Computer Science 773

Robotics and Real-time Control

ROBOTS

FLAGRANT DISCRIMINATION.

Most of this description is written as for an arm robot, and the same is true of all the other sheets about robots. It is true that there are many other configurations for robots, but I'll usually talk about arms, because they're the sort most commonly found in action, and therefore most commonly described in literature. Most comments nevertheless apply more generally, so with appropriate changes to the types of link, actuator, coordinate, etc., these discussions still apply to some extent.

ROBOTS AND MACHINES.

A robot is clearly a machine, and equally clearly not all machines are robots. What is the special feature that determines that a machine is a robot ?

I doubt whether there's a precise answer to that question, for there is no hard and fast line of distinction. A robot is programmable (but so is an NC machine tool); it can move things about (so can a fork-lift truck); it can pick things up (so can a crane); it is jointed like a human arm (not true – robots can be all manner of shapes). As is not unusual, there are some things which are certainly robots and some which are certainly not, and there are also some about which one can argue.

I'll take the view that, whatever other characteristics it might or might not have, the most important characteristic of a robot is that it's a *general-purpose machine*, in much the same way as a computer is a general-purpose calculator. It isn't built to do a specific job, but to be adaptable to a very wide range of jobs. For any particular job, it must therefore be supplied with instructions of some sort; in other words, it needs a programme.

Of course, you can say just the same about a computer. The difference is that a robot has a significantly different sort of programme. While the programme for a conventional computer can always be summarised as "*do that*", a robot's programme necessarily has two components : "*go there, do that*". That emphasises the special position of moving in space which characterises robot behaviour.

DEFINING ROBOTS.

There are at least three definitions of what is meant by the word "robot", two of them in quite wide use. In practice, it doesn't matter a lot, but the definitions are interesting because they bring out some of the distinctions between different sorts of robot.

Basis of class	*Useful for discussing*	*Main characteristic*	*Remarks*
Form	Machinery	Animal-like articulation	The "Japanese" definition; includes teleoperators.
Function	Control	Programmability	The "American" definition.
Behaviour	Autonomy	Adaptability, can react to the environment	The "Creak" definition.

TELEOPERATORS.

A teleoperator is a machine which is constantly guided by a remote operator, so isn't programmable. They're often called robots, but (by the criteria listed above) that's a misnomer. They include bomb-disposal machines, underwater search vehicles, remote "hands" for manipulating radioactive materials, and so on.

They are not inferior to robots – just different. Some are very interesting machines indeed, as they are built to reflect the forces they experience in moving back to the operator, so that the operator can "feel" the weight of objects picked up, and otherwise receive sensory feedback of what's happening at the remote end. So far as the manipulating machinery goes, they are essentially the same as robots, so much of what we'll say is relevant to teleoperators too.

PARTS OF ROBOTS.

EFFECTORS are a robot's equivalent of limbs. They include arms, legs, wheels, tracks, and many other ways of moving things about. Generally, the effectors are *vehicles*, used to move some more active payload from place to place as desired.

END EFFECTORS are the active payloads moved by the effectors – the equivalent of hands or tools. They do the work. They can be grippers, welding tools, paint sprays, or whatever you can fasten on to the end of a robot.

ACTUATORS correspond to muscles; they move the effectors. They are motors of one form or another; they can be hydraulic, pneumatic, or electric, they can be rotary or linear.

SENSORS are the equivalent of senses; they are the robot's means of finding out something about the environment. Not every robot has sensors, though most have at least internal sensors. They can be internal (almost universal; usually measuring joint positions, or less commonly joint forces), or external (rather less common, but obviously essential for robots which interact with the environment); external sensors may be contact sensors (touch) or non-contact sensors (vision, hearing). Other specialised senses can be provided if they're useful – magnetic sense, heat, vibration, acceleration .....

COMPUTERS are universally (surely ?) used for control. They are the robot's nervous system; if you're given to exaggeration, they're the brain, but you have to be fairly pessimistic if you think that what robots do now is analogous to real thinking.

Alan Creak,
April, 1998.