Industrial repair 'snake' robot now being tested for cancer surgery

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A repair robot that takes inspiration from the bendiness and sensing ability of snakes to access hard-to-reach places in harsh, industrial environments is now being exploited for use in human surgery.

The continuum (snake-like) robot, called COBRA, has been developed at the University of Nottingham and has been successfully demonstrated in jet engine inspection and repair, as well as nuclear plant installation and maintenance, and is being now refined for medical use.

Based in the Rolls-Royce University Technology Centre (UTC) in Manufacturing and On-Wing Technology at the University, COBRA's researchers are the only group in the world to have perfected this kind of remote-controlled technology for industry.

The UTC has now secured Engineering and Physical Sciences Research Council Impact Accelerator funding to adapt COBRA into the first robot in the UK specifically for throat cancer and injury surgery.

Such kinds of medical procedures are currently performed with endoscopic tools, but COBRA could offer more dexterity, accuracy, and high-definition views for surgical teams.

"We have started early tests to see if the robot can navigate and has enough motion capabilities to perform surgical procedures," explains UTC Director, Professor Dragos Axinte. "For medical applications there are a lot of safety adjustments to make on the design and control method of the probe to make it suitable for inspecting inside the human body. The robot has potential in a broad range of applications and medicine is an exciting direction for our research to take."

Just like the real reptiles, the 5m long, ultra-slender robot, which is only about the same thickness as a pencil (9mm in diameter)—can easily slither through crammed spaces and round tight bends in safety-critical machine parts—where miniature scales and inhospitable locations make it physically impossible for a person to inspect or repair without fully dismantling.

This system has extraordinary maneuverability and responsiveness due to a series of tendons routed along the robot snake's "backbone"—a compliant-joint structure and multiple continuous sections that enable it to bend at around 90°. When these tendons are pulled (by remote commands) it drives the bending motions—mimicking the range of movements of a human operator's hands when handling the repair tools. The snake-arm can be different widths and has a hollow interior, through which different tools or instruments can be fitted.

COBRA is easily operated remotely after only a few minutes of training via a controller, much like a large gaming joystick.

This means maintenance engineers, based thousands of miles away, can guide COBRA via a computer screen as it navigates through complex componentry deep inside engines or narrow pipe networks, such as in nuclear applications—some only the same diameter as a £1 coin.

To perform complex industrial repair, COBRA is currently equipped with a stereovision camera and a miniature cutting tool attached to the 'head' of the snake (an end-effector); however, other devices to mend or monitor can be interchanged, depending on the task required.

Preliminary studies for COBRA's medical use have now been carried out with Dr. Oladejo Olaleye, a Consultant Ear, Nose and Throat and Robotic Surgeon at University Hospitals of Leicester NHS Trust.

COBRA was tested on a human dummy to access hard-to-reach parts at the back of the throat via the mouth—locations currently inaccessible without highly invasive surgery. The high-definition camera provided excellent views of the throat displayed on an operating screen.

Given that the robot is deliberately so easy to manipulate, it took only five minutes of training for the consultant to carry out the demonstration at the UTC laboratory. The robot was maneuvered round bends using a hand-held drive and locked into positions in the throat to achieve optimal operating views for the surgeon.

Dr. Oladejo Olaleye believes COBRA is "the interface between engineering and medical surgery" and "the future of diagnostic endoscopy and therapeutic surgery" providing a viable and minimally invasive option both for making diagnoses and treatment of diseases in the throat, chest, or bowel.

He said: "COBRA's strengths include a flexible construct, ability to bend and hold in position, high-definition views, ease of adaptation and portability. Achieving clear views of throat and voice-box cancers will hopefully translate into full clearance of the tumors with less pain, quicker recovery from hospital, improved survival and better rehabilitation outcomes for our patients."

The few robots in existence for surgical use are huge machines, not built specifically to navigate small cavities inside the human body. COBRA, by comparison is very compact and portable, opening up its potential in thoracic, stomach and bowel operations as well as throat for application in different operating settings.

The next steps for COBRA are a series of validation studies before clinical trials take place to translate the robot's design into medical practice.

For aerospace and nuclear applications, the robot is at Technology Readiness Level 6—just one step away from being available on the market—and is an important monitoring tool in safety-critical installations.

Repairing an aircraft engine, for example, is a complicated process.

Specialist maintenance engineers are needed, and most repairs must take place with the engine in-situ, as taking it off the plane takes time—something to be avoided in the fast-paced aviation world.

At present, these engineers often fly thousands of miles to fix affected aircraft, but with COBRA they will be able to simply access them from a computer screen wherever they are. This step change will help the aviation industry to reduce its carbon emissions, while also significantly saving it both time and money, without compromising the health and safety of the operators.

The team is also in the midst of building a "disposable" version of COBRA for use in the decommissioning of nuclear plants where there is a need to inspect radioactively contaminated components, but for safety the robot would need to be left at the scene after use.

Another potential application for COBRA, which the researchers are keen to progress with funding support, is disaster rescue.

"The snake arm robot is the ideal design to explore tight spaces inside collapsed structures or a caving accident, for instance. It could really help in the search for survivors, especially where its hazardous for rescuers. With a carbon dioxide detector attached to the tip of its probe it could pick up human breathing and a camera could report back visual updates. Additional pipes connected to the length of the robot could also provide anyone trapped or injured with vital oxygen and water supplies," adds Professor Axinte.

Provided by University of Nottingham

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