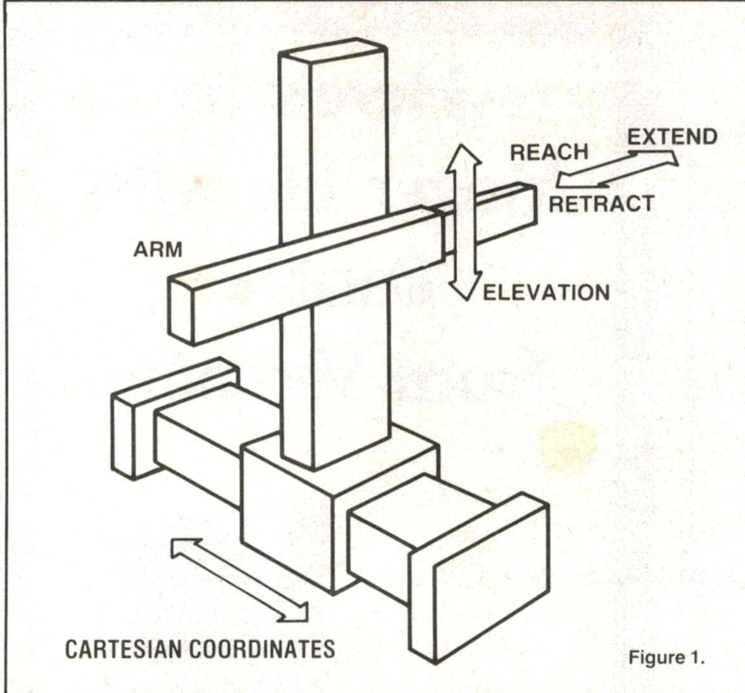


Figure 1.

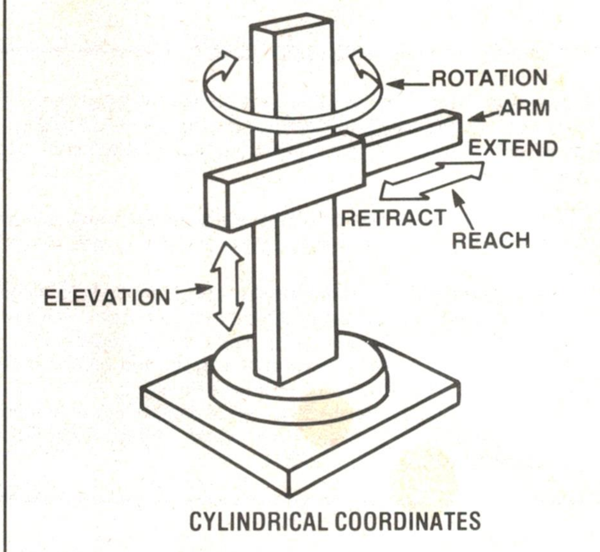


Figure 2.

Robotic arm techniques

The problems surrounding the remote manipulation of objects under the control of a computer have long been a topic of discussion between and among mechanical and electronic engineers and scientists. This article takes a brief look at the four fundamental systems that have been evolved and suggests an approach for hobbyists interested in robotics.

Roger Harrison

MANIPULATING OBJECTS by means of a robotic arm requires a 'marriage' between mechanical engineering and electrical engineering if one is to arrive at an effective system. Four basic coordinate systems for moving an 'arm' have been evolved. Each has its merits and disadvantages. The four systems are:

1. The cartesian coordinate system.
2. The cylindrical coordinate system.
3. The polar coordinate system.
4. The revolute coordinate system.

The number of fundamental motions that a robotic arm can perform is determined by the number of axes employed in the system. The number of axes are often referred to as the **'degrees of freedom'.** Thus, a robotic arm that can move on four axes is said to have 'four degrees of freedom'. The number of axes, and thus the degrees of freedom, endemic to a particular arm are important when considering the tasks it may have to perform. Another important consideration is the 'work envelope'. If you put a paint brush on the end of a robotic arm and then had the arm describe its complete area of movement (with the arm fully extended), the brush would 'paint' a surface in the air — that surface would be its work envelope.

The four basic systems illustrated have only three degrees of movement but vastly different capabilities.

The cartesian coordinate system is illustrated in Figure 1. Here, a pillar can move back and forth along a base. The arm is mounted on the pillar and can move up and down it (elevation). The arm is in two pieces, one piece being capable of extension and retraction.

As all movements are linear, the cartesian system has a work envelope shaped like a cube.

By fixing the pillar of the cartesian system and making it rotate, we make the cylindrical coordinate system, so called because it has a cylindrical work envelope. Two linear movements are left and an angular movement added. Somewhat more complex movement is possible with this system, over and above the cartesian system.

By pivoting the arm around a rotating pillar, one produces the polar coordinate system. This has a work envelope shaped like a half-sphere and the complexity of motion is another step better than the previous system.

The revolute system, Figure 4, emulates the human arm. It is pivoted in two places and can rotate on its base. All movements are angular and, for a three degrees of movement system, it is capable of very complex motion. The work envelope approximates a major portion of a sphere as the arm can be made to reach below the plane of the base.

A really complex system having ten degrees of freedom is illustrated in Figure 5. This is a combination of the cylindrical, polar and revolute systems mounted on a mobile platform.

Gripping

An arm is useless without some mechanism to grip the 'work objects'. For hobbyists, a simple jaw grip system is probably the easiest to implement. Hinged tongs with a spring system to hold them open and a solenoid or motor to pull them shut are simply constructed and controlled. The general principle is shown in Figure 6.

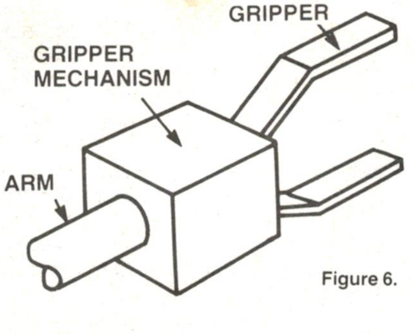
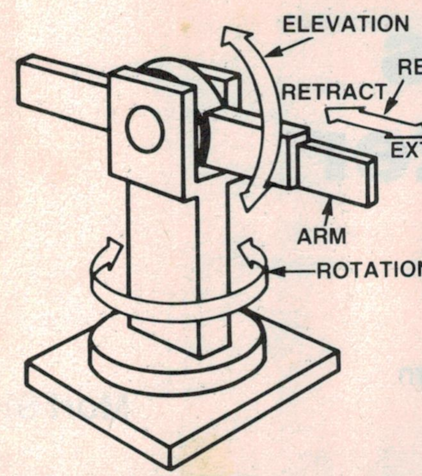
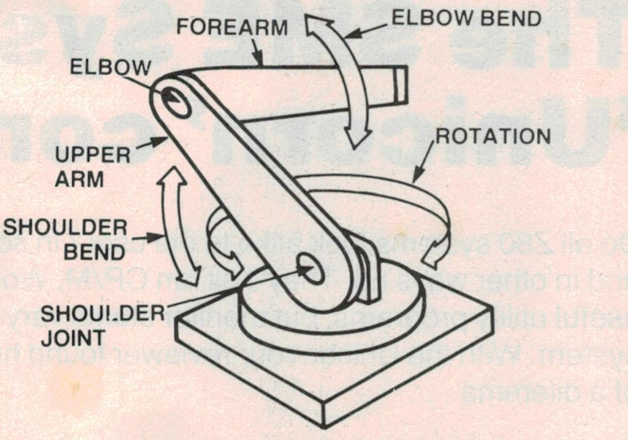


Figure 6.



POLAR COORDINATES

Figure 3.



REVOLUTE COORDINATES

Figure 4.

Drive systems

Industrial robots require physical strength and thus use large, multiple-horsepower electric motors and/or pneumatic or hydraulic drives. Even in relatively small industrial robot arms, hydraulic systems have many advantages. At present, such systems have distinct disadvantages for the hobbyist, not the least of which is cost.

Small electric motors are the most cost-effective drives for small arms and electric/electronic control is readily implemented and interfaced to a computer system.

Grasp the nettle

'Personal robotics' is following in the footsteps of personal computing. In fact, they're related in many ways — via the microprocessor.

In early-1982 we published the construction details for an Australian-designed and manufactured 'turtle-style' robot — the Tasman Turtle, that was controlled by a microcomputer system via an interface. It created a great deal of interest. Since then we have searched for other robotics projects of wide appeal and within the means of enthusiastic constructors.

Late in 1982 we found a British firm who had designed and was manufacturing a reasonably-priced robotic arm kit employing the revolute coordinate system, called 'The Micro-Grasp'. The firm was Powertran. Local kit and component supplier, Jaycar, sought and obtained the agency for Powertran kits — which have a much-envied reputation for quality in Britain — and we sought the rights to publish the project here.

The Micro-Grasp is an articulated arm jointed at shoulder, elbow and wrist positions. The entire arm rotates about the base and there is a motor driven gripper. Each of the arm movements is servo-controlled i.e: there are position sensors feeding back information to the interface board where it is compared with the programmed intended position and automatically takes corrective action.

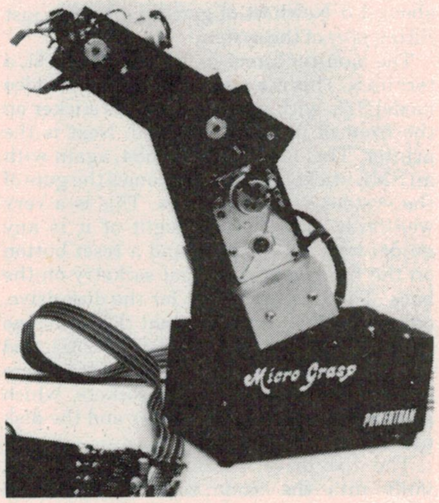
This servo action is independent of the computer, greatly simplifying the software to drive the robot and all programming is carried out with a small number of BASIC commands.

The interface board is memory mapped using only 64 bytes at any of 1024 switch selectable locations. The control signals required are the address buss, data buss, write and memory request or alternatively I/O request if it is preferred to operate the robot as an I/O device.

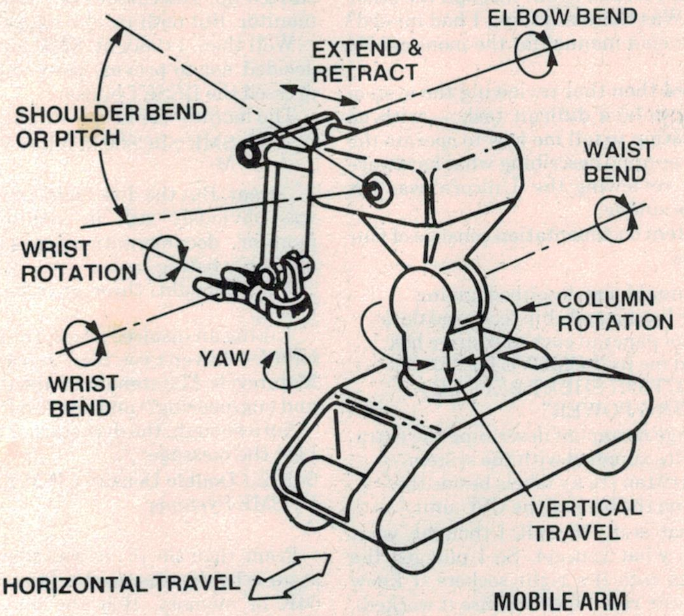
The edge connector format could be arbitary as the board is suitable for almost any computer.

The newly-formed Cybernetics division of Jaycar will be importing and marketing the Powertran Micro-Grasp in Australia.

The Micro-Grasp project is scheduled to be published in the April issue of ETI — don't miss it! ●



This'll grab you! The Micro-Grasp, a computer controlled robot arm project, scheduled to be described in April ETI, features four degrees of freedom, a motorised gripper and simple interfacing.



MOBILE ARM

Figure 5.