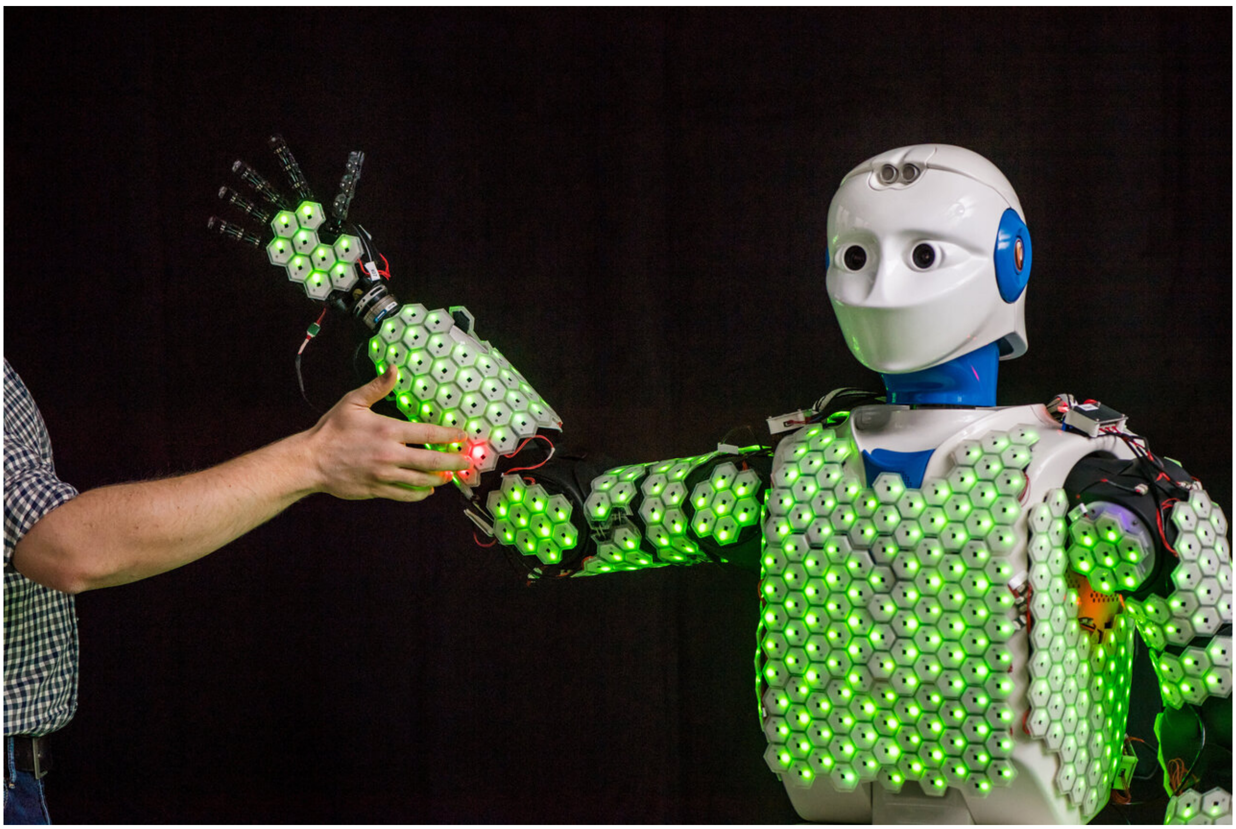
A highly performing and efficient e-skin for robotic applications

April 29 2020, by Ingrid Fadelli



The H-1 robot covered with the electronic skin developed by the researchers. Credit: A. Eckert / TUM.

Researchers at Technische Universität München in Germany have recently developed an electronic skin that could help to reproduce the human sense of touch in robots. This e-skin, presented in a paper published in MDPI's *Sensors* journal, requires far less computational power than other existing e-skins and can thus be applied to larger portions of a robot's body.

"Our main motivation for developing the e-skin stems from nature and is centered on the question of how we humans interact with our surrounding environment," Florian Bergner, one of the researchers who carried out the study, told TechXplore. "While humans predominantly depend on vision, our sense of touch is important as soon as contacts are involved in interactions. We believe that giving robots a sense of touch can extend the range of interactions between robots and humans—making robots more collaborative, safe and effective."

Bergner and other researchers led by Prof. Gordon Cheng have been developing e-skins for approximately ten years now. Initially, they tried to realize e-skin systems with multi-modal sensing capabilities resembling those of human skin. In other words, they tried to create an artificial skin that could sense light touch, pressure, temperature, and vibrations, while effectively distributing its sensing across different places where tactile interactions occurred.

"Humans cannot only discern between different kind of touches but also where they occur," Bergner said. "In addition to replicating this ability, an e-skin system should sustain physical stress of contacts, be scalable and support integration with minimal effort."

The new e-skin system developed by Bergner and his colleagues is composed of hexagonal sensing modules. Each of these modules is approximately the size of a €2 coin. When they are connected, they form flexible pieces of artificial skin, or skin patches, which can be attached to a variety of surfaces, both flat and curved.

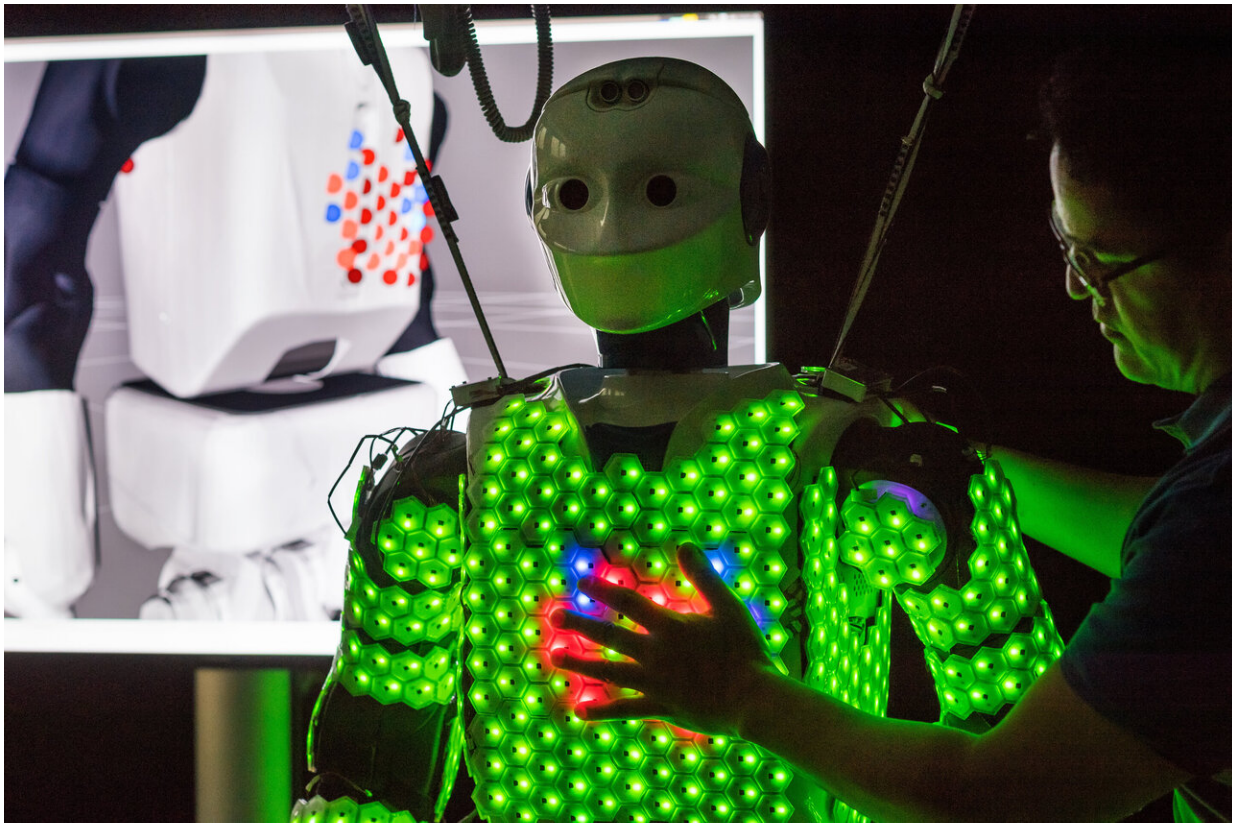
So far, e-skins that can be applied to large surface areas have been found to present significant limitations in terms of the amount of touch information they can detect at once. The e-skin system developed by Bergner and his colleagues, on the other hand, retains advanced sensing capabilities without requiring extensive computational power.

"Traditional information processing leads to unacceptably high requirements of computational power, high power consumption, high information transfer rates, information loss, and delay," Bergner said. "On the other hand, humans can process the tactile information gathered by around 5 million skin receptors without any great effort. In our recent study, we asked ourselves: How can the human sense of touch achieve this, and how can we exploit findings in neuroscience to mitigate the limitations of our e-skin systems?"

Instead of continuously sending information to the brain, receptors on the human skin tend to remain inactive until they detect a change in touch pressure, temperature or vibration. When they detect a change, the receptors trigger spikes that make their way to the brain, traveling through nerve fibers.

As a result of this process, human skin only provides the brain with new touch-related information. Bergner and his colleagues studied this biological process in depth and tried to replicate it in their e-skin system.

"In our system, each artificial skin cell monitors its sensors to detect changes," Bergner explained. "When they detect large enough changes, then the skin cells report the novel information to the computer, when it doesn't it goes into a sleeping mode. This operation significantly reduces demands on computation power."



The H-1 robot covered with the electronic skin developed by the researchers. Credit: A. Eckert / TUM.

The e-skin system developed by Bergner and his colleagues is scalable, efficient and flexible. Initial tests revealed that it can handle the flow of touch-related information in systems with a large surface area without requiring customized hardware, and using only standard computers.

Bergner and his colleagues successfully applied their e-skin on H1, a human-sized robot. They were able to cover its whole body using 1260 skin cells, which include over 10,000 sensors, something that had never been done before.

"The H1 robot operates autarkically with onboard systems only," Bergner explained. "Covering it with skin cells has only been possible thanks to the benefits of our novelty-driven e-skin, which reduces the computational load by around 80%. A more traditional e-skin would have completely saturated the systems of H1, resulting in delays and a continuous information loss of around 25%."

In the future, the highly efficient e-skin could provide a variety of robots with enhanced touch capabilities. In addition to increasing the safety of human-robot interactions, which could be particularly valuable in industrial or healthcare settings, the e-skin cells could be used to develop new technological tools, such as touch-sensitive prostheses, smart objects, or sensing suits.

"After solving the challenge of handling the tactile information of large-area e-skin, we can now look into downsizing the skin cells and thus reaching higher sensing densities," Bergner said. "H1, with its large-area e-skin, could now allow us to investigate human-robot interactions and whole-body control. Another interesting research direction could be investigating novelty-driven tactile information to enhance perception and control algorithms."

More information: Florian Bergner et al. Design and Realization of an Efficient Large-Area Event-Driven E-Skin, *Sensors* (2020). DOI: 10.3390/s20071965

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