

Can a cockroach teach a robot how to scurry across rugged terrain?

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The roaches used in the study are a Central American species with bodies about 2 inches long. Credit: Will Kirk/JHU

When they turn up in family pantries or restaurant kitchens, cockroaches are commonly despised as ugly, unhealthy pests and are quickly killed.

But in the name of science, Johns Hopkins researchers have put these unwanted bugs to work.

In a crowded, windowless lab, scholars and students are coaxing the insects to share some crucial locomotion tips that could help future robotic vehicles traverse treacherous terrain.

Picture the aftermath of an earthquake or the cluttered, unexplored surface of another planet. Human teams might hesitate to enter such hazard-strewn regions. But what earthly lifeform—other than the one jokingly said to be able to survive even an atomic bomb blast—is more likely to persist on dangerous alien landscape?

For missions like these, the Johns Hopkins researchers want to build robots that behave more like cockroaches. The team's early findings are the subject of two related research papers published [here](#) and [here](#) in the Feb. 2 issue of the journal *Bioinspiration & Biomimetics*.

Sean W. Gart, a postdoctoral fellow who puts the roaches through their paces, was lead author of the two papers. The senior author was Chen Li, an assistant professor of [mechanical engineering](#) who directs the Terradynamics Lab. It focuses on movement science at the interface of biology, robotics and physics.



A roach climbs over an obstacle, providing a model for roboticists to study.
Credit: Will Kirk/JHU

Inside the lab, cockroaches scurry along tracks laden with two types of obstacles: large "bumps" and equally large "gaps." These mimic the holes and barriers that the roaches might have encountered in their rugged natural habitat. The bugs contort their heads, torsos and legs until they find a way to get themselves over or across the obstacles in order to remain on course.

High-speed cameras capture the body and leg motions used by these roaches, a Central American species with bodies about 2 inches long. These videos can later be slowed down to help the researchers learn the precise travel tactics that small robots could use to surmount the same

type of obstacles. The roaches, native to a rainforest region highly cluttered with vegetation, need these skills.

"Where they live, you have all sorts of stuff around you, like dense vegetation or fallen leaves or branches or roots," Li said. "Wherever they go, they run into these obstacles. "We're trying to understand the principles of how they go through such a complex terrain, and we hope to then transfer those principles to advanced robots."

Some of these roach-inspired improvements have already materialized. Li's team has constructed a multi-legged robot to replicate the insect's running patterns. After carefully reviewing their bug videos to discover the underlying physics principles, the researchers added a "tail" to help the robots replicate body positions that helped the real roaches get past the large bumps and gaps on the lab track. This simple change increased the largest gap size that the robot could traverse by 50 percent and the largest bump size it could traverse by 75 percent.

"We are just beginning to understand how these critters move through a cluttered 3-D terrain where you have obstacles that are larger than or comparable to the animal or robot's size," Li said.

The next step will be to determine whether their findings will also apply to movement through more randomly scattered terrain such as rubble from a demolished building.

But don't expect the team to abandon its use of cockroaches in unraveling the mysteries of animal movement. Li has been working with them since 2012 when he became a UC Berkeley postdoctoral fellow studying animal locomotion.

"I knew I would be working with these animals, and I was a little scared at first because they just run so fast, and they were so creepy," Li recalls.

"But as soon as I started working in the lab, I learned that it's actually very easy to work with them, and they're actually a very nice, fantastic model organism. Not just because they're so robust and move so fast, but also because they're very easy to handle and motivate to run and very easy to care for. So, they're currently one of the main species in our lab, serving as a model system."

Co-authors on the journal article about traversal of large gaps were graduate students Changxin Yan and Ratan Othayoth and undergraduate Zhiyi Ren, all from the Department of Mechanical Engineering.

More information: Sean W Gart et al, Dynamic traversal of large gaps by insects and legged robots reveals a template, *Bioinspiration & Biomimetics* (2018). [DOI: 10.1088/1748-3190/aaa2cd](https://doi.org/10.1088/1748-3190/aaa2cd)

Sean W Gart et al. Body-terrain interaction affects large bump traversal of insects and legged robots, *Bioinspiration & Biomimetics* (2018). [DOI: 10.1088/1748-3190/aaa2d0](https://doi.org/10.1088/1748-3190/aaa2d0)

Provided by Johns Hopkins University

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