Computer Science 773

Robotics and Real-time Control

SORTS OF REAL-TIME SYSTEM

WHAT SORTS OF TASK ?

There are many circumstances in which computers must respond to events under stringent time constraints; this list is unlikely to be exhaustive, but gives some idea of the range of application areas.

Control : controlling the behaviour of some object outside the computer : it is the computer's job to decide what should happen next. (Automatic pilot; traffic lights.)

Data logging : receiving data from sensors, reducing them to some useful form, typically involving combining values from different sensors operating at different rates, and recording them for later reference. The computer's job here is to ensure that all required data are collected and recorded, to take appropriate action if some data are missed, and often to respond to requests for the data, typically by transmitting them through some communications medium.

Supervisory control : controlling other computer systems performing real-time work, typically in some hierarchic structure. This is not such a "hard" function as direct control of machinery or other plant, and is more concerned with ensuring that materials or facilities are available before they are needed, that the overall flow of work through the plant goes smoothly, and so on.

Signal processing : dealing with fast-moving data; a data stream enters the system and undergoes some sort of treatment before leaving the system at essentially the same rate. Very high-speed signal processing systems are often constructed of specialised hardware; slower systems might use conventional microcomputers. (Telephone exchange; digital picture processing.)

MODES OF CONTROL.

Control systems can be classified according to the way in which they exercise control.

Continuous : the aim is to control some property of the system, keeping its value constant or changing it according to a specified pattern : a *single* property is controlled *continuously*. (Automatic pilot. The "single property" is the aircraft's flight path; obviously, many other parameters of the aeroplane might need to be controlled in order to achieve the required result, but they are subsidiary. That's why some control systems of this type are exceedingly complex.)

Sequencing : the system is led through a series of operations : *several* properties of the controlled system are given attention *intermittently*. (Traffic lights.)

On-off : as in continuous control, the aim is to manage the value of a variable in the system, but this is accomplished to an adequate degree of accuracy by either switching some transducer either full on or right off. Such simple-minded control

can be very successful if the precision required is not very high and it is feasible to perform the switching at a frequency significantly higher than characteristic frequencies of the controlled system.

In a digital control system, the distinction between these modes is to some extent blurred. The sequencing and on-off systems are handled in much the same way as they were with the older relay-based controllers, but true continuous control isn't possible even in principle. Instead, the behaviour of a continuous controller is mimicked by a cyclic programme which reads condition variables from the controlled system, then decides what control signal to produce, then produces it. If a single processor has nothing more than that to do, very rapid response might be achievable; more commonly, a processor is shared between several simple control functions, and behaves in much the same way as the processor of a sequencing controller.

CONTROL TECHNIQUES.

The purpose of a control system is to compute a control signal which, when applied to the controlled system, causes it to behave in the required way.

Open loop : given a number of parameters (required result, known characteristics of the controlled system) the control signal is found by table look-up or function evaluation.

Closed loop : the control signal is determined by some criteria which depend both on the stated requirements and on the current state of the controlled system.

MAKING COMBINATIONS.

These different control attributes can be combined together in many ways. Here are some examples of practical cases.

	Continuous	Sequential	On-off
Open loop	Standard function repeated ("robot" painter)	Static sequence of events : matrix sequencer (Washing machine)	Timer causes switching (Simple thermostat)
Closed loop	Most of what's usually called "control theory" (Automatically guided vehicle)	Sequencing with waiting (Traffic lights)	Threshold causes switching (Refrigerator)

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