Snake-charmers

Helen Wraige talks to the researchers whose reptile-like robots could soon wriggle their way into a variety of important jobs in manufacturing

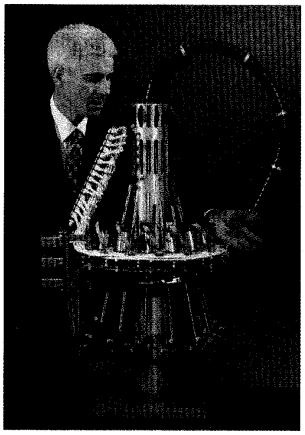
When most people think of robots, the image most likely to springs to mind is of the radio-controlled machines that appear on the BBC TV show *Robot Wars*. But these are a far cry from the industrial robots used on many production lines.

Robots come in many guises. Snake-arm robots, as the name suggests, have arms that move like a snake and have been used in research for more than two decades. Now a Bristol engineering company is intending to take snake-arm robots from the hidden recesses of research labs into the commercial world.

Rob Buckingham and Andrew Graham, both of whom have research backgrounds, formed OCRobotics in 1997. Buckingham says: "We are not just mad inventors. We are intent on resolving commercial issues and not just technical ones."

Buckingham has written most of the software to drive the robots, but has found that, as managing director, his energies tend to be directed elsewhere. Mariusz Lichon, who worked with Buckingham at Bristol University, has taken over the software development. Graham designed the hardware. Parts are made locally and most are off-the-shelf components to keep costs down.

Graham says: "There is nothing rocket science-like about the snake-arm robot, otherwise the price would be unattainable. We have designed with attention to detail, but with manufacturability foremost."



Playing ball: Buckingham (above) and his five-segment snake-arm robot

What makes a snake-arm robot different from a typical industrial robot is its extra manoeuvrability, owing to more than the minimum degrees of freedom in the arm. The snake-arm robot operates like a human arm and is known as a redundant robot, as Buckingham explains: "We can hold our hand up in a fixed position, while our arm behind it can take any number of shapes in order to keep it there, demonstrating the in-built redundancy of the arm."

Out on a wing

Buckingham says snake-arm robots are best suited for complicated problems in a variety of situations where access is restricted. "The most obvious applications are within aerospace. For example, aircraft wings need a man-sized hole for inspection purposes, which obviously affects the structure. Using a snake-arm robot means the hole can be reduced by a factor of 100 because the tools can reach tight places. This will have implications for aircraft design."

Graham adds that a jet engine can be inspected on the wing before a decision is taken as to whether the engine needs dismantling for maintenance work. "This is obviously better than dismantling something to find out if it needs dismantling. Considering the six to eight hours it takes to change an engine and all the downstream costs, this is a big incentive. We believe we can seriously reduce the cost of maintenance."

Buckingham believes that redundant robots are the way of the future. "We are a growing company, and we can offer something that can make a difference. We are not aiming at a niche market, and all the industries we have looked at have applications."

Flexible robots could take on jet cutting, laser welding and inspection tasks

Graham says the principles behind the snake-arm robot are easy to explain. A robot arm with three rotary joints will have variables for each joint for a given position of the tip. For any given tip position there will generally be two solutions, called left and right elbows. Where there is an obstruction in the path of one elbow the other elbow is available but, when there are obstacles to both, an extra joint is needed. This produces more possible configurations for the same tip position.

"In the case of the five-segment OCRobotics' snake-arm robot, there are 10 joint variables that operate in five-dimensional space – three dimensions for position and two for orientation. This means that half the robot's flexibility is available to avoid obstacles or follow a particular path, while keeping the tip at the required position and orientation."

The snake arm can have a number of segments, each of which is manipulated by three steel wires. The length-to-diameter ratio of the arm is critical because this affects the bending and torsion. The arms are interchangeable and different tools can be fitted to the end. Tip vision is the standard tool, but the only limiting factors for tools and sensors are size and weight. The company is investigating tools for water jet cutting, laser welding and ultrasonics.

The drive unit houses an actuator system for each wire to make the arm move, and the computer that calculates how to make the arm follow the designated path. While the drive unit for five segments can be used for fewer segments, Buckingham says the next stage is to make modular units so that segments and drivers can be added as necessary.

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