Introduction to Computer Control

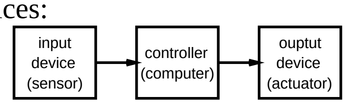
This lecture provides an overview of the topics that will be covered in the course.
After this lecture you should be able to give examples of computer control systems and identify their inputs and outputs.

Computer Control

This course is about using computers for industrial control. Although we will look briefly at computer architecture and the details of some input and output (I/O) devices, most of the course is about implementations using existing computers and interfaces – not about hardware design.

Examples

These days everything from running shoes to nuclear power plants are controlled by computers. Therefore it's not difficult to find examples of computer control. In spite of this wide range of applications, almost all computer control systems can be broken down into three components: input devices, a computer, and output devices:



For example, a microwave oven controller's inputs might include a keypad and a "door open" sensor. The outputs might include circuits to control the microwave power generator, an LED time display and a buzzer.

A traffic light controller's inputs might include timers and vehicle sensors and the outputs would be the traffic lights.

The inputs to an airplane's autopilot might include speed, altitude and attitude sensors and the outputs would include actuators to control the throttle, rudder, elevator, etc.

Exercise: Give three additional examples of devices that are probably computer-controlled and identify the inputs and outputs.

Real-Time Control

One feature that distinguishes control computers from other computer applications is that control computers are usually real-time systems. This means that the system must respond to changes in the inputs within a certain maximum allowable delay. Of course, this maximum response time will depend on the application. In the case of an air-bag controller the maximum allowable delay might only be a few milliseconds while in the case of a control system for a water reservoir it might be several minutes.

Exercise: Decide whether each of the following computer systems is an example of real-time control. If so, give the response time that you expect would be required: a word processor, the ignition control system for an engine, a weather forecasting computer and an airline reservation system.

Sensors

The purpose of a sensor is to convert a physical quantity such as position, light intensity, temperature, pressure, etc. into an electrical signal that can be processed by the computer.

A sensor's output has to be converted to a number so it can be used by a computer. Often a sensor's output can only take on one of two values and thus it can be easily converted into a 1-bit number. Other sensors generate a signal (a voltage or a current) that varies continuously and must be quantized into one of a discrete range of values. The circuit that does this is called an analog-to-digital (A/D) converter.

Later in the course we will study various sensors and A/D converters in detail.

Exercise: What types of sensors might be used by the examples you chose earlier? Would they generate continuous (analog) or discrete (digital) values?

Microcomputers

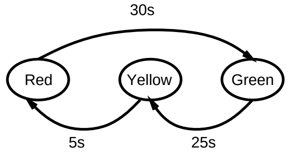
A *microprocessor* is an integrated circuit (IC) that contains all of the electronics required to implement a computer except memory and I/O devices. A *mi-*

crocomputer is a computer built around a microprocessor. It therefore includes some type of memory and I/O devices. Most modern computers are, in fact, microcomputers. A microcontroller is an IC that combines a microprocessor, memory and I/O devices on the same chip. Microcontrollers are used for simple control applications.

The microprocessor executes a sequence of computer instructions (a program) stored in its memory. The program determines the behaviour of the controller. Most of this course is spent learning to write computer programs that will make the control system behave as desired. We will describe the behaviour of the controller in two ways: as a state machine and as a computer program written in the C language.

State Machines

All modern digital circuits (including all computers) can be described as state machines. A state machine representation describes the controller as a set of states plus rules that govern the transitions between these states. For example, a traffic light can be in one of three states and the transitions between states (in a simple controller) are determined by the passage of time. The state diagram below shows the three states and the state transition conditions.



The simplified description provided by the state machine allows us to examine the behaviour of the controller without concerning ourselves with the implementation details.

C Programs

The operation of a controller can also be described in the form of a computer program. In some cases this is clearer than using a state machine. In this course we will use the C language, a popular language for control applications. A part of a C program might look as follows:

```
void waitms ( int ms )
{
  int i ;
  while ( ms-- > 0 ) {
    i = 100 ;
    for ( i=MSLOOP ; i > 0 ; i-- ) ;
    if ( ( P3 & BUTTONMASK ) == 0 )
      pushed = 1 ;
  }
}
```

Actuators

For a control system to have any effect it must have outputs. The outputs of most control system are electronically-controlled actuators such as solenoids or electric motors. These may produce the desired effect directly or they may control hydraulic or pneumatic valves.

Later in the course we will look at various types of actuators and simple control circuits.

Safety and Reliability

Some spectacular system failures have been attributed to poor design of computer control systems. In many cases the designers failed to take into account the consequences of certain hardware failures or unexpected combinations of inputs. By studying examples of failed systems we will derive principles that can be used to build safer and more reliable control systems.