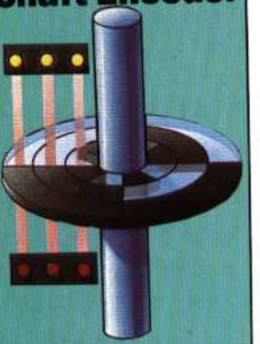
Shaft Encoder



A shaft encoder allows a robot to know how far it has moved by measuring how much the axles of its wheels have rotated. The device is a calibrated disc, which is fitted on a shaft or axle. The circular plate is divided into a number of concentric rings, each marked out in areas that are either transparent or opaque. With a light source and a light sensor for each ring it is possible to work out the exact orientation of the shaft.

The accuracy of a shaft encoder depends on the number of rings there are on the disc. Our illustration shows a shaft encoder with three rings, which can encode the binary numbers 000 to 111 (decimal 0 to 7). This encoder gives an accuracy of 360/8 = 45 degrees. Eight concentric rings would give an accuracy of 1.41 degrees

is to wander around until the output from the sensor rises again, showing that it is once more over the line. Then it can continue in the direction it is headed. This system is not quite as random as it may appear. For example, if the robot was going left when the output from the sensor dropped, then it makes sense that it would turn right in an attempt to find the line again. Also, having found the line, it is fair for the robot to asume that the direction it should now head in is somewhere between the (left) course it was following when it lost the line and the (right) course it had to follow in order to find it again.

A system that reduces the amount of time a 'derailed' robot has to spend finding the right direction again uses two sensors aimed at either side of the line. This means that when the robot is on the line, the output from both sensors is low. If the robot starts to wander off the line then the output from one sensor will rise. This means that the robot knows immediately that it has gone wrong and in which direction it has made its mistake. If the robot wandered to the right, the output from the left-hand sensor would rise, and the robot would take this as a signal to turn to the left, which would bring it back on course again.

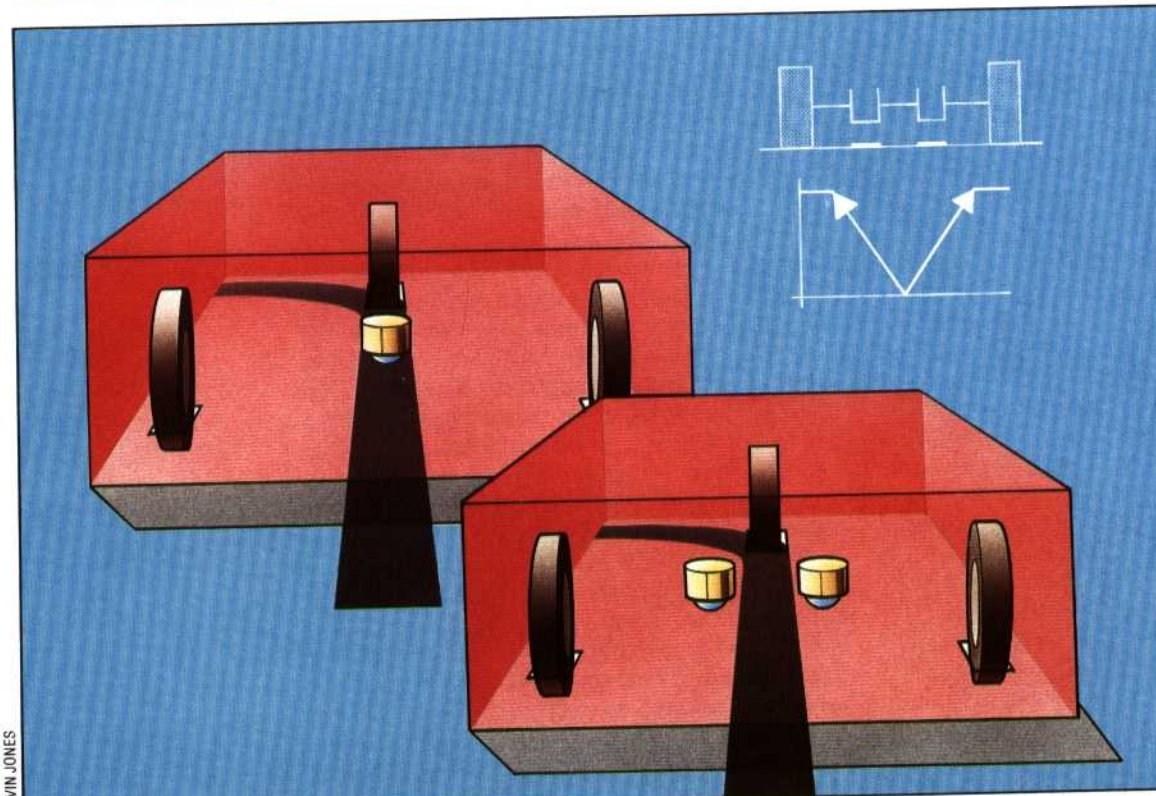
This system does not have to have a white line on a dark background — it would work equally as well with a dark line on a light background. What matters is the contrast — and that the programming tells the robot what to do when a sensor reads an incorrect value.

The other system used for track-following robots involves sending a small electric current along a wire placed in the floor. This current generates a small magnetic field around the wire, which is detected by a sensor. This need not be a complicated sensor — a small coil of wire will pick up the magnetic field and produce a small voltage that can then be amplified and will act in just the same way as the light sensors do. Industrial robots that need to move around often rely on a wire buried in the ground beneath them. If they relied on a line painted on the surface all would be well until the floor got dirty.

REMOTE CONTROL

Another method involves a human operator controlling the robot from a distance. This is particularly useful in circumstances where the tasks that the robot has to perform could be performed just as well by a human being but the environment is too hostile for this to be safe. Examples of this are bomb disposal, handling dangerous chemicals or radioactive materials and working in areas which are too hot, too cold or simply too dangerous for people to work in. A well-known robot of this type is the Russian Lunokhod 1, which was landed on the moon by Luna 16 in 1970. This was a robot on wheels that collected information from the surface of the Moon under the radio control of human beings back on Earth.

Controlling robots of this type is little different to controlling a radio controlled model aeroplane. The radio signal may be either an analogue signal, which varies in strength according to the amount by which the robot is required to move, or it may be a digital signal, which makes up a bit pattern giving details of the movements to be made. Analogue communications tend to be less successful than digital methods because other



Light Sensors

Robots can be designed to follow tracks on the ground using a light sensor. The track could be a light colour on a dark background, or a dark track on a light background. Either way, a photoelectric cell is used to detect a change in the brightness of the ground beneath the robot.

With a single track sensor, the robot can tell only whether it is on or off the track. If it strays from the track it has to search randomly for it again. With a double track system using a dark coloured track, the robot knows it is on the right path when both sensors detect the light background on either side of the track. When the robot wanders off the track, one sensor detects the line and its output goes high. The robot then knows which way to turn back onto the track according to the sensor that has been activated

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