Access all areas

As the sophistication of automation technology increases, robots are finding their way into some new arenas. Ben Hargreaves reports

THE advances in automated systems for manufacturing over recent years have undeniably been remarkable, but there are still many processes in which robots have yet to make their mark. The advanced robotics system that has enough flexibility to operate in confined and inaccessible spaces may have been on the secret wish-list of manufacturers for some time, yet suppliers proffering workable solutions have been notable by their absence. Such systems have tended to occupy a hinterland of theory and speculation.

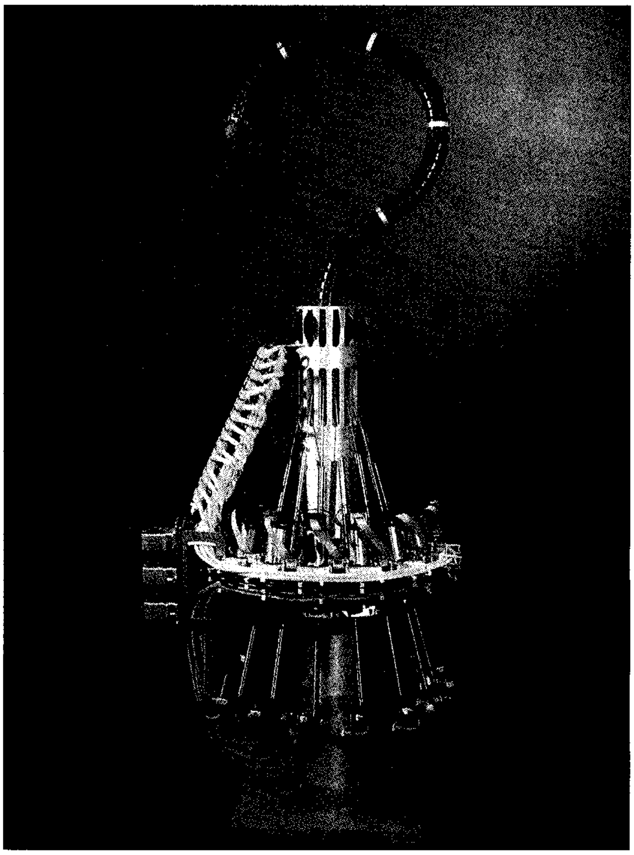
Until now, that is. OC Robotics, a start-up automation firm formed in Bristol, believes it has developed an innovative and timely new kind of technology – the robot that gets to the parts other robots cannot reach. The company's 'snake-arm' robot, the key selling point of which is that it can operate in confined and inaccessible places, is expected to find applications in all sorts of diverse fields, including aerospace, nuclear, and biomedical.

Dr Rob Buckingham, formerly a lecturer in robotics at the University of Bristol, started the company in 1997 to ensure that some interesting research on snake-arm robotics didn't suffer the fate of many such projects and fall by the wayside before being exploited commercially. "I didn't want to see it just gather dust," he explains.

Sophisticated

A snake arm robot is a flexible arm that is designed to follow complex paths. The device is more sophisticated than a medical endoscope because the operator can control it in its entirety, rather than just the tip. Typically, the arm is mounted on a mobile vehicle or another robot, or a linear slide. The arm is made up of a number of independently controlled segments with a drive unit that controls a certain number of segments. The unit consists of the actuator systems that make the arm move and the computer that calculates how to make the arm follow the prescribed path.

The modular segmented arm has been designed to be highly interchangeable. The user can select an arm of the required length and bend to achieve the required task. The arm can also carry a range of tools for different purposes. Although vision tips are most commonly used, OC Robotics is investigating laser cutting and welding tips. In theory, the only limit to the kind of tool or sensor placed on the arm is its size or weight. The user interface for the robot is image based, from either a camera on the arm's tip or a scene camera, or from computer generated views of actual or pre-planned action. Joystick control and off-line path planning, says OC Robotics, is intuitive and simple, with the software able to support many different configurations of arm.



The snake arm robot can reach inaccessible areas for inspection or repair applications, but its many redundant degrees of freedom make software control challenging

Obvious

According to Buckingham, in conceptual terms at least, his product is not an entirely new thing. "In a sense, it's an obvious idea. You could probably go back to sci-fi films and find all sorts of robotic mechanisms that look as if they have snaking arms. But the problem was actually cracking the engineering to make it happen."

The principal challenge lay in designing the robot's software control system – at the root of which lies some extremely complex mathematics. "When you have simultaneous equations," explains Buckingham, "you have two knowns, two equations, and two unknowns, and you can solve those equations. But with snake arm robots, you've got more unknowns than you've got equations. A normal robot works by defining where you want the tip of the robot to be, and you define that with six variables that describe X-Y-Z and three rotations. Typically you'd have six joint angles – six things you're controlling that control the shape of the arm. That gives you either one unique solution, or perhaps two or four – but only that many. To get the tip into position, you've got a very limited number of positions of the arm to get it there. But with a snake arm robot, there are many more joints in the arm: you can

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hold the tip of the arm at a certain point but move the rest of it all over the place. That way you can avoid things – but the challenge is to choose where to put the arm whilst holding the tip in a specific place. The software is key."

Potential

Although the snake arm is still in a nascent stage as a commercial proposition, OC Robotics is already in discussions with two major aerospace companies. Buckingham says they were quick to see the potential advantages of the technology. Inspection of parts inside an aero engine is one possible application where considerable time and money could be saved. "Normally, you'd have to take the engine off the wing and dismantle it to inspect a component," explains Buckingham, "but if you could do it on-wing, and use the air path to get to a part within the engine to have a look, or do whatever you want to do, it could be much faster and much less intrusive. It's a bit like keyhole surgery, but on an engine. You could do the same with wings and fuselages."

Other applications may come in nuclear decommissioning. Buckingham believes that those tasked with the extraordinarily complex and painstaking task of dismantling nuclear plant will find the snake arm a useful complement to existing tools, particularly in planning stages where operators have to get to grips with what they're dealing with. Further down the line, medical uses should emerge – once, of course, the safety of the technology has been proven in other applications.

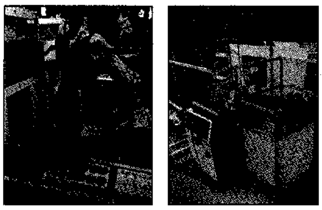
The telecommunications industry is also starting to benefit from advances in automation. Short timescales are required by mobile phone manufacturers in getting the product to market, and this, together with the generally short life of an individual phone model, has meant that automation suppliers have had to develop solutions which are based on proprietary items rather than traditional bespoke systems. These systems also have to be flexible to enable them to be used on the next model, with a minimum of re-tooling.

Solution

Robot systems, both six-axis and SCARA systems, are starting to be seen as the optimum solution to the requirement for short timescales and flexibility. The six-axis robots are finding their way into the injection moulding industry, offering the user maximum flexibility to deal with new products, and also enabling more out-of-mould operations to be performed.

The downstream assembly operations on mobile phone components also have the same requirement for short introduction timescales and flexibility, and here a combination of small six-axis robots and SCARA robots is increasingly being employed. The need to base systems on proprietary items has also – in some cases – generated a closer working relationship or partnership between the suppliers of proprietary items such as gasket feeding systems, tray handling systems and the automation system supplier itself.

These flexible, robot-based systems have been designed to enable easy interchangeability of proprietary component presentation and feeding systems, such as bowl feeders, tape and reel units. This is achieved by assembling the units on their own individual sub-plate. In turn, the sub-plate is located by dowels on the machine base. Service to these units is achieved by Harting Plug & Socked



Shortening lead times in the telecoms sector are making flexible robots more attractive

connections, and quick release air fittings. This principle enables other feeding units to be assembled to a sub-plate off-line, and subsequently brought and integrated to the machine as needed, minimising machine development time, and enabling the machine to achieve production in a reduced timeframe.

Impact

The change from bespoke system design and build to that of 'system integration' of proprietary items can also have a potential impact on the skill base of an automation supplier. Bespoke systems require a reasonably high content of mechanical design and assembly work, and also a high content of electrical design and panel building. In some cases, these systems also require extensive development time by technicians before being ready to ship to the customer. By comparison, robot-based systems incorporating 'off-the-shelf' integrated items dictate less mechanical design, and less panel build and development time – and thus a potentially different skill base, with fewer mechanical designers but greater numbers of control engineers with robot programming experience and integration skills.

Scope

One company with its roots in portal style robots that has widened its scope to supply six-axis machines is ATM Automation. In one application for a moulder of mobile phone components, ATM designed a system based on a Fanuc M6 unit. "The customer was a long standing user of 'traditional' robots for injection moulding, but the ATM/Fanuc system was its first experience of a six-axis installation," says Tom Petit of ATM.

"The task was to load decoration foils into the tool, and to remove the finished mouldings. While in-mould decoration is today a standard process in a host of moulding applications, from technical parts to packaging, it is where the foil is pre-shaped in three dimensions that production calls for particular accuracy. Only the accuracy and repeatability achieved with a six-axis robot was deemed suitable."

The foils were loaded manually into two magazines, which presented them to the robot. The robot took two foils and passed them in front of a Teknek unit to remove dust and debris. They were then de-ionised and loaded into the tool. Absolute accuracy of alignment was called for to prevent foil creasing or misalignment with the profile of the moulding, and the six-axis robot offered positioning to better than ±0.1mm.

The cell was controlled by Fanuc's RJ3 robot controller with PMC software generating the Euromap interface between the moulding machine and the robot. Other control features used in the cell included 'soft float' and collision detection. Soft float allows the robot arm to be pushed back by the ejector or enables the gripper to locate on dowel pins inside the tool. Collision detection, meanwhile, is an emergency stop function for when the robot is within the tool area. The flexibility of operation of a six-axis robot was a further benefit in meeting rapid model changes.

"With the telecoms industry still changing rapidly, new phone models appearing regularly and with mould tool lead times shortening to four to six weeks, and volume predictions continuing to fluctuate wildly," concludes Petit, "automation suppliers will continue to remain under pressure to develop flexible automation systems which have a high utilisation element for future products." E