A Swarm of Cyborg Insects Might Save You From Disaster

Researchers have hacked living cockroaches to create new search-and-rescue tech.

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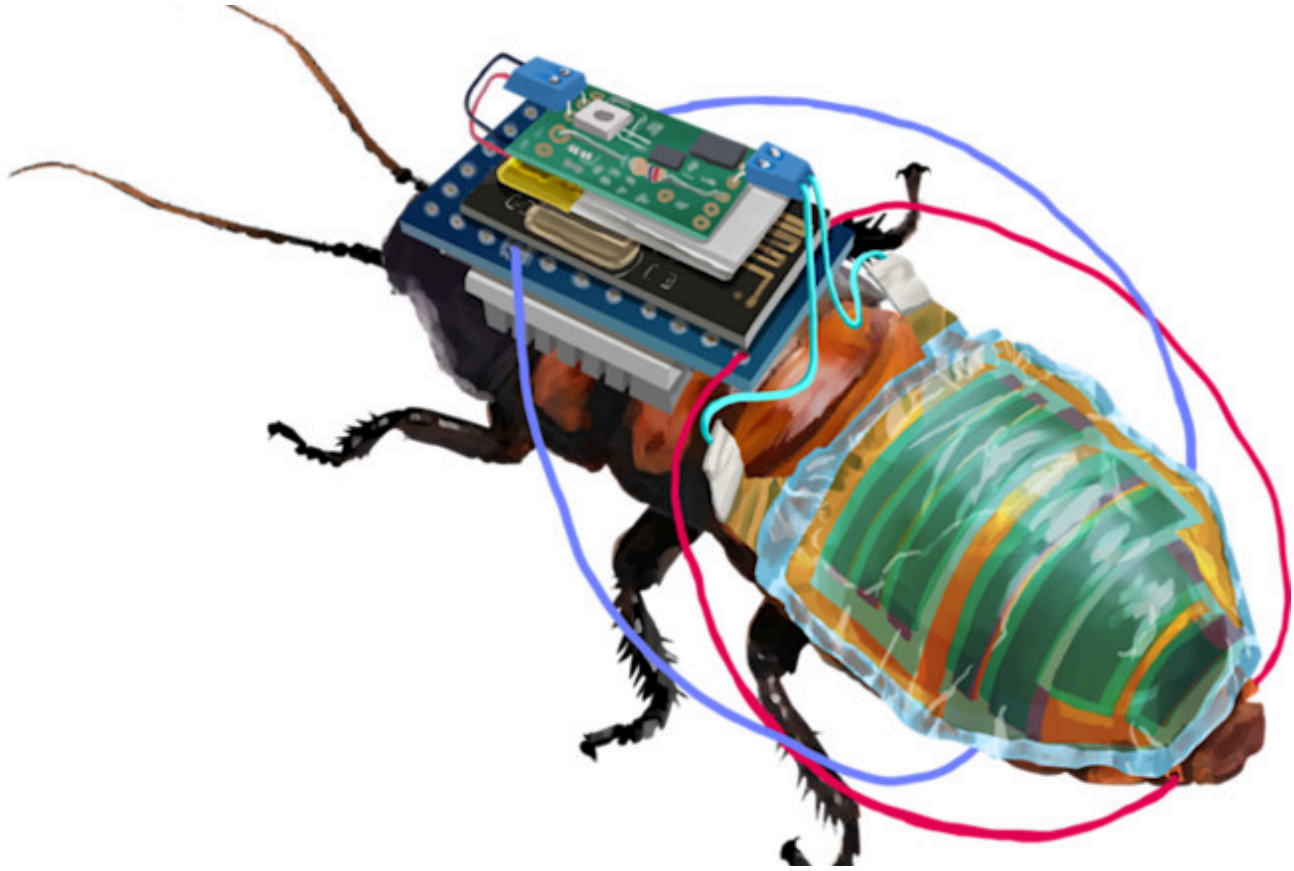

Researchers at RIKEN, Japan have created remote controlled cyborg cockroaches, equipped with a tiny wireless control module that is powered by a rechargeable battery attached to a solar cell. (Credit: RIKEN)

Earthquakes, tornadoes, air strikes — all around the world, countless lives are lost not just to the direct impacts of disasters, but those that are trapped in the resulting wreckage.

Search and rescue efforts, both professional and amateur, are dangerous in themselves, as digging through rubble creates risk for secondary collapse and exposure to hazardous materials. Meanwhile time is short, and the larger the affected area, the harder it is to search efficiently and effectively. Dogs can sniff out people, but these specialized pooches are often rare compared to the vast footprint of the wreckage.

A team of scientists out of Singapore and Japan believe they have a rather unconventional tool to offer search-and-rescue efforts: swarms of cyborg cockroaches. The research is published in ***Nature Communications***.

For the last two decades, researchers have been developing technology that allows them to remotely control live insects through implants to their nervous systems. Early work developed remote-controlled flying beetles (*Mecynorrhina torquata*), and quickly expanded to include Madagascar hissing cockroaches (*Gromphadorhina portentosa*).

“I have communicated with rescue teams and found that they urgently need insect-sized vehicles capable of traversing small openings in rubble to locate humans trapped in disasters,” says Hirotaka Sato, professor at Nanyang Technological University, who has long led this work.

Early in 2025, Sato’s team announced a new breakthrough that brings the tech one step closer to launch: A new algorithm that can be used to deploy a swarm of the insects to navigate through unknown terrain and identify the locations of humans.

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Remote-Controlled Insects

How do you make a cyborg cockroach? Apparently, the process only takes 15 to 20 minutes, the researchers say. While the insect is anesthetized with CO2, an ultra-thin silver wire is inserted into each cerci – taillike sensory appendages (picture the tail end of an earwig or cricket) – as well as into each antennae and a tiny hole cut into its second abdominal segment. These electrodes connect to a tiny backpack, 1.5 cm on a side, affixed to its back.

Sending an electrical current through the abdomen and one antenna signals the roach to turn in the opposite direction. A similar signal sent through the cerci signals it to speed up. It takes less than a second of stimulus to elicit the response.

not more, without food or water (don't worry: these cyborgs are well-fed on a diet of carrots and apples). And when it comes to navigating difficult terrain, a cockroach doesn't need to be programmed to move over, under, and around obstacles in its path.

"Despite decades of advancements in robotics, miniature vehicles remain impractical due to high power consumption for locomotion and structural fragility," explains Sato. "To address this challenge, we developed the concept of using living insects as a platform — cyborg insects."

Cyborg Search-And-Rescue

Sending individual cockroaches into rubble like RC Cars couldbe helpful for a search-and-rescue team, but the potential impact of the cyborgs is multiplied when a larger swarm can be deployed to cover more ground.

To develop the swarming capabilities of the cyborgs, Sato's team worked with Naoki Wakamiya at Osaka University and Masaki Ogura at Hiroshima University, both leading experts in swarming control algorithms, as a part of Japan's national research program, MOONSHOT.

The concept of using the behavior of social insects to inspire algorithms dates back over 30 years, initially applied to software agents rather than physical robots.

"In general, you cannot say insects are 'programmed,' but the result of evolution is that they are good at doing things that maximize the probability of their reproduction," says Marco Dorgio, research director for the Belgian Fonds de la Recherche Scientifique and co-director of the artificial intelligence research laboratory (IRIDIA) at the Université Libre de Bruxelles, and was not involved in this study.

Controlling the Swarm

In their new system, the researchers designate one cyborg in the swarm as the leader and the rest as followers. This provides a general direction for the group while allowing individuals to choose their own paths through the uneven terrain. Each cyborg can detect the location of its nearest neighbors and the leader, while only the leader knows the location of the group's destination.

The benefits of this swarm are greater than the sum of its parts. Because the insects have free motion when they're in the group, they naturally avoid obstacles that have caused others to slow down, and they won't pile up on each other. They can even help each other get unstuck or flip an overturned comrade rightside-up — the insects instinctively will grab onto a passerby to right themselves.

This system also reduces the need for guiding the cockroaches at all by 50 percent, the researchers report. The time spent in free motion while inside the swarm is meaningful, reducing the battery power needed in the control backpacks and reducing the likelihood of habituation to the signals.

The researchers are continuing their work to refine their swarming algorithms and control systems. They hope that their cockroach rescue teams may soon scuttle their way from the lab into disaster zones, helping emergency responders locate survivors in the rubble faster and more efficiently than ever before.

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