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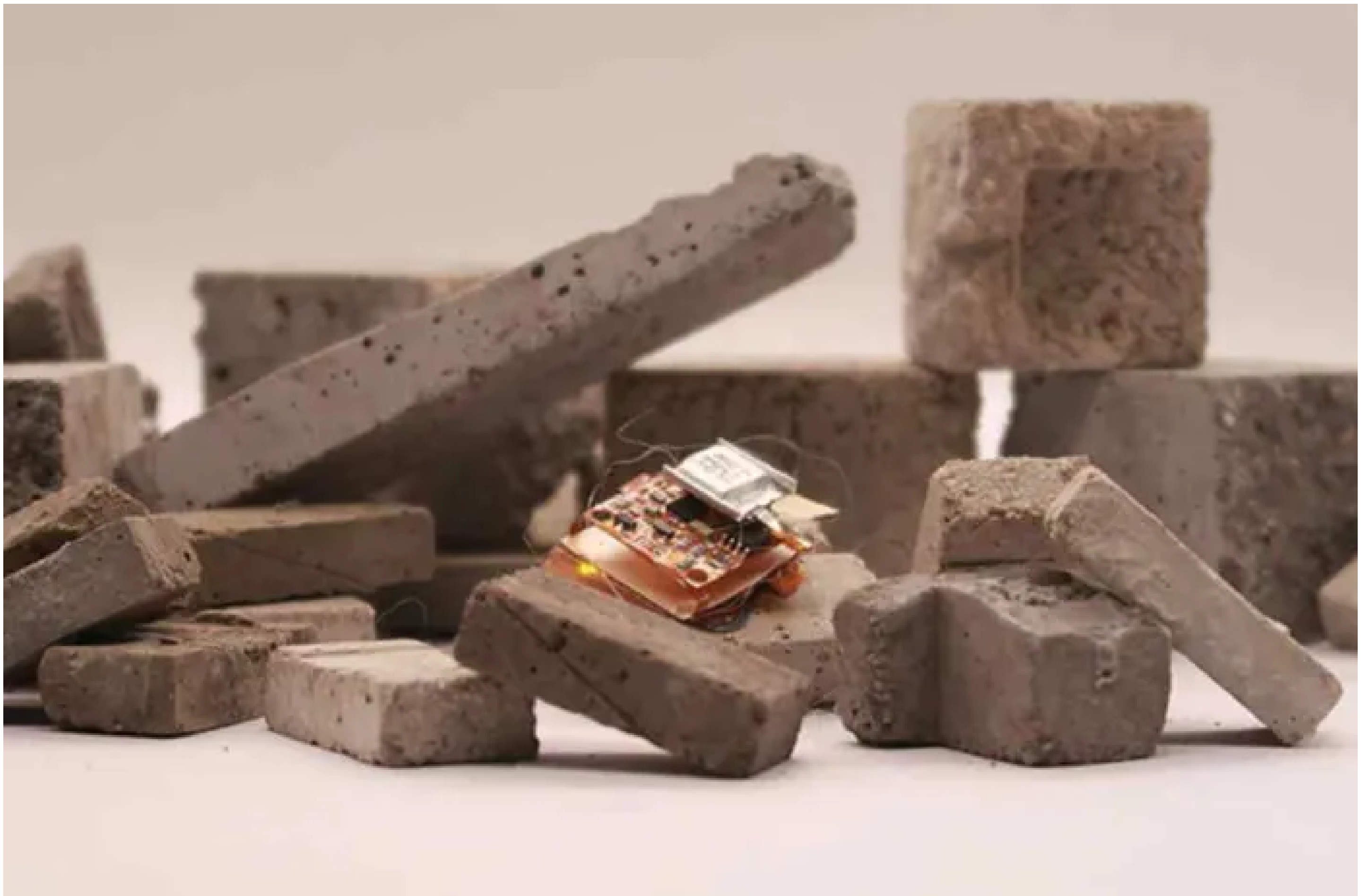
A Robot That Moves Like a Bug (and a Cheetah)



The robot is built of a layered material that bends and contracts when an electric voltage is applied, allowing it to scurry across the floor with nearly the speed of an actual cockroach. (UC Berkeley photo courtesy of Jiaming Liang & Liwei Lin)

Billy Hurley, Digital Editorial Manager

Engineers at UC Berkeley have made a lightweight robot with bug-like control and cheetah-like agility. The secret to such speed and swerve-ability: Footpads.

By modulating the electrostatic forces between the robot's feet and the traversed surfaces, the UC Berkeley researchers got their technology to navigate complex terrain and unexpected obstacles in seconds. (*See a video below of the bot navigating a Lego maze*).

According to the robot's inventors, these small, robust systems could someday support search-and-rescue operations or detect potential gas leaks.

The robot moves with the speed of a scurrying cockroach, thanks to a thin, layered outer material that bends and contracts when an electric voltage is applied. In a 2019 paper [https://news.berkeley.edu/2019/07/31/you-cant-squash-this-roach-inspired-robot/] , the research team demonstrated that the roach-bot could move at a rate of 20 body lengths per second, or about 1.5 miles per hour — nearly the speed of living cockroaches themselves.

In the new study [https://robotics.sciencemag.org/content/6/55/eabe7906] , the researchers upgraded the robot by adding two electrostatic footpads — and some volts.

Applying a voltage to either of the footpads increases the electrostatic force between the footpad and a surface, making that footpad adhere to the surface more firmly and forcing the rest of the robot to rotate around the foot.

The two footpads give operators full control over the trajectory of the robot, and allow the robot to make turns with a centripetal acceleration that exceeds that of most insects, according to Liwei Lin, a lead researcher and professor of mechanical engineering at UC Berkeley.

> **The highest speed we have achieved is 28 body lengths per second**
>
> **— Prof. Liwei Lin**

“Our original robot could move very, very fast, but we could not really control whether the robot went left or right, and a lot of the time it would move randomly, because if there was a slight difference in the manufacturing process — if the robot was not symmetrical — it would veer to one side,” said Prof. Lin “In this work, the major innovation was adding these footpads that allow it to make very, very fast turns.”

To demonstrate the robot’s agility, the research team filmed the robot navigating Lego mazes while carrying a small gas sensor and swerving to avoid falling debris.

And even if debris hit the flying robot, it would likely be just fine; the robot can take a hit.

In a previous study, the UC Berkeley engineers demonstrated the robo-roach could withstand being stepped on by a 120-pound human. (*See the video below*.)

The team has both a "tethered" and "untethered" version of the technology. The "tethered" robot is powered or controlled through a small electrical wire. The untethered, battery-powered options runs for up to 19 minutes and 31 meters while carrying a gas sensor.

One of the biggest challenges facing robotics engineers today is how to make smaller-scale robots that maintain the power and control of bigger robots.

“With larger-scale robots, you can include a big battery and a control system, no problem. But when you try to shrink everything down to a smaller and smaller scale, the weight of those elements become difficult for the robot to carry and the robot generally moves very slowly," Lin said in an earlier news release from the university [https://news.berkeley.edu/2021/07/02/insect-sized-robot-navigates-mazes-with-the-agility-of-a-cheetah/] .

"Our robot is very fast, quite strong, and requires very little power, allowing it to carry sensors and electronics while also carrying a battery.”

In a short interview with *Tech Briefs* below, Lin explains more about the benefits of a low-power robot, and how it makes its way through a maze.

***Tech Briefs*: What initiates the subtler movements of the robot? How does it, for example, avoid debris and steer itself through a maze? Does it know the obstacles and terrain ahead of time?**

Prof. Liwei Lin: It was able to move through a maze control externally. In other words, we activate the left turn, right turn or forward commands to steer the robot to move through the maze. One future work is to add a camera toward autonomous steering.

***Tech Briefs*: How fast have you gotten this robot to go?**

Prof. Liwei Lin: The highest speed we have achieved is 28 body lengths per second (similar to those of a cockroach). As you may have seen in the real-time maze video, the trajectory manipulation demonstration is accomplished by navigating the robot to pass through a 120 cm-long track in a maze in 5.6 seconds. Human can give turning commands several times in this period.

***Tech Briefs*: Can a fast robot lead to a potential lack of control? For search and rescue, does a scurrying robot provide a disadvantage, because of its fast, frantic movements?**

Prof. Liwei Lin: Yes. A fast robot can lead to a potential lack of control – we are working on a flying robot and it is so fast and difficult to control it (not published yet). For search and rescue applications, one does need to balance the speed and control. We think the speed and control of our prototype are adequate. For example, the robot may have to sneak through small holes and find specific paths to find the survivors in ruins.

***Tech Briefs*: What makes the robot robust?**

Prof. Liwei Lin: The robot is made of polymer materials such that it is very robust. One can step on it and it will still be operational.

***Tech Briefs*: What's next? What are you working on now with this robot?**

Prof. Liwei Lin: The common problem of small-scale robot is the tradeoff between the mass and power as an important academic and practical issue. In our current prototype, the version of the untethered robot powered by battery can run for 19 minutes and 31 meters. We are hoping to extend these parameters and have it carry other sensors, such as camera and wireless communication systems, for possible search-and-rescue missions.

***Tech Briefs*: What is most exciting to you about this robot and what's possible with it?**

Prof. Liwei Lin: The most important feature of this robot is the agility and tractor control – we have the highest agility among all artificial robots (including the large-scale ones) in terms of the relative centripetal acceleration of 28 body-length/s^2.

More Robots on Tech Briefs

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A robotic finger [/component/content/article/tb/stories/blog/39348] from MIT senses buried items.

For the latest innovations, go to our Robotics Hub [/tb/topic/motion-control-automation/robotics-automation-control] .

Lin is senior author of a paper describing the robot, which appears this week in the journal Science Robotics.

Co-authors of the paper include Jiaming Liang, Huimin Chen, Zicong Miao, Hanxiao Liu, Ying Liu, Yixin Liu, Dongkai Wang, Wenying Qiu, Min Zhang and Xiaohao Wang of the Tsinghua University in China; Yichuan Wu of the University of Electronic Science and Technology of China; Justin Yim of Carnegie Mellon University; and Zhichun Shao and Junwen Zhong of UC Berkeley.

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What do you think? Share your questions and comments below.