SQuad: A miniature robot that can walk and climb obstacles

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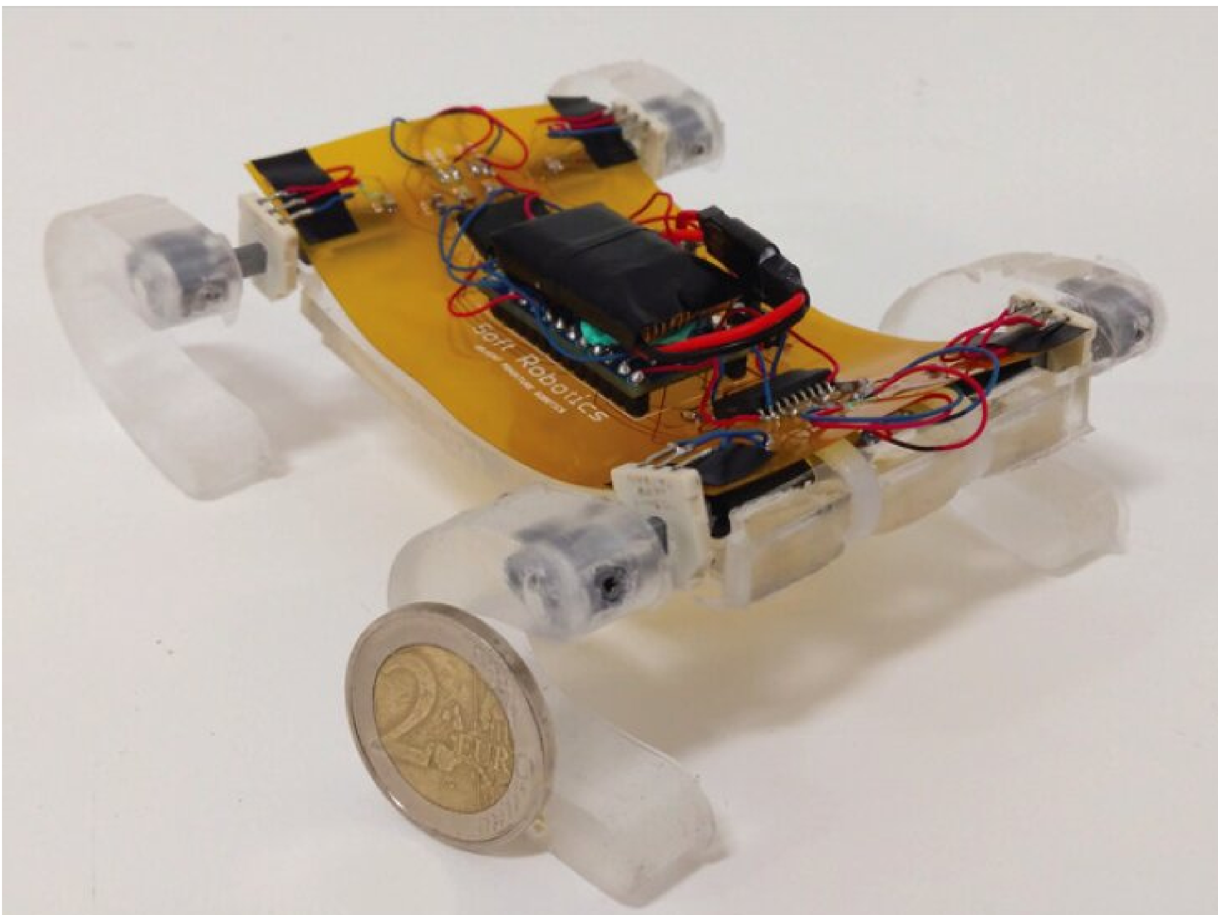


SQuad, the miniature robot developed by the researchers. Credit: Kalin et al.

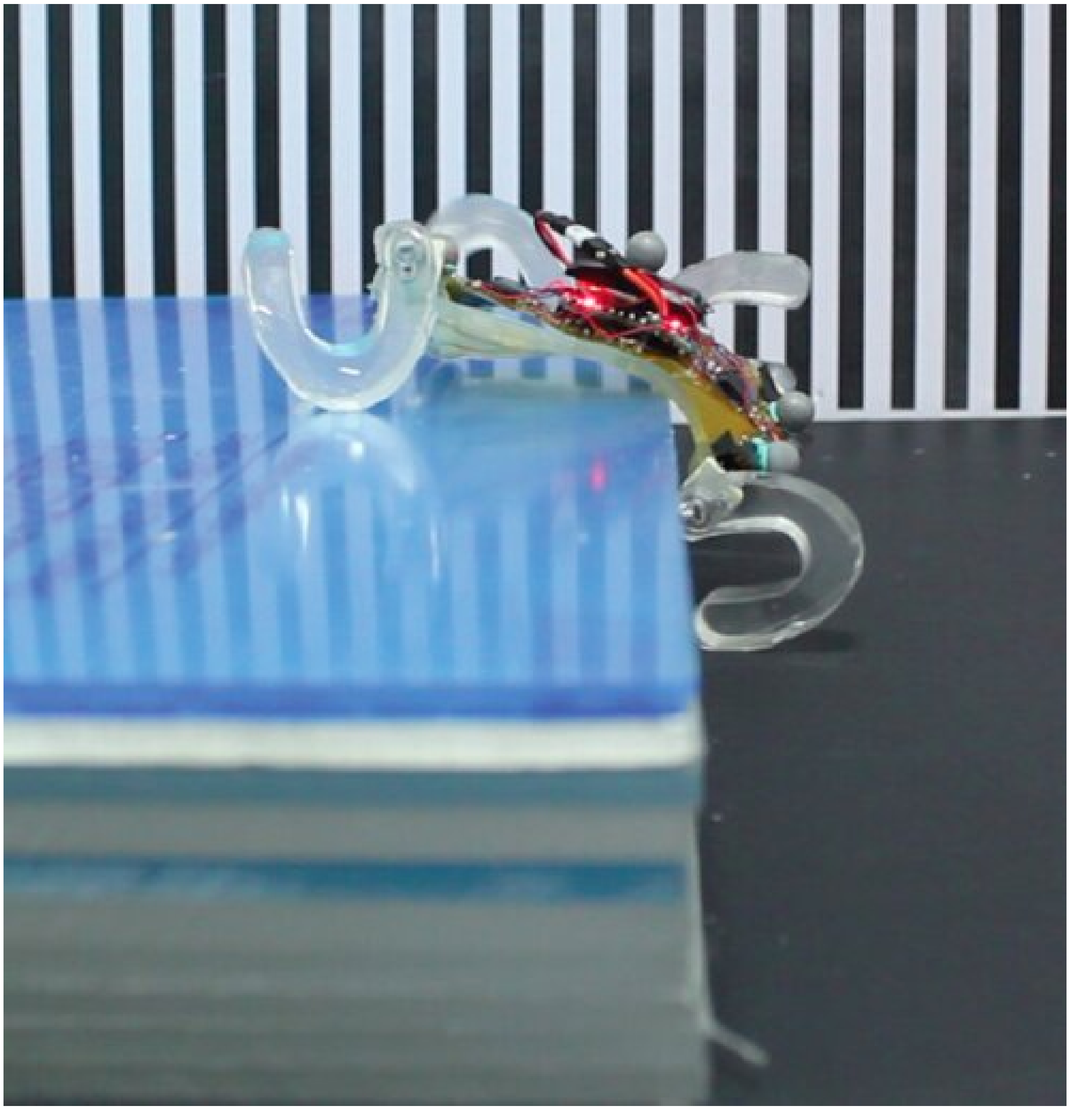
Researchers at Bilkent University in Turkey have recently created a small quadruped robot called SQuad, which is made of soft structural materials. This unique robot, presented in a paper published in *IEEE Robotics and Automation Letters*, is more flexible than existing miniature robots and is thus better at climbing or circumventing obstacles in its surroundings.

"We have been working on miniature robots for almost a decade now," Onur Ozcan, one of the researchers who carried out the study, told TechXplore. "Even though miniature robots have many advantages, such as being cheap, as they require fewer materials, and the ability to access confined spaces, one of their major drawbacks is their lack of locomotion capabilities, especially on uneven terrain."

Tiny robots tend to get stuck easily while moving in the surrounding environment, as their height does not allow them to climb or avoid obstacles. Ozcan and his colleagues tried to overcome this limitation by implementing a principle known as 'body compliance."

"We thought that by making our miniature robots soft, they would be able to exploit their body compliance to go over obstacles, just like most biological systems like insects or mice do," Ozcan said.

SQuad, the palm-size and four-legged robot developed by the researchers, is primarily made of soft materials, such as polydimethylsiloxane (PDMS). The robot also has soft C-shaped legs with integrated DC motors, which enable their rotation.



SQuad climbing an object. Credit: Kalin et al.

"Most soft robots are built using pneumatic actuators," Ozcan said. "These actuators work and integrate with soft materials very nicely, but they need a compressed air source, which often makes the robots bulky and sometimes does not allow untethered locomotion. We wanted to design a robot that brings best of the two worlds together; using soft materials to make a compliant robot but also using regular actuators such as DC motors that easily enable miniaturization and untethered locomotion."

The researchers evaluated their robot in a series of experiments, comparing its locomotion performance to that of an identical robot made of a rigid material. SQuad outperformed the other robot by a significant margin, climbing obstacles far more effectively.

Remarkably, the robot developed by Ozcan and his colleagues could overcome obstacles that were 1.44 times taller than its body height. The rigid robot they compared it with, on the other hand, could only successfully climb over obstacles that were 0.88 times its body height.

"The difference we observed in scalable obstacle height arises from SQuad's body compliance," Ozcan said. "We think that with such an improvement we can use this robot for inspection purposes (with a small camera added on board), or to find survivors under a collapsed building (again maybe integrating a camera and a microphone for detecting survivors)."

In the future, the robot developed by Ozcan and his colleagues could complete a variety of simple missions on land. Its high flexibility, body compliance and enhanced ability to climb obstacles could also potentially allow it to crawl through small openings and move on unstructured or uneven terrain, for instance on a site where a building collapsed.

The researchers are now planning several additional studies aimed at improving their robot's performance and locomotion capabilities. Firstly, they plan to investigate techniques that could enhance SQuad's gait and movements. They also plan to develop and synthesize new polymers with favorable properties that could be used to build miniature robots. These new materials could enhance their robot's locomotion skills or could be used to create soft sensors to be integrated directly into their robot's body.

"We are constantly updating our design," Ozcan said. "We are adding a body contraction mechanism to make our robot go through openings that are smaller than its cross-section. It will briefly contract and pass through small openings, in a way that resembles the behavior of mice. We are also working on robot's dynamic model to understand the locomotion of miniature and soft robots in a better way."

More information: Design, fabrication, and locomotion analysis of an untethered miniature soft quadruped, SQuad. DOI: 10.1109/LRA.2020.2982354.
ieeexplore.ieee.org/abstract/document/9043717