3D display could soon bring touch to the digital world

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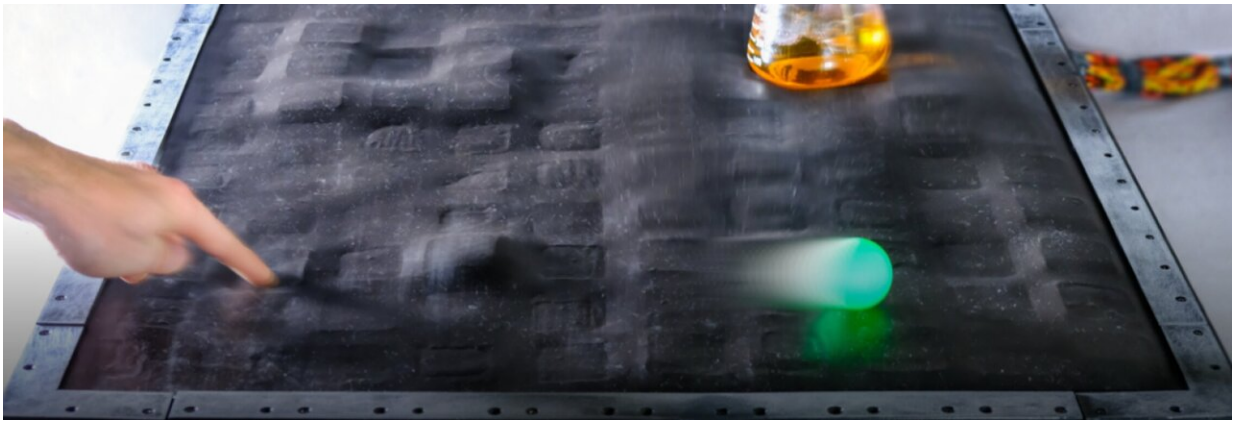

A new, shape-shifting display can sense and respond to human touch. (Credit: Brian Johnson)

Imagine an iPad that's more than just an iPad—with a surface that can morph and deform, allowing you to draw 3D designs, create haiku that jump out from the screen and even hold your partner's hand from an ocean away.

That's the vision of a team of engineers from the University of Colorado Boulder. In a new study, they've created a one-of-a-kind shape-shifting display that fits on a card table. The device is made from a 10-by-10 grid of soft robotic "muscles" that can sense outside pressure and pop up to create patterns. It's precise enough to generate scrolling text and fast

enough to shake a chemistry beaker filled with fluid.

It may also deliver something even rarer: the sense of touch in a digital age.

"As technology has progressed, we started with sending text over long distances, then audio and now video," said Brian Johnson, one of two lead authors of the new study who earned his doctorate in mechanical engineering at CU Boulder in 2022. "But we're still missing touch."

Johnson and his colleagues described their shape display July 31 in the journal *Nature Communications*.

The group's innovation builds off a class of soft robots pioneered by a team led by Christoph Keplinger, formerly an assistant professor of mechanical engineering at CU Boulder. They're called Hydraulically Amplified Self-Healing ELectrostatic (HASEL) actuators. The prototype display isn't ready for the market yet. But the researchers envision that, one day, similar technologies could lead to sensory gloves for virtual gaming or a smart conveyer belt that can undulate to sort apples from bananas.

"You could imagine arranging these sensing and actuating cells into any number of different shapes and combinations," said Mantas Naris, co-lead author of the paper and a doctoral student in the Paul M. Rady Department of Mechanical Engineering. "There's really no limit to what these technologies could, ultimately, lead to."

Playing the accordion

The project has its origins in the search for a different kind of technology: synthetic organs.

In 2017, researchers led by Mark Rentschler, professor of mechanical engineering and biomedical engineering, secured funding to develop what they call sTISSUE—squishy organs that behave and feel like real human body parts but are made entirely out of silicone-like materials.

Co-investigators on the grant include Keplinger, now a director at the Max Planck Institute for Intelligent Systems in Germany; Nikolaus Correll, associate professor in the Department of Computer Science at CU Boulder; and Sean Humbert, professor of mechanical engineering.

"You could use these artificial organs to help develop medical devices or surgical robotic tools for much less cost than using real animal tissue," said Rentschler, a co-author of the new study.

In developing that technology, however, the team landed on the idea of a tabletop display. The research is part of the Materials Science and Engineering Program.

The group's design is about the size of a Scrabble game board and, like one of those boards, is composed of small squares arranged in a grid. In this case, each one of the 100 squares is an individual HASEL actuator. The actuators are made of plastic pouches shaped like tiny accordions. If you pass an electric current through them, fluid shifts around inside the pouches, causing the accordion to expand and jump up.

The actuators also include soft, magnetic sensors that can detect when you poke them. That allows for some fun activities, said Johnson, now a postdoctoral researcher at the Max Planck Institute for Intelligent Systems.

"Because the sensors are magnet-based, we can use a magnetic wand to draw on the surface of the display," he said.

Hear that?

Other research teams have developed similar smart tablets, but the CU Boulder display is softer, takes up a lot less room and is much faster. Each of its robotic muscles can activate as much as 50 times per second.

The researchers are focusing now on shrinking the actuators to increase the resolution of the display—almost like adding more pixels to a computer screen.

"Imagine if you could load an article onto your phone, and it renders as Braille on your screen," Naris said.

The group is also working to flip the display inside out. That way, engineers could design a glove that pokes your fingertips, allowing you to "feel" objects in virtual reality.

And, Rentschler said, the display can bring something else: a little peace and quiet.

"Our system is, essentially, silent. The actuators make almost no noise."

More information: B. K. Johnson et al, A multifunctional soft robotic shape display with high-speed actuation, sensing, and control, *Nature Communications* (2023). DOI: 10.1038/s41467-023-39842-2

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