Light-driven thin-film robots could feel

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Mini kirigami SLiR thin-film robots. Credit: Ghim Wei Ho and Xiao-Qiao Wang

Biological systems can actively sense and adjust their mechanical response to changes in their environment.

Until now, the mainstream research on biomimetic robotics is to mimic the complex motion of animals and plants, and the developed robots have limited or no sensory capability, one of essential functions of natural intelligence.

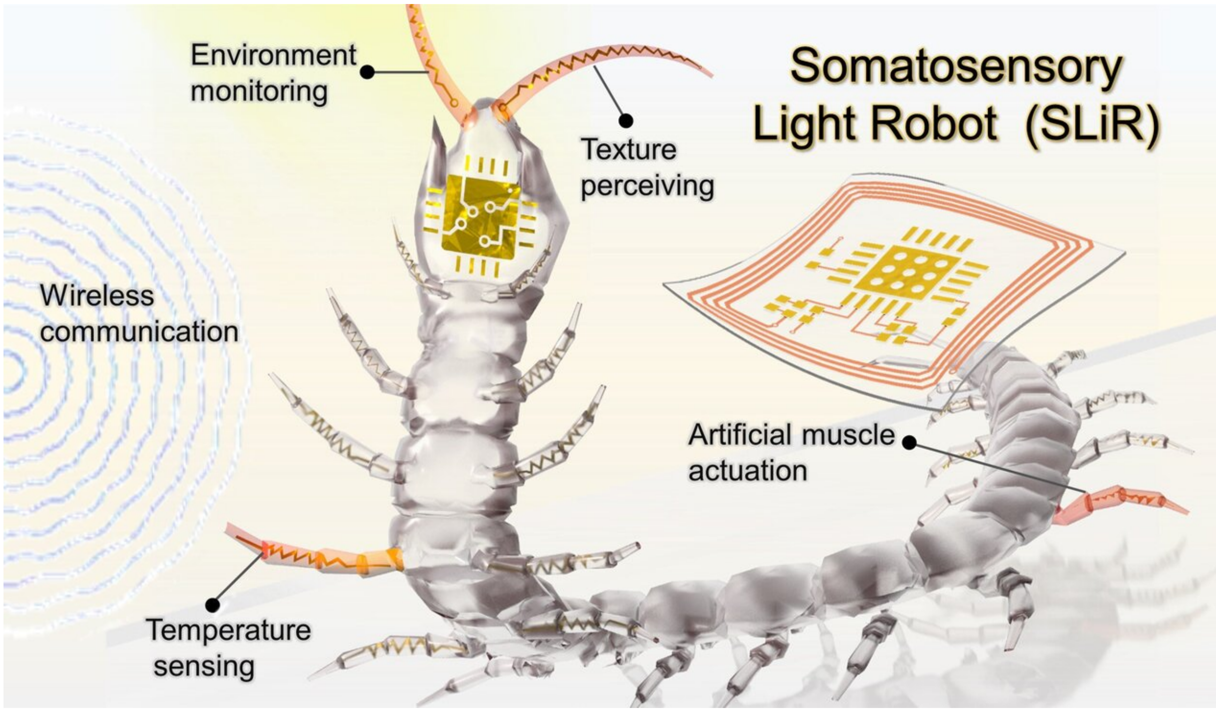
It's a grand challenge to achieve highly integrated actuation and sensing function in soft robot body, especially when the robot size is small-scale, down to centimeters.

However, my research team has developed a thin-film robot that compactly integrated a strain sensor, a temperature sensor and an actuator, allowing simultaneous reflex-like and locomotive capabilities.

How does it work?

A flexible thin film with thickness of ~115 μm, includes a bilayer actuator responsive to light heat, pyroelectric polymer layer sensing temperature, and a piezoresistive circuit sensing bending strain.

We tried to detect the robot body temperature and deformation simultaneously, and devised independent electrodes for the two sensors, facilitating separated and non-interfering pyroelectric voltage and piezoresistive resistance read-out signals.



Untethered SLiR centipede with collective motility and multitude of sensors. Credit: Ghim Wei Ho and Xiao-Qiao Wang

Combining 3-D printing and kirigami techniques, we could selectively print sensing circuits and programmatically pattern the robot shapes, and different robot prototypes can be fast customized and easily downsized.

What can it do?

We developed several kirigami soft robot prototypes for on-demand deployment, and they all display capabilities of proprioceptive and exteroceptive feedback in different situations. A robotic walker provides feedback on its detailed locomotive gaits as well as the subtle terrain textures. An anthropomorphic hand possesses somatosensory receptions, could feel each finger movements and hot/cold touch, and distinguish hardness/softness of different materials. Yet another design is an untethered centipede, can walk, turn, and wirelessly sense light intensity, wind speed and human touch.

What do we expect?

The design principle and robot presented here demonstrate readily manufacturable autonomous and sensory soft-bodied systems. We are now still working with the collaborators to solve the problem of close-loop feedback control between the sensors and actuators, looking toward developing small-sized robots capable of own decisions. We hope to achieve soft robots that can finally work autonomously, response and adapt to changing environments like living organisms.

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More information: Xiao-Qiao Wang, Ghim Wei Ho et al. "Somatosensory, Light-Driven, Thin-Film Robots Capable of Integrated Perception and Motility", *Advanced Materials* (2020), DOI: 10.1002/adma.202000351

Bio:

Xiao-Qiao Wang received her PhD degree in Material Chemical Engineering at Nanjing Tech University, China, in 2016. She is now a research fellow at the Department of Electrical & Computer Engineering at National University of Singapore (NUS). Her research interests include soft electronics, miniature robotics and bioinspired systems."

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