



KEVIN JONES

union of sight and sound would be crucial.

At present, the amount of data a robot can accept and deal with is severely restricted by the amount of memory required to store sensory input, and by limitations on processing power and speed. A robot can store a visual image of an object, such as an apple, and connect the image to a name. Storing the image occupies memory, and the better the robot's visual resolution the more memory is needed to maintain the image. Since all apples are not alike, however, the robot must either have enough memory to store a characteristic sampling of apple images, or an algorithm that recognises variations and is able to rotate the basic image so the apple can be viewed from any position. With even a minimal level of resolution — say 256 pixels per image — the number of variations can reach well into the thousands.

Memory demands will probably be met in the future by higher capacity RAM chips (1 Mbit chips are currently being developed), and through the use of dedicated RAM chips that store 'variational' data. The general-purpose data held in these chips can be called on as needed by the processor to clarify a variety of different images, almost like a subroutine in a BASIC program.

In addition to a huge memory, true sensory awareness for a robot would require data to be coming from many sources simultaneously, and to be processed very rapidly. Existing processors would be unable to handle the sheer volume of information coming in at any one time, and data would soon begin to pile up, waiting to be processed. The likely solution to this problem is the use of two or more high-speed, high-capacity processors, working in parallel. A controlling processor could then act as a manager, distributing tasks to idle processors elsewhere in the system.

Progress is being made very rapidly toward solving the hardware problems facing researchers. But a robot will need very complex software to enable it to understand what is being processed. In other words, the robot needs a mind to know what to do with its perceptions.

MIND

As we have seen in discussing movement and sensors, there are two major directions for robotics. The first, and most likely to be exploited soon, is the area of intelligent tools, or utility robots. Industrial arms and automated manufacturing systems that perform specific tasks, no matter how intricate, need only be provided with carefully-defined controlling software. A robot arm can be given a set of co-ordinates and programmed to execute a sequence of actions without understanding what it is doing, where it is or any details of its environment. The result might be a perfectly painted door panel on a car assembly line, or a well-cleaned car in an automated car wash. As robots are asked to do a wider variety of jobs, however, these are necessarily less clearly defined. If they must move about a room where the contents change from day to day, they must be able not only to gather and process information, but also to incorporate new perceptions into their understanding of the world. The robot must be given controlling and operating software, but it must have room to grow.

Trying to create a mechanical mind opens important questions, as yet to be resolved, about the way humans think and learn. For instance, how much does a human infant actually know at birth? Is a human adult entirely the product of its environment, or of its heredity, and what is the relationship between the two? Does a human being start out with a set of internal constructs that help it learn language and mathematics and aesthetics, and if so how do they work? As Igor Aleksander and Piers Burnet point out in their robotics book, *Reinventing Man* (published by Kogan Page in 1983), it is difficult to answer these questions without being able to experiment directly on the human brain. Perhaps, in the future, the robots we create in our image will help us to improve our understanding of ourselves. Although such questions are not purely theoretical, as experiments being carried out now aim to accomplish just this, the idea of a thinking robot is unlikely to be realised for a very long time.

Convoy!

The techniques of robotics are likely to make their biggest impact on society when incorporated in special-purpose low-grade tools such as cranes, earth-movers, local delivery vehicles and heavy transport. Here we show a robot earth-mover loading a train of robot trucks on a construction site. When loaded, each truck moves semi-intelligently to an assembly point and hitches itself to a train of trucks. The train moves along the public roads under the power of the individual trucks that comprise it, but is controlled by the human driver of the lead vehicle. Blending the human skills of decision and command with the brute strength and single-minded intelligence of robots is likely to prove the cheapest and most profitable use of existing resources and future technology.