# USING COMPUTERS TO CONTROL MACHINES - A NEW APPROACH

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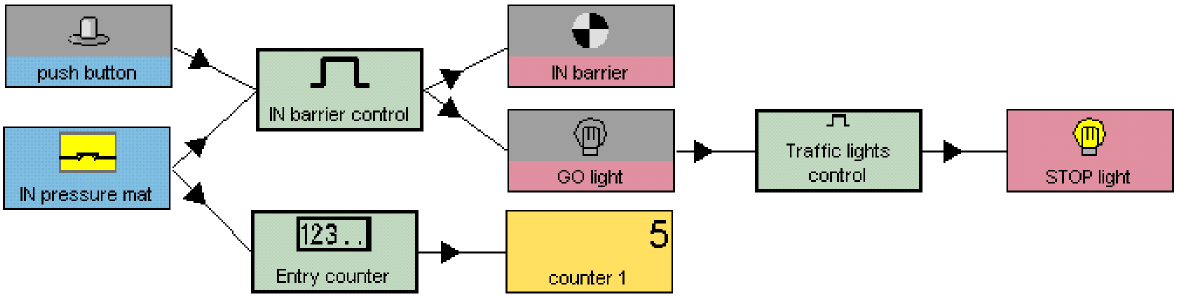
Although physics education in secondary schools in England and Wales currently has a formal alliance with chemistry and biology, in many schools there exist strong links between physics and technology. The teaching of electronics has long been a common feature of physics at advanced level and in recent years computer control has emerged as a significant application of this technology.
Until now the teaching of computer control technology has been dominated by the need to teach computer programming skills, using either *LOGO* type languages or flow chart diagrams. In *Control Insight* a new approach has been recently developed, offering easy access to problem-solving activity, eliminating the need to learn a computer language or flow chart manipulations. The essence of the approach is to describe the problem in terms of 'systems' which emphasise how information is passed between systems and focus on how information is used for making decisions. The function of each system is described in normal English rather than a stylised computer syntax. Presented in a multimedia environment with animated graphics and sound, the new program encourages progression from simple problems suited to age 8 pupils through to more sophisticated problems suited to age 15.

The National Curriculum for schools in the UK [1] includes a programme of study for Information and Communication Technology (ICT) both in terms of developing pupils' capability for using the technology and in applying the technology in their learning of their other subjects. In this second respect all subject teachers have a responsibility for teaching pupils to use ICT to enhance the learning of their subject. Under the heading 'Developing ideas and making things happen', the ICT programme of study specifies the 'use of ICT to measure, record, respond to and control events by planning, testing and modifying sequences of instructions' [2]. The type of activity which fulfils this requirement has been developing for many years and typically involves the use of the computer to control machines and has been an attractive aspect of ICT for physics teachers with an active interest in the applications electronics.

To enable a computer to control an electrical device, an interface box is necessary. Pupils build models with low voltage (4 volt) motors, bulbs, relays, switches and sensors; these are connected to an interface box which in turn is connected to the serial port of the computer. To make the model work and perform a useful task, the computer needs a program which detects signals from the interface and switches the output devices on an off. The intelligence for such actions depends upon a series of instructions formulated by pupils and stored within the program. Various methods have been devised to enable pupils to create instructions. Some use direct programming techniques based on machine code, BASIC or LOGO languages. In recent years graphical methods involving the manipulation of flow charts have also been developed. All these methods, however, suffer the disadvantage that a considerable amount of operational skill required to create instructions for quite simple tasks. The necessary training to acquire such skill is an unwanted distraction from the problem solving activity which should occupy the more important focus of attention. The new *Control Insight* program [3] has explicitly addressed the need to simplify operational aspects of the control process; it offers a new metaphor for solving control problems which frees pupils to focus their thinking on the structure of the problem and its potential solutions.

The central feature of *Control Insight* is the representation of the components of the control system on the screen as functional blocks which are linked to show the passage of information signals. The blocks are assigned the properties of input, process and output units characteristic of control systems. The concept builds on the 'systems' approach developed for the teaching of electronics. Pupils select the blocks they require by dragging them from toolbars surrounding the 'System' window and linking them appropriately. A typical system is shown in Figure 1.

Figure 1. Control system for a model car park barrier.



The essence of 'systems' approach is that the user does not concern himself with the details of how the block works; the description of the block is confined to what the block does in terms of providing or receiving or processing a signal. *Control Insight* employs three types of block representing a range of sensors, processes and output devices shown in Table 1.

Table 1. Types of components and processes used in *Control Insight*.

| **Input Sensors** | **Process Modules** | **Output Devices** |
|---|---|---|
| push button | simple control | lamp |
| switch | signal control | buzzer |
| microswitch | pulse control | bell |
| pressure mat | timer | relay |
| magnet switch | counter | solenoid |
| light switch | memory | motor |
| light gate | message | sign |
| temperature | sound | |
| light level | data logger | |
| sound level | | |

The process modules contain a key innovative feature of the program: Pupils define their function by making choices in a properties dialogue box and as a result of these choices the program builds a sentence which describes the function. The sentences for all the process modules are displayed at the top of the window. Thus a script describing the actions of the system appears in plain English.

When pupils have completed their design in the System window, they can test how it works by switching to a simulation 'Run' mode. Sensor blocks may be activated by pointing and clicking, and output blocks are animated to show their on or off state. The system can be further edited until it performs the task in the desired manner. When pupils are satisfied with their design they can switch to the 'Connections' window which shows how to connect real sensors and devices to the interface. Finally the real model can be connected and controlled by the program.

We now have a complete view of the problem solving process: First, the problem has to be stated. Then pupils decide what sensors and output devices are needed in a solution. The solution needs to be described in a series of single sentence instructions for the computer and one process module is needed for each sentence. All the components are assembled on the screen and the process module properties are adjusted to give the appropriate sentences. The resultant control system is then tested on the screen. Thus the designing and testing processes are all conducted in a simulation environment on the screen in a manner which emulates industrial practice; only when the design is proven is the first prototype model built. The building, connection and control of a real model is the culmination of the process.

A further special feature is designed to make the system appeal to young pupils from age eight upwards: An alternative 'Scene' window is provided for building models, but, instead of using diagrammatic blocks, life-like pictures are used to represent the switches, sensors, motors, lights and other components. All these pictures are assembled in front of a background picture to create a complete scene. The picture comes to life when the program is set to 'Run' mode. All the components are animated and each makes a sound when activated.

Experience with the program so far has confirmed that, for all ages, pupils gain confidence rapidly in solving control problems. For the youngest pupils the picture based context is motivating and simple to use. For older pupils systems of great sophistication can be built. Teachers appreciate that many pupils can engage with the control technology without the need of peripheral equipment until the final stage.

**References**

1. The National Curriculum for England: Information and Communication Technology. Department for Education and Employment, Sanctuary Buildings, London, 1999.
2. As above, page 20.
3. Control Insight, Logotron, 124 Cambridge Science Park, Milton Road, Cambridge, CB4 4ZS UK, 2000. www.logo.com

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