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# Novel robot works its way around the problems of inaccessibility

Access can be a major problem in many industries, such as for inspecting jet engines, decommissioning nuclear plant, or searching for people trapped in collapsed buildings. Jon Severn reports on a new type of snake arm robot that reaches those previously unreached parts.

**L'accès peut être un problème majeur dans de nombreuses industries comme, par exemple, l'inspection des moteurs à réaction, le retrait de service d'une centrale nucléaire ou la recherche de personnes coincées dans des bâtiments effondrés. Jon Severn présente un article sur un nouveau type de robot à bras en serpent qui atteint les endroits qui jusqu'à présent étaient hors d'atteinte.**

**Zugang kann in vielen Bereichen ein großes Problem darstellen. Beispiele dafür sind: Überprüfung von Düsentriebwerken, Stillegung von Atomkraftwerken oder die Suche nach Verschütteten. Jon Severn berichtet über einen neuen "Schlangenarm"-Roboter, der selbst schwer zugängliche Bereiche erreichen kann.**

While the concept underlying the design of a jet engine is relatively simple, the engines fitted to modern aircraft are highly complex and extremely expensive. Maintenance costs are similarly high because only a limited amount of work can be carried out with the engine still fitted to the aircraft; other tasks need the engine to be removed from the wing and stripped down to its component parts. It has been estimated that many millions of euros could be cut from aircraft maintenance costs if a means existed for inspecting inside an engine without removing it from the aircraft.

Endoscopes and boroscopes are useful to a degree, although the user has little control over the device, making these instruments far from ideal for manoeuvring through or between delicate or sensitive components to gain access to the required position. But the question of access is not just restricted to aircraft engine maintenance: inspection and cleaning inside aircraft wings and fuselages poses similar problems and, beyond the aircraft industry, there are parallel requirements in the nuclear industry, for inspecting complex pipework, or for locating people inside collapsed buildings.

Carrying out visual inspections in such environments is clearly extremely beneficial, but it can be equally important to perform physical tasks with grippers or other tools, or to inspect using ultrasonics, eddy current probes or other non-destructive testing technologies, to clean using vacuum or water, or to cut with water jets, lasers, drill heads or grinding tools. The challenge is to find a way of steering the tool to the final location without disturbing the surroundings.

A company in Bristol, UK, has been working on the development of what it is calling a snake arm robot. In some ways this term is helpful because it suggests a snake-like device that can twist and turn. However, the design does not truly mimic the movement of a snake, and it is more likely it will be used as a highly manoeuvrable tool-carrier mounted on a much larger robot. Snake arm robots have been the researched for more than 20 years, but this is the first time one has been available commercially.

One of the most important factors behind the design of the Ocrobotics snake arm robot is that the movement of the segments that make up the arm must be mathematically describable. Each segment has two degrees of freedom and is typically controlled by three wires that act in a similar way to tendons, with the length of each wire being controlled by a servo-actuator housed within the drive unit. Although the first prototype snake arm has five segments and measures 1 m long by 35 mm in diameter (Fig. 1), designs exist for snake arms with up to

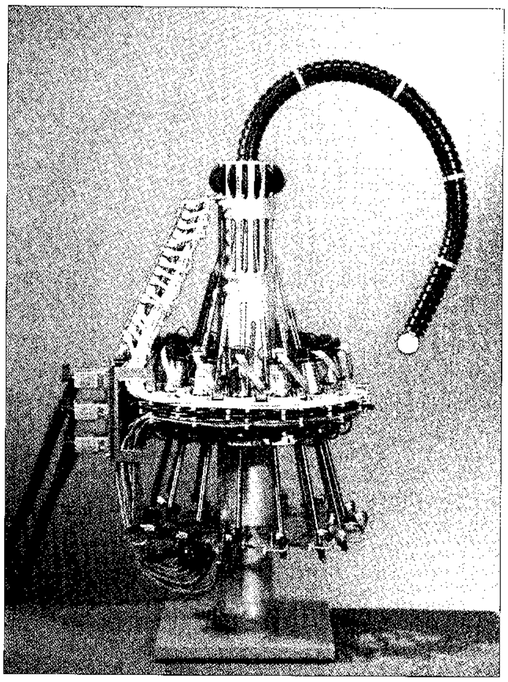

Fig. 1. The prototype snake arm has five segments and measures 1 m long by 35 mm in diameter.



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20 segments and it is expected that most applications will call for at least 10 segments.

Regardless of how many segments the arm has, the movement is such that the second, third, and subsequent segments all follow exactly the same path as that taken by the tip (Fig. 2) – unlike pulling a piece of string, which always tries to form a straight line between the point where it is held and the last obstruction passed.

Ocrobotics has designed the snake arm robot as a modular device, with the four main modules being the

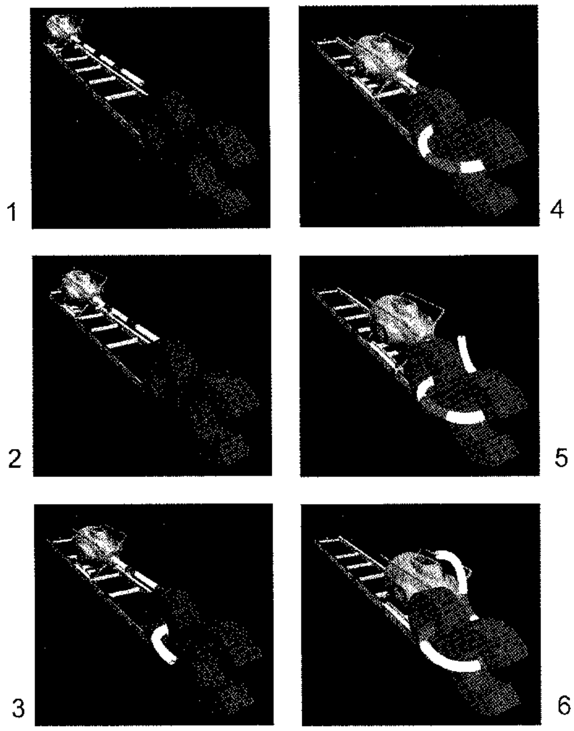


**Fig. 2. This model of an 11-segment arm shows how the second, third, and subsequent segments all follow exactly the same path as that taken by the tip.**

arm, drive unit, tool and user interface. The arm is the flexible part that is made up of a number of segments to suit the length and total curvature required. Different diameters – with corresponding bore sizes – are offered, and the payload will depend on the arm selected (see Table 1). For most of the applications mentioned so far, the arm would need to be fully self-supporting (Fig. 3) but, in some situations, it may be acceptable for the arm to be supported partly by the surface across which it is moving; such supported arms could be significantly longer for a given diameter. In the future, arms could be designed with force sensors on the outside so that the load imposed on the surroundings could be controlled within acceptable limits.

A quick-release mechanism has been designed to

Table 1. Typical snake arm specifications.

| | | | | |
|---|---|---|---|---|
| **Length (m)** | **0.5** | **2** | **3.5** | **10** |
| **Diameter (mm)** | **6** | **70** | **120** | **120** |
| **Payload (kg)** | **10** | **2** | **50** | **2** |
| **Total curvature (degrees)** | **108** | **450** | **270** | **720** |
| **Bore diameter (mm)** | **2** | **40** | **75** | **75** |

enable different arms to be used on a single drive unit, which is the more expensive element. It might be that inspection tools are used first, followed by other devices that allow cleaning or repairs to be carried out, though probably with additional vision capability to allow the operator to monitor the work in progress.

The drive unit houses the servo-actuators for controlling the tendon-like wires that control the arm movement. Compared with the arm, the drive unit is considerably more bulky, so it is envisaged that this will usually remain outside the assembly or system being worked on. To minimise downtime in the event of a failure, the servo-actuators are designed to be hot-swappable in the field.

At the other end of the arm, a tool-change facility can also be provided to allow different tools to be used. In many cases the tool may weigh only a few kilograms, but Ocrobotics has already designed arms to accept a payload of 50kg, and another potential customer has enquired about the feasibility of an arm to carry 500 kg.

A PC-based user interface has been developed that provides the operator with three views. The first of these is an image from a tip-mounted camera or a camera installed as part of another tool. This image provides the operator with the information necessary to enable the tip to be guided forwards. Unlike the driver of an articulated lorry, the operator only has to worry about guiding the tip, because the computer in the drive unit carries out the necessary calculations to ensure that the rest of the arm follows the tip. When the task is complete, the operator can simply instruct the computer to reverse the calculations to enable the arm to be withdrawn along exactly the same path. ■

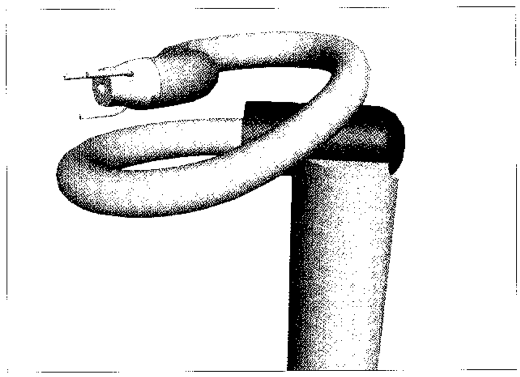

Fig. 3. A CAD model of a 3.5 m self-supporting arm with a payload of 50 kg.