Singapore: NTU's Cyborg Insects Enhance Disaster Response

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Researchers at NTU Singapore have unveiled a pioneering robotic system that automates the creation of insect-hybrid robots, marking a major breakthrough in the future of smart disaster response technologies. The new system, believed to be the world's first automated assembly line for cyborg insects, drastically reduces the time and effort needed to prepare these biological robots for search and rescue missions.

The project, led by Professor Hirotaka Sato from NTU's School of Mechanical and Aerospace Engineering and supported by the Japan Science and Technology Agency (JST), automates the attachment of tiny electronic backpacks onto Madagascar hissing cockroaches. These devices transform the insects into controllable cyborgs capable of navigating complex environments where conventional machines often fail.

The robotic system uses artificial intelligence and computer vision to guide the process. It identifies the optimal anatomical site on each cockroach's back for electrode implantation and precisely mounts a lightweight circuit board that controls the insect's movements via gentle electrical stimulations.

The entire procedure takes just 1 minute and 8 seconds per insect, about 60 times faster than manual methods, which can exceed an hour. The system can assemble four cyborgs in under eight minutes, representing a substantial leap toward scalable deployment.

"This development brings us closer to making cyborg insects a practical reality for large-scale deployment in time-critical situations such as natural disasters," said Professor Sato. "Manual preparation is time-consuming and requires skilled operators. Our automated system offers consistency, efficiency and speed—factors essential for real-world use."

The backpacks are designed to be removable, allowing the insects to resume their normal behaviour when not in use. The latest generation of these electronic modules is also more energy efficient, using 25% less voltage than earlier versions while maintaining precise control over movement. This improvement helps to extend operational time and reduce the risk of overstimulation.

In laboratory tests, cyborg cockroaches exhibited reliable mobility, including sharp turns of over 70 degrees and speed modulation of up to 68% on command. A swarm of four cyborg insects successfully covered more than 80% of an obstacle-filled area in just 10.5 minutes, showcasing their ability to explore confined and cluttered spaces with ease.

The system's accuracy and repeatability also reduce stress on the insects and allow the devices to function longer and more reliably in the field during critical search and rescue operations.

Although the automated assembly system is still in its prototype phase, earlier versions of cyborg insects prepared manually have already been deployed in the field. On 30 March 2025, a team of ten such cyborg insects was sent to Myanmar alongside the Singapore Civil Defence Force's Operation Lionheart, following a devastating 7.7-magnitude earthquake. This marked the

first time insect-hybrid robots were used in a real-life humanitarian mission.

The deployment highlighted the potential of cyborg insects to operate in disaster zones, where small size, agility and extended operational duration offer critical advantages.

“With learnings from our fieldwork, we see the urgent need to build the supporting infrastructure for large-scale production,” said Professor Sato. “This assembly line is our first step in that direction.” The team is also exploring new backpack designs and integrating real-time sensing modules to enhance data collection during missions.

Professor Sato is internationally recognised for his groundbreaking research in cyborg insects, which has previously been featured in TIME magazine’s “50 Best Inventions” and MIT Technology Review’s “10 Emerging Technologies”.

The research is part of JST’s Moonshot R&D Programme under Moonshot Goal 3, aiming to realise AI-enabled robots that learn, adapt and collaborate with humans by 2050. It is conducted under the project titled “New World of Inspiration by Co-evolution of Humans, AI Robots and Biological Cyborgs”.

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