Computer Science 773

Robotics and Real-time Control

MACHINE TOOLS

DEFINITION.

Tools have been equipped with machines of one sort or another for a very long time; anything with a motor in it qualifies by that criterion. The term "machine tools" is usually reserved for tools in which the machine doesn't merely provide brute force, but also in some way contributes to the control of the operation. This might be by automatically placing the workpiece (that's the material to be dealt with) in the right position, or by performing a controlled sequence of operations rather than just one.

We're interested because of the automatic aspect of the definition. As with most other automatic systems, computers get into the act because they're very good at following sequences of instructions – and, as they're also very good at communications, the result is a tool which can talk to other systems, which makes it easy to control from afar and easy to integrate into larger manufacturing plants.

HISTORY.

Machine tools in the modern sense of the phrase came into use during the 1939-1945 war, when there was lots of money about (there always is when you want to kill someone) and a great demand for large numbers of comparatively complicated machines, particularly small and accurate machines, such as those used for controlling various means of killing people.

The earliest tools simply helped the operator a bit by guaranteeing that parts would be properly aligned and that holes would be properly drilled, and so on. They had analogue controllers where they would work, and people elsewhere.

The move to digital control came at the end of the war, when digital computers became rather more readily available. Development thereafter proceeded in several steps, clearer in hindsight than they were at the time, as different manufacturers gave different priorities to the different directions of development. Here's a summary.

Numerical control	A "part programme" is written in the control language of the tool and transcribed to paper tape.	No feedback from the machine tool.
Programming languages	Write the part programme in a part-programming ("high-level") language, compile to the control language with a computer.	No change.
Direct numerical control	Abolish the paper tape; connect the computer directly to the tool.	Feedback necessary, but usually limited to reporting ends of operations.
Computer numerical control	Combine the computer and the machine.	Feedback comparatively easy; can now feed back cutting speeds, etc. to the controller, and use it to improve control.

OPERATIONS.

There are no laws to restrict what you can do with a machine tool, but in practice three operations turn out to be rather prominent.

Drilling	Rotating tool, moves in the direction of the rotation axis.	A drill.
Milling	Rotating tool, moves perpendicular to the direction of the rotation axis.	A milling machine.
Turning	Rotating workpiece, tool moves arbitrarily.	A lathe.

Originally, these operations were carried out on separate machines, but later developments have introduced *machining centres*. These are single, very complicated, machine tools, which combine some of the functions of the traditional separate machines. It is also common to find several specialised tools arranged to work together as a *workcell*, in which individual workpieces can be operated on by any of the tools in any desired order. A workcell also requires some means of moving the workpiece around – often a robot – and a higher-level controller (PLC or computer) to coordinate the operations.

REFERENCE.

L.M. Sweet : "People and technology in the globally competitive factory", *IEEE Control Systems* **11#7**, 4-8 (December, 1991)

Alan Creak,
March, 1998.