Researchers give robots intelligent sensing abilities to carry out complex tasks

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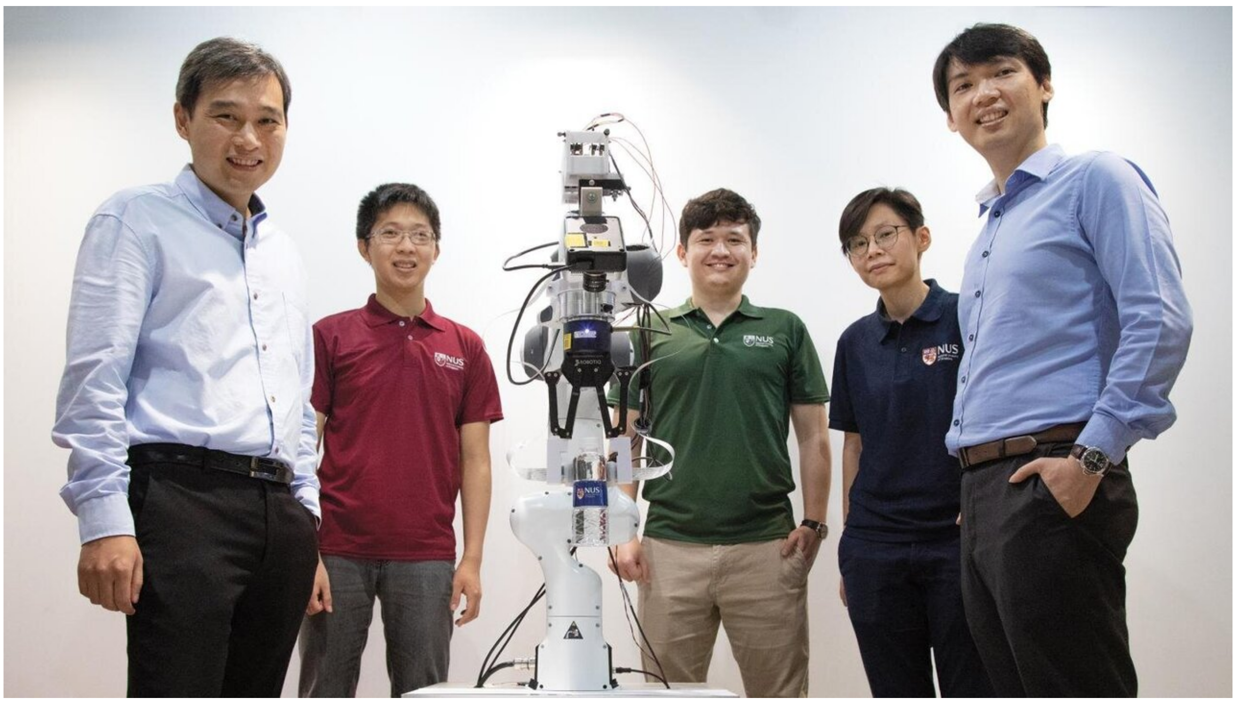


The NUS research team behind the novel robotic system integrated with event-driven artificial skin and vision sensors was led by Assistant Professor Harold Soh (left) and Assistant Professor Benjamin Tee (right). With them are team members (second from left, to right) Mr Sng Weicong, Mr Tasbolat Taunyazov and Dr See Hian Hian. Credit: National University of Singapore

Picking up a can of soft drink may be a simple task for humans, but this is a complex task for robots—it has to locate the object, deduce its shape, determine the right amount of strength to use, and grasp the object without letting it slip. Most of today's robots operate solely based on visual processing, which limits their capabilities. In order to perform more complex tasks, robots have to be equipped with an exceptional sense of touch and the ability to process sensory information quickly and intelligently.

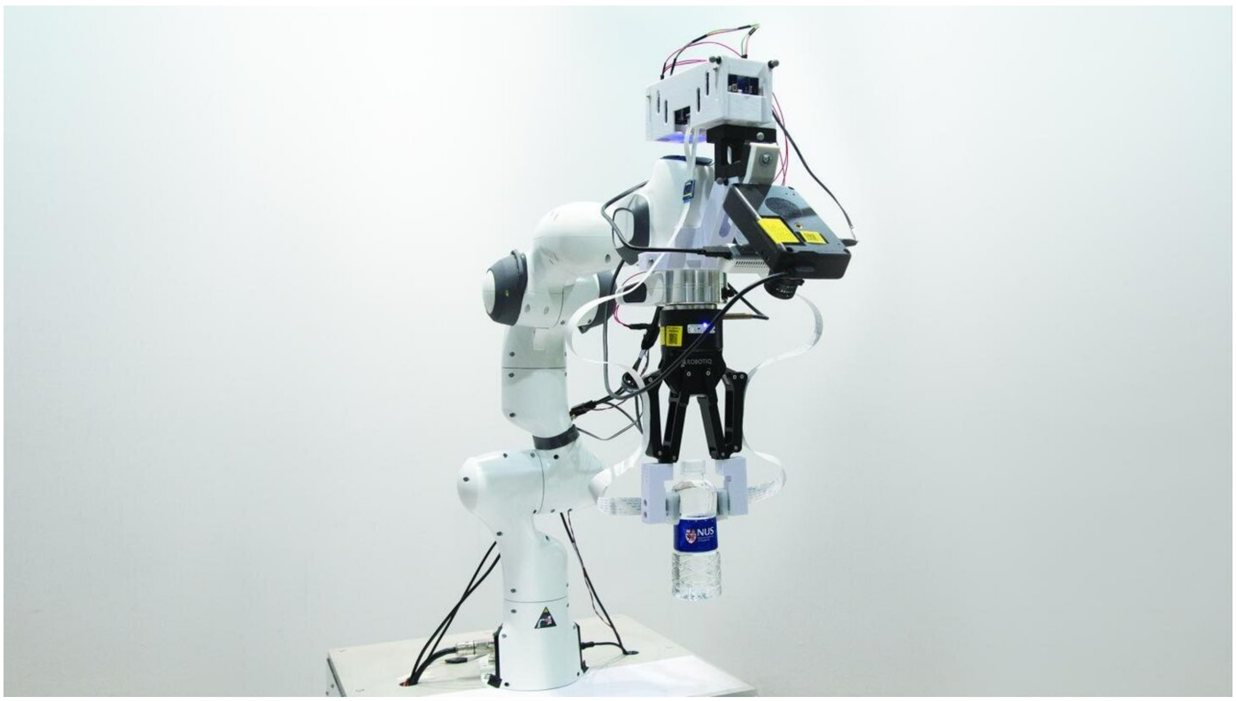
A team of computer scientists and materials engineers from the National University of Singapore (NUS) has recently demonstrated an exciting approach to make robots smarter. They developed a sensory integrated artificial brain system that mimics biological neural networks, which can run on a power-efficient neuromorphic processor, such as Intel's Loihi chip. This novel system integrates artificial skin and vision sensors, equipping robots with the ability to draw accurate conclusions about the objects they are grasping based on the data captured by the vision and touch sensors in real-time.

"The field of robotic manipulation has made great progress in recent years. However, fusing both vision and tactile information to provide a highly precise response in milliseconds remains a technology challenge. Our recent work combines our ultra-fast electronic skins and nervous systems with the latest innovations in vision sensing and AI for robots so that they can become smarter and more intuitive in physical interactions," said Assistant Professor Benjamin Tee from the NUS Department of Materials Science and Engineering. He co-leads this project with Assistant Professor Harold Soh from the Department of Computer Science at the NUS School of Computing.

The findings of this cross-disciplinary work were presented at the renowned conference Robotics: Science and Systems conference in July 2020.

Human-like sense of touch for robots

Enabling a human-like sense of touch in robotics could significantly improve current functionality, and even lead to new uses. For example, on the factory floor, robotic arms fitted with electronic skins could easily adapt to different items, using tactile sensing to identify and grip unfamiliar objects with the right amount of pressure to prevent slipping.



This novel robotic system developed by NUS researchers comprises an artificial brain system that mimics biological neural networks, which can be run on a power-efficient neuromorphic processor such as Intel's Loihi chip, and is integrated with artificial skin and vision sensors. Credit: National University of Singapore

In the new robotic system, the NUS team applied an advanced artificial skin known as Asynchronous Coded Electronic Skin (ACES) developed by Asst Prof Tee and his team in 2019. This novel sensor detects touches more than 1,000 times faster than the human sensory nervous system. It can also identify the shape, texture and hardness of objects 10 times faster than the blink of an eye.

"Making an ultra-fast artificial skin sensor solves about half the puzzle of making robots smarter. They also need an artificial brain that can ultimately achieve perception and learning as another critical piece in the puzzle," added Asst Prof Tee, who is also from the NUS Institute for Health Innovation & Technology.

A human-like brain for robots

To break new ground in robotic perception, the NUS team explored neuromorphic technology—an area of computing that emulates the neural structure and operation of the human brain—to process sensory data from the artificial skin. As Asst Prof Tee and Asst Prof Soh are members of the Intel Neuromorphic Research Community (INRC), it was a natural choice to use Intel's Loihi neuromorphic research chip for their new robotic system.

In their initial experiments, the researchers fitted a robotic hand with the artificial skin, and used it to read braille, passing the tactile data to Loihi via the cloud to convert the micro bumps felt by the hand into a semantic meaning. Loihi achieved over 92 per cent accuracy in classifying the Braille letters, while using 20 times less power than a normal microprocessor.

Asst Prof Soh's team improved the robot's perception capabilities by combining both vision and touch data in a spiking neural network. In their experiments, the researchers tasked a robot equipped with both artificial skin and vision sensors to classify various opaque containers containing differing amounts of liquid. They also tested the system's ability to identify rotational slip, which is important for stable grasping.

In both tests, the spiking neural network that used both vision and touch data was able to classify objects and detect object slippage. The classification was 10 per cent more accurate than a system that used only vision. Moreover, using a technique developed by Asst Prof Soh's team, the neural networks could classify the sensory data while it was being accumulated, unlike the conventional approach where data is classified after it has been fully gathered. In addition, the researchers demonstrated the efficiency of neuromorphic technology: Loihi processed the sensory data 21 per cent faster than a top performing graphics processing unit (GPU), while using more than 45 times less power.

Asst Prof Soh shared, "We're excited by these results. They show that a neuromorphic system is a promising piece of the puzzle for combining multiple sensors to improve robot perception. It's a step towards building power-efficient and trustworthy robots that can respond quickly and appropriately in unexpected situations."

"This research from the National University of Singapore provides a compelling glimpse to the future of robotics where information is both sensed and processed in an event-driven manner combining multiple modalities. The work adds to a growing body of results showing that neuromorphic computing can deliver significant gains in latency and power consumption once the entire system is re-engineered in an event-based paradigm spanning sensors, data formats, algorithms, and hardware architecture," said Mr Mike Davies, Director of Intel's Neuromorphic Computing Lab.

This research was supported by the National Robotics R&D Programme Office (NR2PO), a set-up that nurtures the robotics ecosystem in Singapore through funding research and development (R&D) to enhance the readiness of robotics technologies and solutions. Key considerations for NR2PO's R&D investments include the potential for impactful applications in the public sector, and the potential to create differentiated capabilities for our industry.

Next steps

Moving forward, Asst Prof Tee and Asst Prof Soh plan to further develop their novel robotic system for applications in the logistics and food manufacturing industries where there is a high demand for robotic automation, especially moving forward in the post-COVID era.

Provided by National University of Singapore

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