Soft e-skin that communicates with the brain

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The e-skin is soft and stretchable, while also being able to mimic sense of touch and run efficiently at a low voltage. Credit: Jiancheng Lai and Weichen Wang of Bao Research Group at Stanford University

Researchers at Stanford University have developed digital skin that can convert sensations such as heat and pressure to electrical signals that can be read by electrodes implanted in the human brain.

Although such capability was developed years earlier, the components required at that time to convert digital signals were rigid and unwieldy.

This new e-skin is soft as, well, skin. The conversion elements are seamlessly incorporated within the skin, which measures a few tens of nanometers thick.

The development holds promise for more natural interaction between AI-based prosthetic limbs and the brain. It also is a step forward in efforts to construct robots that can "feel" human sensations such as pain, pressure and temperature. This would allow robots working with accident victims, for instance, to better relate to signs of comfort or distress.

"Our dream is to make a whole hand where we have multiple sensors that can sense pressure, strain, temperature and vibration," says Zhenan Bao, a chemical engineering professor at Stanford University, who worked on the project. "Then we will be able to provide a true kind of sensation."

The researchers said a key reason people forgo the use of prosthetics is that a lack of sensory feedback feels unnatural and makes them uncomfortable.

The e-skin was first tested in the brain cells of rats. The animals twitched their legs when their cortexes were stimulated. The extent of twitching corresponded to varying levels of pressure.

"Electronic skin would eliminate the boundary between the living body and machine components," the researchers said.

Their report, "The disappearing boundary between organism and machine," appeared in the journal *Science* this week.

An early challenge was to create a flexible e-skin that could run on low voltage. Early efforts required 30 volts. By creating stretchable field-effect transistors and solid-state synaptic transistors, the team was able to reduce the required voltage and gain greater efficiency.

"This new e-skin runs on just 5 volts and can detect stimuli similar to real skin," said Weichen Wang, an author of the paper who has worked on the project for three years. "It provides electrical performance—such as low voltage drive, low power consumption, and moderate circuit integration—comparable to that of poly-silicon transistors."

A related development was announced by scientists at the University of Edinburgh last March. They created an e-skin composed of a thin layer of silicone embedded with wires and sensitivity detectors "to give soft robots the ability to sense things only millimeters away, in all directions, very quickly," according to Yunjie Yang, who lead the university team's study.

A university press release stated the development "gives robots for the first time a level of physical self-awareness similar to that of people and animals."

More information: Tsuyoshi Sekitani, The disappearing boundary between organism and machine, *Science* (2023). DOI: 10.1126/science.adf0262

Weichen Wang et al, Neuromorphic sensorimotor loop embodied by monolithically integrated, low-voltage, soft e-skin, *Science* (2023). DOI: 10.1126/science.ade0086

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