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News Bulletin

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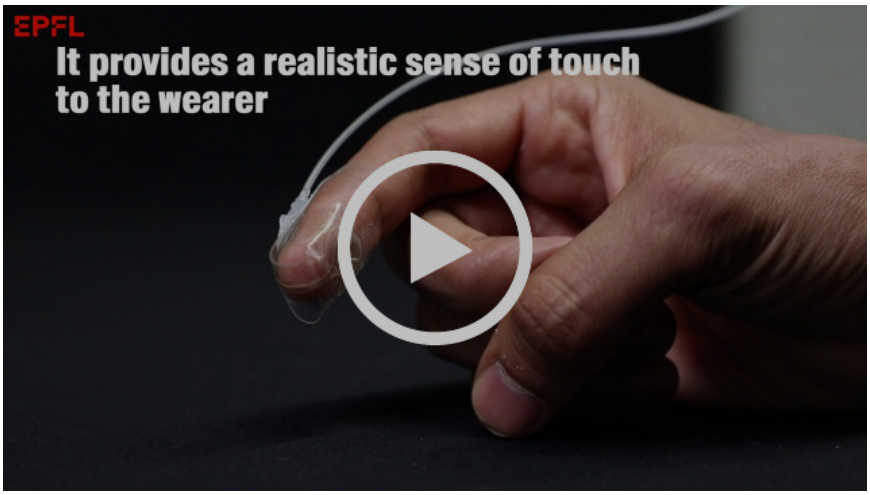
An artificial skin for rehabilitation and virtual reality

Two NCCR Robotics labs at EPFL have developed the first soft, wearable interface with high-fidelity tactile feedback. It paves the way for new applications and research tools.

The sense of touch is a big part of how we perceive the world around us and interact with it. And yet, this sensory channel is exploited much less than sight and hearing for human-computer and human-robot interfaces. We often use our hands and fingers to control electronic devices and robots, and in some cases we get some tactile feedback in return, typically in the form of vibrations or pressure. But because of lack of sensors, there is currently no way to make sure that the user gets a consistent feedback when the external conditions change. For example, if the user is moving and interacting with the environment, it is difficult to know the perceived strength of this applied feedback.

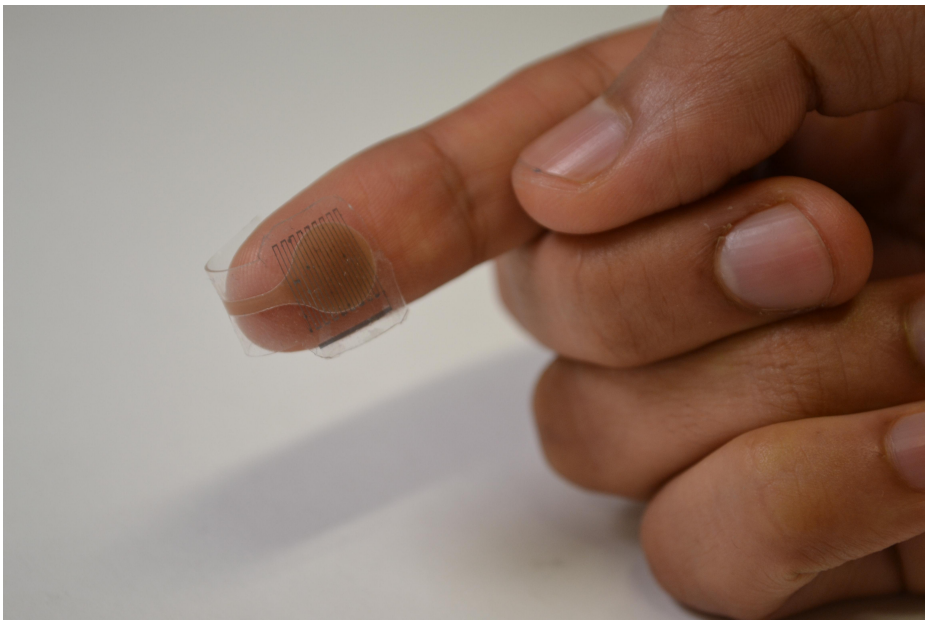
To pave the way for wearable technologies that can not only conform to the body but also provide a consistent feedback to the wearer, the Reconfigurable Robotics Lab (RRL) led by Prof. Jamie Paik and the Laboratory for Soft Bioelectronics Interfaces (LSBI) led by Prof. Stéphanie Lacour at EPFL have designed and tested a soft skin made out of silicone, capable of providing vibratory feedback for a range of frequencies. The soft skin also host soft strain sensors, filled with liquid metal, that continuously measure its deformation. This way, the vibration can be tuned in real time in response to the actual deformation that it is causing in the material, and thus to the feeling it is transmitting to the user. The device is based on Soft Pneumatic Actuators (SPAs), made out of light and flexible materials that can be precisely controlled by adjusting their internal air pressure. The work is described in a paper in the journal Soft Robotics.



Towards a fully wearable prototype

Both laboratories are part of NCCR Robotics. The collaboration has allowed to combine different soft robotics technologies and apply them to wearable applications, one of the consortium's main research lines. "For the first time, we have an entirely soft wearable interface consisting of integrated sensors and actuators, that produces a consistent tactile feedback with high fidelity" explains Harshal Sonar, a researcher in Paik's lab and the first author of the paper. "This opens the door for various applications and new research, from bidirectional communication with humans or machines to more precise, quantitative experiments on somatosensory feedback in humans".

The SPA skin comprises an actuator layer – a membrane that can be inflated by pumping air into it – and a sensor layer based on o mix of liquid and solid gallium, that can be used to convert mechanical stress into change in electrical resistance.



The presence of sensors with soft actuators has minimum impact on the functionality and makes the device "monolithic", meaning that it behaves as one piece: when the actuator inflates, the sensor also does equally. This way, the researchers were able to accurately model and predict the actuator inflation, using it to "close the loop" and provide consistent output force despite the complex behaviour of soft materials.

In order to demonstrate that the device can indeed provide a tuneable and reliable tactile sensation, the researchers applied onto it a silicone cube that simulated contact with the human skin. They then tuned the actuator to varying pressures and frequencies (up to 100 impulses per second) and used the sensors to measure how the deformation of the material varied in response to the actuator impulses and to contact with the silicone cube. Next, they were able to select a desired target deformation and use information coming from the sensors to adjust the pressure in the actuator. This way, a real user wearing the device would be sure to get the right feeling regardless of how the actuator is positioned and of which external factors my affect it.

"The next step will be the development of a fully wearable prototype for applications in rehabilitation, virtual and augmented reality" says Sonar. "The prototype will also be tested in neuroscientific studies, where it can be used to stimulate the human body while studying dynamic brain activity in magnetic resonance experiments".

Literature

H. A. Sonar, A. P. Gerratt, S. P. Lacour and J. Paik, "Closed-loop haptic feedback control using a self-sensing soft pneumatic actuator skin", Soft Robotics, 2019.

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NCCR Robotics

The Swiss National Center of Competence in Robotics (NCCR Robotics) is a federally funded programme bringing together robotics laboratories from EPFL, ETH Zurich, University of Zurich, IDSIA, UNIBE and EMPA to work on wearable, rescue and educational robots.

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