TECHNOLOGY

This seed-sized robot can switch between five surgical tools in less than a second

The robot has different tools and functions, such as activating a small blade to cut fabric or emitting heat.

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NTUSG

Surgical microrobot developed by NTU.

When we talk about robotics , **the first things that come to mind are humanoids** capable of lifting heavy boxes or assembling parts on complex assembly lines, even capable of defeating professional table tennis

players or running faster than any human. Perhaps we also think of highly dexterous artificial hands or biomimetic androids with artificial intelligence and the ability to walk. But robotics is much more than that.

For example, miniature robots. A group of researchers at Nanyang Technological University (NUT) in Singapore has developed **a seed-sized surgical robot** that can switch between five different functions in less than a second, offering a potential new tool for minimally invasive medical procedures. NUT is one of the country's two largest public universities and has tens of thousands of students. It is globally recognized for its engineering, technology, artificial intelligence, and business programs.

The tiny robot can move across soft and uneven surfaces. At **just 4.4 millimeters long** , it is controlled by weak magnetic fields, allowing it to move, cut biological tissue, release drugs, hold and store tissue samples, and generate heat remotely —all in the same instant. As mentioned, it can switch between its functions in less than a second.

THE RESEARCHERS TESTED THE SURGICAL FUNCTIONS

The team, led by Associate Professor Lum Guo Zhan of NTU's School of Mechanical and Aerospace Engineering (MAE), successfully enabled the robot to deploy various tools and perform different functions, such as **activating a small**

blade to cut tissue or emitting heat to a specific area, using magnetic coils in the lab for remote control. This could be very useful for heat-based cancer treatments.

Associate Professor Lum, a pioneer in miniature robots made from soft, flexible materials, said: “ **Most magnetic robots of this type can only perform one or two functions** . Our latest invention can now perform five, and our long-term goal is for doctors to use these mini-robots inside the body, direct them to a specific location, and use them to perform treatments.”

Several projects worldwide are studying mini-robots as a way to make minimally invasive surgical and medical procedures safer, less painful, and more precise. If successful, **they could help doctors perform specific surgeries** deep within the body without large incisions or bulky surgical instruments. They can reach areas where traditional surgery never could.

Instead of flooding the entire body with a drug or performing invasive surgeries, **minirobots and microrobots navigate the bloodstream** . They could travel through arteries directly to a tumor, loaded with chemotherapy, and release the drug right there to prevent destructive side effects in the rest of the body. And because they are controlled externally by magnetic fields, they can remove clots or clear cholesterol plaques without having to open the patient.

To integrate multiple functions into a robot just a few millimeters long, the NTU team developed **a movement control device activated by magnetic fields** that can be reprogrammed in less than a second. The robot is made of soft magnetic materials, such as PDMS and Ecoflex, which are silicone-based materials

commonly used in soft robotics because they are flexible and can be molded into small structures.

At the heart of the device is **a magnetic module that can be magnetized, demagnetized, and remagnetized** in different directions. Each magnetic orientation activates a different function of the robot, allowing it to perform five distinct tasks, including cutting and grasping tissue. The researchers also designed different regions of the robot to ensure that only one part, and not the rest, responds to the same magnetic field.

Only a portion of the robot reacts to a magnetic field to change shape and activate a tool or function, while other parts remain stationary and unchanged in their current form. **The NTU robot incorporates a sixth movement, rolling** , which allows it to rotate on its own longitudinal axis, providing more precise control over its positioning—essential for navigating narrow, soft, and irregular spaces, such as those found inside the human body.

Researchers tested the tiny robot's surgical functions on biological tissue, such as chicken liver, as well as gelatin-based materials that mimic soft tissue. In laboratory tests, **the robot cut biological tissues** , dispensed particles that simulated drug molecules, **held and stored tissue samples, and generated localized heat** after being induced by magnetic fields. More than 99 percent of the cells remained viable after exposure to the robot's materials.