Flexible tactile sensors could help robots work better

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A robot's sensitivity to touch could be vastly improved by an array of polymer-based tactile sensors that has been combined with a robust signal-processing algorithm to classify surface textures. The work, performed by a team of researchers at the University of Illinois at Urbana-Champaign, is an essential step in the development of robots that can identify and manipulate objects in unstructured environments.

“We are developing artificial tactile sensors that will imitate the functionality and efficiency found in biological structures such as human fingers,” said Chang Liu, a professor of electrical and computer engineering at Illinois. “We have shown that simple, low-cost sensor arrays can be used to analyze and identify surface textures.”

Biological sensors provide a wealth of information concerning the shape, hardness and texture of an object. Robots, which typically possess a single pressure sensor in their grip, can’t determine whether an object is hard or soft, or how hard it is squeezing an object.

“One of the unsolved problems in robotics is the handling of delicate objects such as eggs,” said Douglas Jones, a professor of electrical and computer engineering. “The distributed sensing we have in our hands allows us to grab an egg with enough force that it won’t slip, but without so much force that it breaks. One of our goals is to develop an array of sensors that provides robotic systems with a similar source of tactile feedback.”

The research team consisted of Liu and Jones (who also are researchers at the Beckman Institute for Advanced Science and Technology), and graduate students Jonathan Engel and Sung-Hoon Kim. They describe the construction and operation of their tactile sensory array in the May issue of the *Journal of Micromechanics and Microengineering*, published by the Institute of Physics (www.iop.org/EJ/journal/JMM).

The sensors are fabricated from an inexpensive polymer sheet using photolithographic patterning techniques. In the reported work, the researchers created a 4 x 4 array (16 sensors) and evaluated its performance.

"Each sensor resembles a little drum head about 200 microns in diameter with a tiny bump in the center," Engel said. "On the surface of the drum head, we deposit a thin-metal strain gauge that changes resistance when stretched. Pressure on the sensor is converted into digital data that is sent to a computer and analyzed with a signal-processing algorithm."

In any detection problem, implementation is a key issue. "Speed is important, but complex tasks like tactile sensing tend to be very time consuming," Kim said. "We came up with advanced algorithms that make the process more computationally efficient. Our algorithms can quickly determine which sensors are activated in the array, and whether the object is flat, or shaped like a box or the letter X."

In future work, the researchers want to improve efficiency by further simplifying the signal-processing algorithm so it can be performed by circuitry mounted on the same substrate as the sensor. They also want to build larger arrays with distributed sensors, and develop more effective ways to import and utilize sensory data.

Such improvements could expand the functionality of robots in assembly-line environments and facilitate the development of autonomous vehicles.

“Our ultimate goal is to allow robots to operate in unstructured environments,” Liu said. “To build more trust between humans and robots, we must make reliable sensor systems that can analyze their physical surroundings quickly and accurately. Our work is a step toward making trustworthy sensors that give robotics the power to really help people.”

Source: University of Illinois at Urbana-Champaign

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