Your Obedient Servant

Industrial robots can now visually recognise objects and learn new tasks by imitating human actions

The term 'robot' is derived from the Czech word for work, *robota*. It was coined by playwright Karel Čapek in his 1920 play *R.U.R.* (Rossum's Universal Robots) and was subsequently enthusiastically adopted by science fiction writers. Despite the many fictional accounts of the powers of robots, they are nothing more than an electromechanical extension of the computer, with all a computer's limitations and failings.

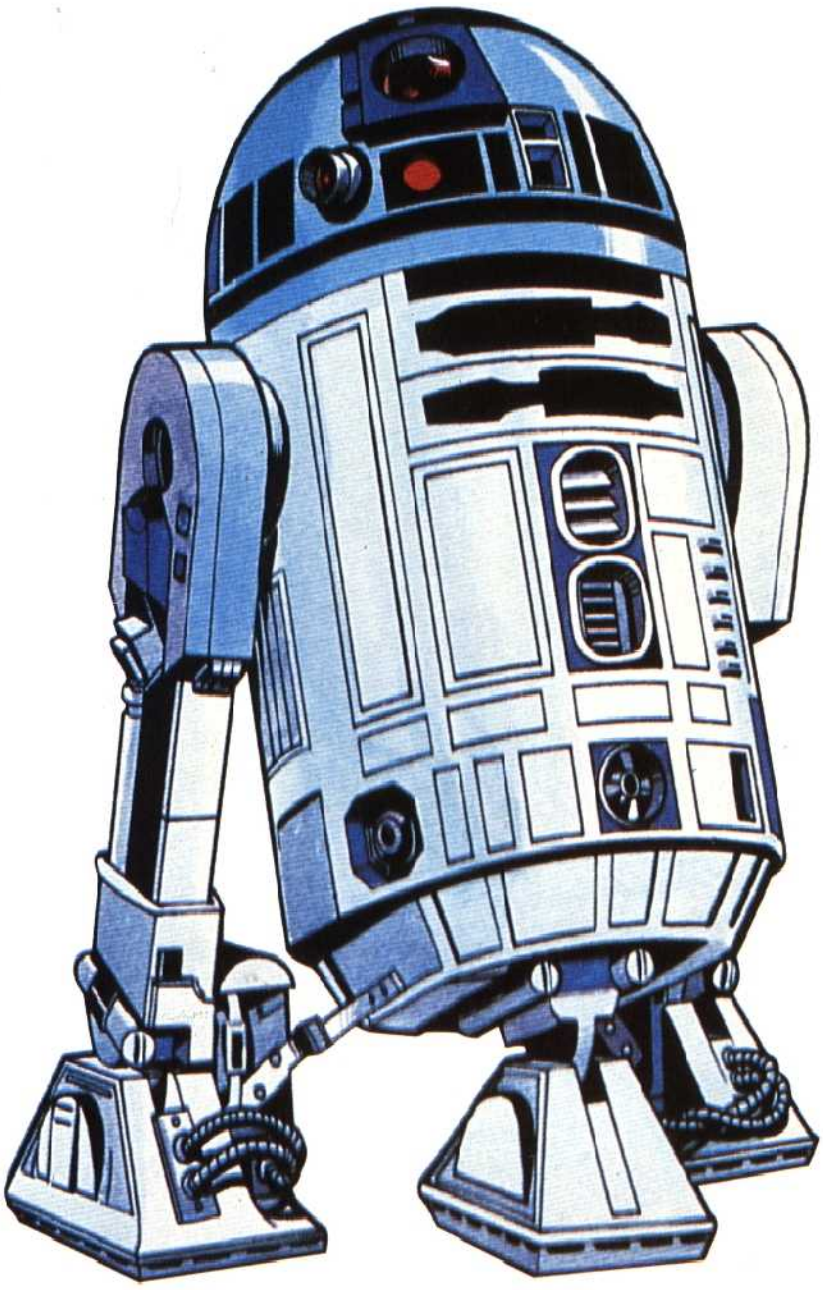
Their origins are to be found in the machine shops of the fifties, where the theory of numerical control of machine tools was first applied. These first efforts were predictably crude: machines that were controlled by five-hole paper tape (the sort used by telex machines), which at best could only move one fixed tool from point to point around the object they were working on.

The next step in their development was the introduction of the ability to change tools in mid-job. This was accomplished by the use of a 'carousel' or rotating rack of tools, all with identical fixings, which could be selected and fitted to the tool holder under program control.

Even with this refinement, a particular machine could perform only one type of task: a lathe was still a lathe, even though it could perhaps do all the turning jobs required in a particular process. At around the same time, remotely-controlled hands and arms were being developed to work in dangerous environments — beneath the ocean, for example, or in laboratories handling radioactive materials. These manipulative devices were merely extensions of the operator's own hands, but computers were soon used to control them directly. The robots that have since been developed are more accurately referred to as 'robot arms', as they consist of one tool holder mounted on an extending or articulated arm.

If we wish to understand how robots are programmed, we must first consider them in relation to the space in which they operate. Most industrial robots are fixed in position, so the space will be a sphere that is flattened at the bottom, and we can think about the question of control of the robot as a simple exercise in three-dimensional geometry. The centre of the spheroid will be the robot's 'shoulder' joint, and the radius will be the length of the extended arm, measured from the 'shoulder' to the tip of the 'fingers' — the gripper or tool holder. Any point within this space can be expressed as three co-ordinates: for example, as distances north/south, east/west and up/down, from a 'datum point' or zero position. In this case the co-ordinates are known as Cartesian, after the 17th-century French mathematician René Descartes. Alternatively, the position can be expressed in spherical co-ordinates. In everyday language this could be, say: 'at a distance of two metres in a direction north-east and thirty degrees above the horizontal'. The datum point in this case is the robot's 'shoulder'.

However, the problem of programming the robot involves giving it a set of instructions about moving from place to place, and so there is yet a third method of positioning the tool holder.



Celluloid Hero
R2D2, the endearing robot from 'Star Wars' was in fact controlled by a human operator. Its design, however, reflected what many people think robots ought to look like