Scientists use AI-powered robot to assemble cyborg insects for use in search and rescue efforts

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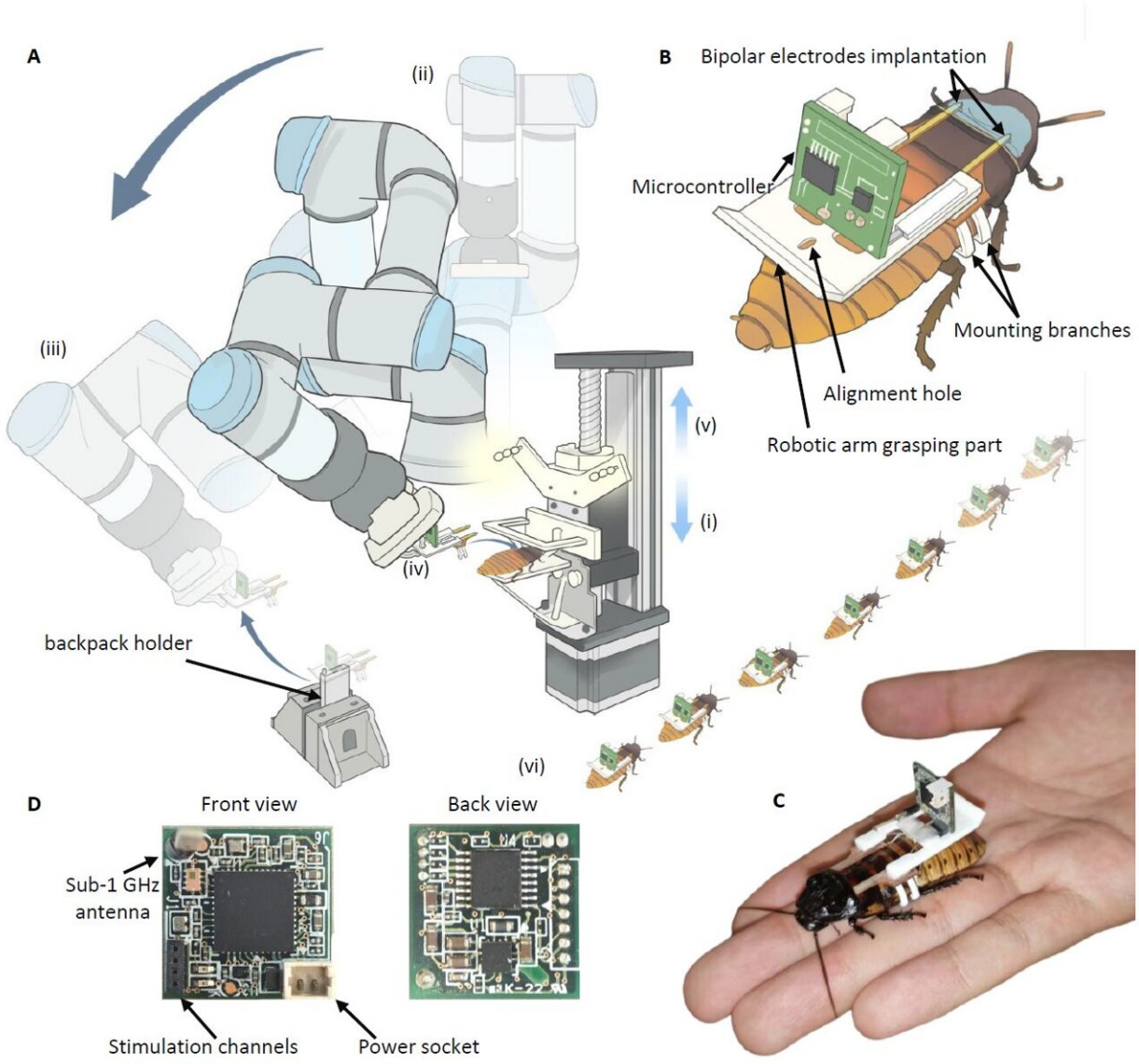

Prototype of the automated cyborg insect factory assembly line. Credit: Nanyang Technological University

Nanyang Technological University, Singapore (NTU Singapore) scientists have built the world's first automated cyborg insect "factory line." This new prototype robotic system automates the attachment of miniature electronic backpacks on the backs of Madagascar hissing cockroaches, turning them into insect-hybrid robots.

This new assembly method significantly reduces preparation time and human error, marking a big step toward large-scale deployment of insect-hybrid robots in complex environments for search and rescue efforts in disaster zones.

Led by Professor Hirotaka Sato from the School of Mechanical and Aerospace Engineering at NTU Singapore, the automated system can attach the electronic "backpacks" to Madagascar hissing cockroaches in just 1 minute and 8 seconds per insect.

This is about 60 times faster than the traditional manual process dependent on trained operators, which often takes more than an hour. When processing four insects, the system completed all assemblies in under 8 minutes, about 30 times quicker than manual methods.

"Our innovation makes the dream of deploying large numbers of cyborg insects in real-life scenarios far more practical," said Prof Sato.

"Manual preparation is time-consuming and very dependent on skilled operators. By automating the process, we can produce insect-hybrid robots rapidly and consistently. It will allow us to prepare them in large

numbers, which will be critical in time-sensitive operations such as post-disaster search and rescue."

When the roaches are no longer deployed or during long periods of rest, the miniature electronic backpacks can be safely removed from their backs without any adverse effects.

How cyborg insects work

Unlike conventional robots, cyborg insects move normally using their limbs, guided by gentle electrical stimulations delivered through implanted electrodes connected to a lightweight circuit board on their backs.

The AI-enabled robotic assembly system uses computer vision and a proprietary algorithm to identify the optimal anatomical site on the cockroach's back for electrode implantation, ensuring accurate placement.

The researchers also designed a new generation of backpack that stimulates the insects more efficiently, using 25% less voltage than earlier versions while maintaining precise control of movement. This extra power efficiency will help to extend operational time and reduce the risk of overstimulation.

In laboratory tests, the hybrid insects demonstrated sharp turns of more than 70 degrees and speed reduction of up to 68% on command.

A swarm of four cyborg roaches covered more than 80% of an obstacle-filled test area in just 10.5 minutes, showcasing their ability to navigate through tight and cluttered spaces.

While the assembly line is still in the prototype stage, cyborg insects with

the first-generation backpack mounted using the manual method have already seen real-world use.

Real-world applications

On 30 March 2025, a team of 10 cyborg insects was deployed to Myanmar together with the Singapore Civil Defense Force (SCDF) as part of its Operation Lionheart contingent.

The humanitarian aid mission was in response to a devastating 7.7-magnitude earthquake that struck on March 28, which claimed more than 3,000 lives.

This marked the first time that cyborg insects were used in a humanitarian operation and the first-ever field deployment of insect-hybrid robots.

The field deployment demonstrated the potential of insect-based robotics for locating survivors in disaster-hit areas where conventional robots would have struggled with access and short operational times.

"With learning from our field deployment, it's now essential to create infrastructure that supports mass production and deployment," said Prof Sato. "Our assembly line is the first step toward that goal, and we believe it will pave the way for more reliable cyborg applications, such as inspecting large civil structures for defects."

Prof Sato is internationally recognized for his pioneering work in cyborg insects. His groundbreaking research has been featured in *Time* magazine's "50 Best Inventions of the Year" and *MIT Technology Review's* "10 Emerging Technologies."

Looking ahead, his team aims to improve the assembly system and work

with local partners to further validate its effectiveness and readiness for industrial use.

Provided by Nanyang Technological University