Reviewing progress in the development of machine learning-enhanced e-skins

May 19 2020, by Ingrid Fadelli

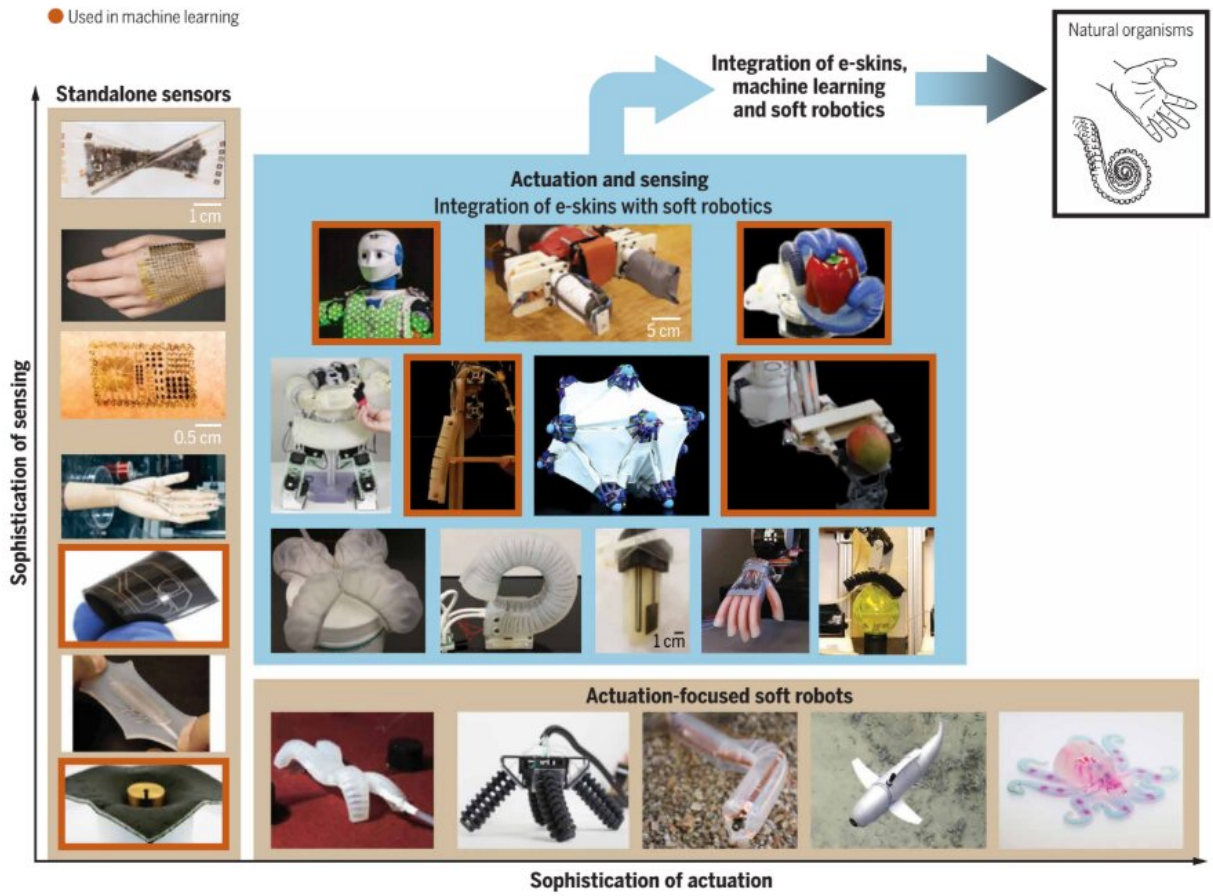

Image summarizing some of the recently developed systems integrating electronic skis and machine learning techniques. Credit: Shih et al.

Researchers at University of California, Yale University, Stanford University, University of Cambridge and Seoul National University have recently carried out a study reviewing recent efforts in the development of machine-learning-enhanced electronic skins. Their review paper, published in *Science Robotics*, outlines how these e-skins could aid the creation of soft robots with touch-like capabilities, while also delineating challenges that are currently preventing their large-scale deployment.

"Our general idea was to summarize current work and open problems in tactile sensing, interaction and exploration for soft robots," Benjamin Shih and Michael T Tolley, two of the researchers who carried out the study, told TechXplore via email. "Recent work in the field has predominantly focused on actuation, some groups have worked on embedded, touch-based sensors and a few have combined them to close the loop and study feedback control and state estimation."

The analysis of past literature carried out by Shih, Tolley, and their colleagues suggests that touch-based sensors have so far not been the primary focus of studies in soft robotics. However, they found a large body of work exploring the potential of e-skins, which soft roboticists could potentially draw upon when developing new robots.

Over the past decade or so, research groups worldwide have been developing sophisticated e-skins with advanced sensing capabilities. These e-skins have become increasingly complex, and many of them are now able to collect a multitude of tactile data. Machine learning techniques could prove to be highly valuable tools for processing and interpreting this data.

"As we build toward matching biological capabilities in robots, the trinity of tools and techniques from soft robotics, electronic skins and machine learning has the potential to significantly elevate the capabilities of today's robots," Shih and Tolley said. "Robotics is already an

incredibly interdisciplinary field and introducing the materials science aspect into the design of robots further increases the variety of backgrounds and expertise required to successfully build intelligent soft robots."

In addition to discussing the potential of recently developed techniques merging e-skins with machine learning, Shih, Tolley and their colleagues highlight in their paper some of the open challenges impeding large-scale production. According to the researchers, one of the key challenges that needs to be overcome before these e-skins can become widely used relates to their wiring. Although multiplexing, a technique that can drastically reduce wiring, could help to tackle this issue, every sensor within the e-skin would still need to be connected by two wires.

"We highlight open challenges and future directions of bringing together the trinity of soft robotics, electronic skins and machine learning to push the boundaries on autonomous soft robots that can not only safely explore and touch their surroundings, but simultaneously understand their interactions," Shih and Tolley said.

According to the researchers, two specific robotic functions that might benefit significantly from the combination of electronic skins and machine learning are shape sensing and feedback control. Both of these capabilities enable more advanced interactions between a robot and its environment, while also allowing it to explore its surroundings more effectively.

As many robots are designed to change shape when they come into contact with specific environmental stimuli (e.g., obstacles or other objects), enhanced shape sensing and feedback control capabilities can provide them with valuable information that can help them to respond most effectively to these stimuli. Moreover, e-skins feature high-resolution taxels and machine learning techniques are typically capable

of advanced processing capabilities, which, combined with a soft robot's highly compliant materials, could lead to remarkable results.

In their review paper, Shih, Tolley and his colleagues also discuss the possibility of drawing inspiration from nature when designing systems that reproduce touch-like capabilities in robots. More specifically, they feel that the way in which neurons transmit signals throughout the body of both humans and animals may be an immensely valuable source of inspiration for e-skin developers.

"The most meaningful aspect of our review, however, is the framework that it lays out for future research goals in soft robotics," the researchers said. "We describe several open challenges and potential next steps for soft roboticists (and roboticists in general) to tackle for the development of intelligent, autonomous robots. As robotics and automation grow increasingly ubiquitous, solutions to these problems will unlock the next generation of capabilities."

Shih, Tolley and their colleagues believe that in the future, robots will become widely implemented within a variety of settings, including people's homes, healthcare facilities, workplaces and many other environments. By reviewing recent approaches to the development of machine-learning-powered e-skins and outlining current challenges impeding their large-scale implementation, they hope that their work will serve as a guide for researchers conducting further research in this particular area.

"We now plan to continue our pursuit of the integration of e-skins and machine learning with soft robotics to develop robots that can understand affective touch (i.e., social communication through physical touch)," Shih and Tolley said. "The ongoing COVID-19 pandemic has demonstrated that robotics and automation may be useful to reduce the labor burden on health care staff. As in the near future, robots may be

collaborating with nurses and doctors in hospitals or could be directly assisting patients, we would like them to understand actions like a high-five or a pat-on-the-back to enable more friendly relationships with people."

More information: Benjamin Shih et al. Electronic skins and machine learning for intelligent soft robots, *Science Robotics* (2020). DOI: 10.1126/scirobotics.aaz9239