on-screen graphics that are both visible and haptic, meaning that they can be felt via touch. The screens are patterned with tiny pixels that expand outward yielding bumps when illuminated, enabling the display of dynamic graphical animations that can be seen with the eyes and felt with the hand. This technology could one day enable high-definition visual-haptic touch screens for automobiles, mobile computing or intelligent architectural walls.

Max Linnander, a PhD candidate in the RE Touch Lab of mechanical engineering professor Yon Visell, led the research, which appeared this month in the journal Science Robotics.

Visell proposed a challenge to Linnander when he first arrived at UCSB, in late September 2021. “The question was simple enough: Could the light that forms an image be converted into something that can be felt?” Linnander said.

“We didn’t know if it was feasible,” added Visell. “The possibility that it might be impossible — and the very idea of enabling people to ‘feel light’ — made the question irresistible.”

The team spent nearly a year testing their idea, during which they worked through the theoretical underpinnings and conducted computer simulations. With a viable concept in hand, they then began to develop prototypes in the laboratory. Months passed without success.

Then, in December 2022, Linnander brought Visell into the lab. “I’d been working on this for a year. I was going to leave for the airport in a few hours, and I had just gotten my latest prototype up and running,” he said. He showed Visell his simple, functional prototype — a single pixel excited by brief light flashes from a small diode laser, with no other electronics.

“I put my finger on the pixel and felt a clear tactile pulse whenever the light flashed,” Visell recalled. “That was a special moment — the moment we knew the core idea could work.”

At the heart of the technology are thin display surfaces that integrate arrays of millimeter-sized optotactile pixels. The pixels are individually controlled by projected light from the low-power laser, a form of optical addressing. The same light source powers the pixels, which contains an air-filled cavity and a suspended thin graphite film. The film absorbs incoming light, and rapidly rises in temperature which, in turn, heats the captive air. The air expands, and the pixel’s top surface deflects outward by as much as one millimeter — yielding an easily perceptible bump above the illuminated pixel.

The process is so fast that scanning a light beam across many pixels in succession yields dynamic graphics — contours, moving shapes, characters — that can be both seen and felt. The refresh rate is fast enough to enable animations to look and feel continuous, as with familiar video displays.

Because light provides both illumination and power delivery, the display surfaces require no embedded wiring or electronics. Instead, a small scanning laser sweeps the surface at high speed, illuminating each pixel for a fraction of a second.

The technology is also scalable: the team has demonstrated devices with more than 1,500 independently addressable pixels — significantly more than comparable tactile displays reported to date, Linnander said. Far larger formats are possible, he added, including displays that leverage modern laser video projectors.

The researchers also studied what users perceived when interacting with the displays. Using touch, participants in their study were able to accurately report the location of individually illuminated pixels with millimeter precision, could accurately perceive moving graphics, and were easily able to discriminate spatial and temporal patterns. The researchers emphasize that these findings indicate the system is able to produce a wide variety of tactile content.

While the team's findings stand out among prior display technologies, Visell noted that the idea of turning light into mechanical action has noteworthy antecedents. In the 19th century, Alexander Graham Bell and others used focused sunlight, modulated by the blades of a rotating fan, to excite sound in air-filled test tubes. The same physical principles underlie the optotactile pixels have now been applied to a digital display technology.

These visual-tactile displays could find uses across many domains. Visell envisions that the technology could be used to create automotive touchscreens that emulate physical controls, electronic books with tangible illustrations that come to life on the page, and architectural surfaces for mixed reality, bridging the digital and physical worlds.

Whatever the future may hold, the technology his team has invented embodies a simple, intriguing idea: anything you see, you can also feel.

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