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Embedded Systems and Industrial Controller EE5563 (8a)

Topics

Two Distinct Section

- Real-Time Control and Embedded Systems
- Systems Theory
- Modern Real-Time Control based on Event Modelling

Objectives of using computer control

- efficiency of operation
- ease of operation
- safety
- improved products
- reduction in waste
- reduced environmental impact
- reduction in direct labour

Batch (Discrete) Control

- a sequence of operations to produce a quantity of product
- important to minimise set-up time (or change-over time)

Continuous Control

- systems which are run over long periods of time (nature of product is continuous (water, oil, gas, electrical power generation and distribution)
- preferred to batch control systems

Computer Control

» data acquisition

» sequence control

» loop control (DDC)

» supervisory control

» data analysis

» data storage

» human - computer interfacing (HCI)

Examples: Smart Buildings, Baggage Handling in Airports, Conveyor Belts, Tracking and Tracing using RFID, water distribution, electric power, …

Embedded Systems

» Many Automated Systems

» pre-dominates in batch systems

» widely used in food processing and chemical industries

» special computer systems have been developed

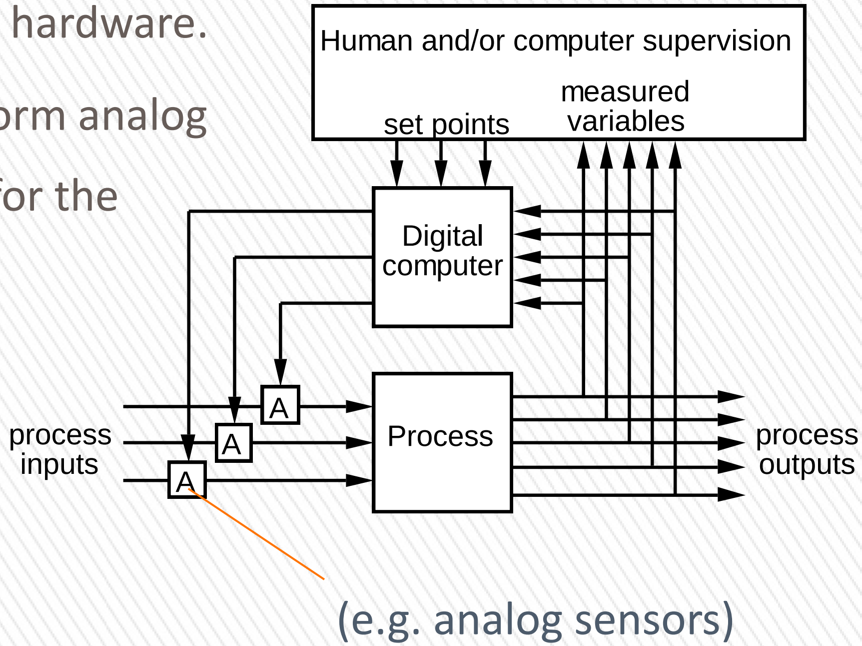
» programmable logic controllers (PLC)

Sequence Control & Monitoring

Consist of:

- networked microprocessor-based controllers connected to analog and digital devices
- either sense information or control components
- The control logic initiates and sequences operations programmed with software stored in the hardware.
- Analog-to-digital (A/D) converters transform analog electrical values into digital information for the microprocessor.

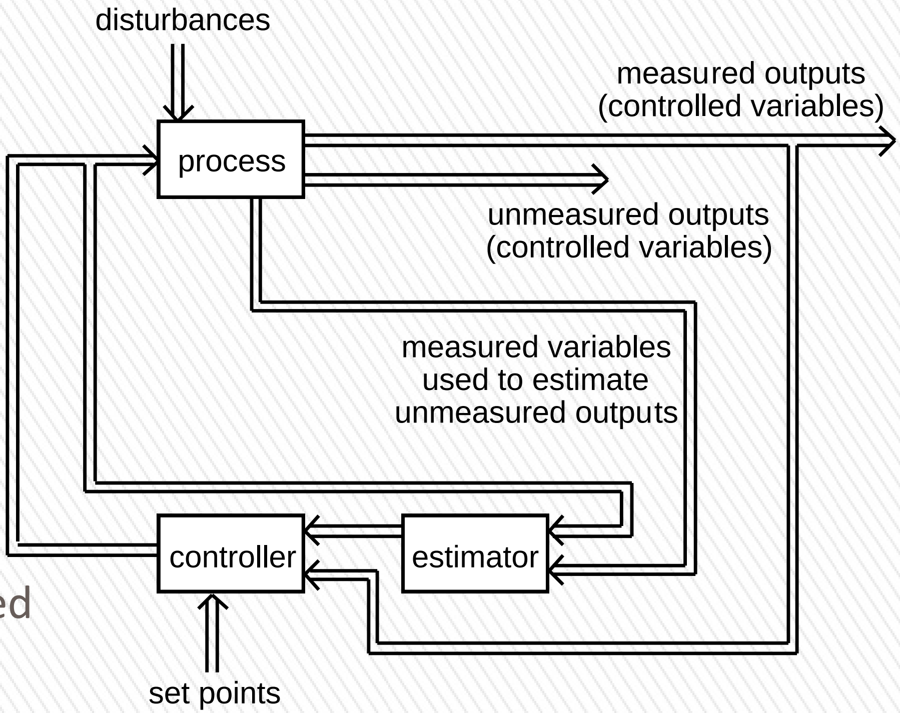
Examples: Air-condition systems



Loop Control (Direct Digital Control)

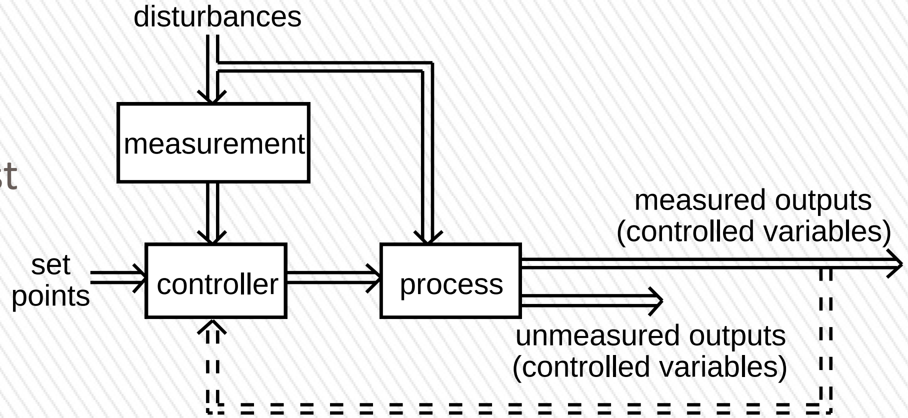
Inferential Control

- Inferential control system is an open loop control system
- Deals with immeasurable disturbance
- Does not consider other possible disturbances.
- Solves the problem caused by non-measurable main output and disturbance,
- the basic method was later widely used for measurable output and non-measurable disturbance



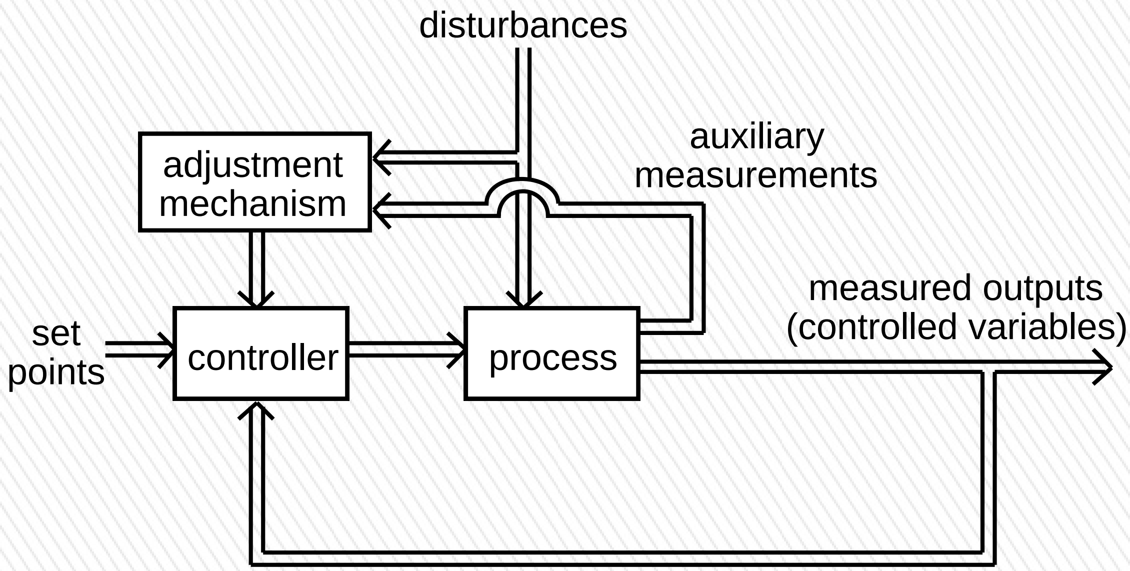
Feedforward Control

- feedforward control acts the moment a disturbance occurs, without having to wait for a deviation in process variable.
- This enables a feedforward controller to quickly and directly cancel out the effect of a disturbance.
- FF controller produces its control action based on a measurement of the disturbance.
- When used, feedforward control is almost always implemented as an add-on to feedback control.
- The feedforward controller takes care of the major disturbance, and the feedback controller takes care of everything else that might cause the process variable to deviate from its set point.
- Speed up control actions



» Adapts to variations

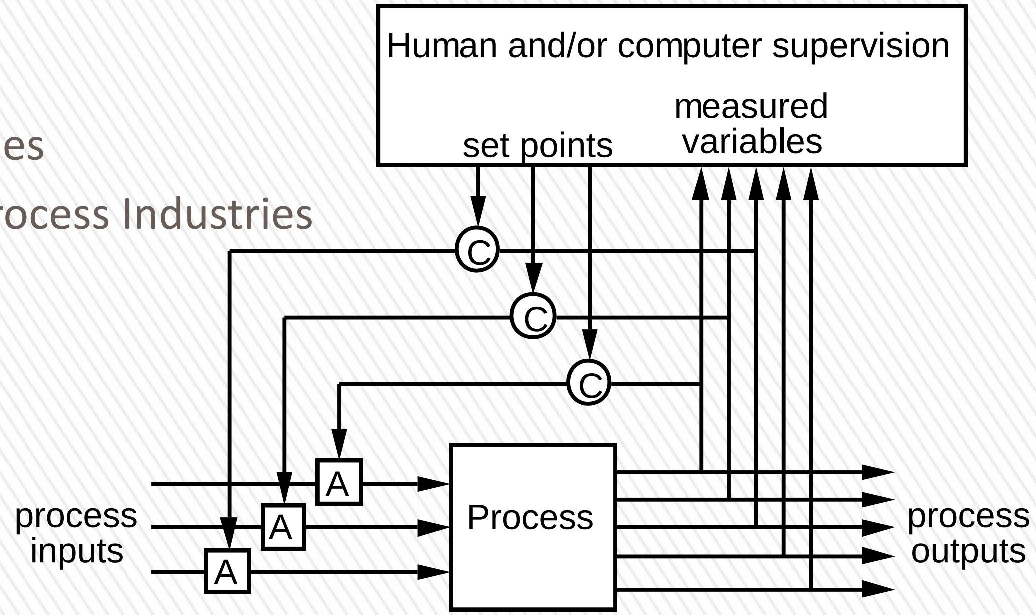
» Adjustment mechanism



Adaptive Control

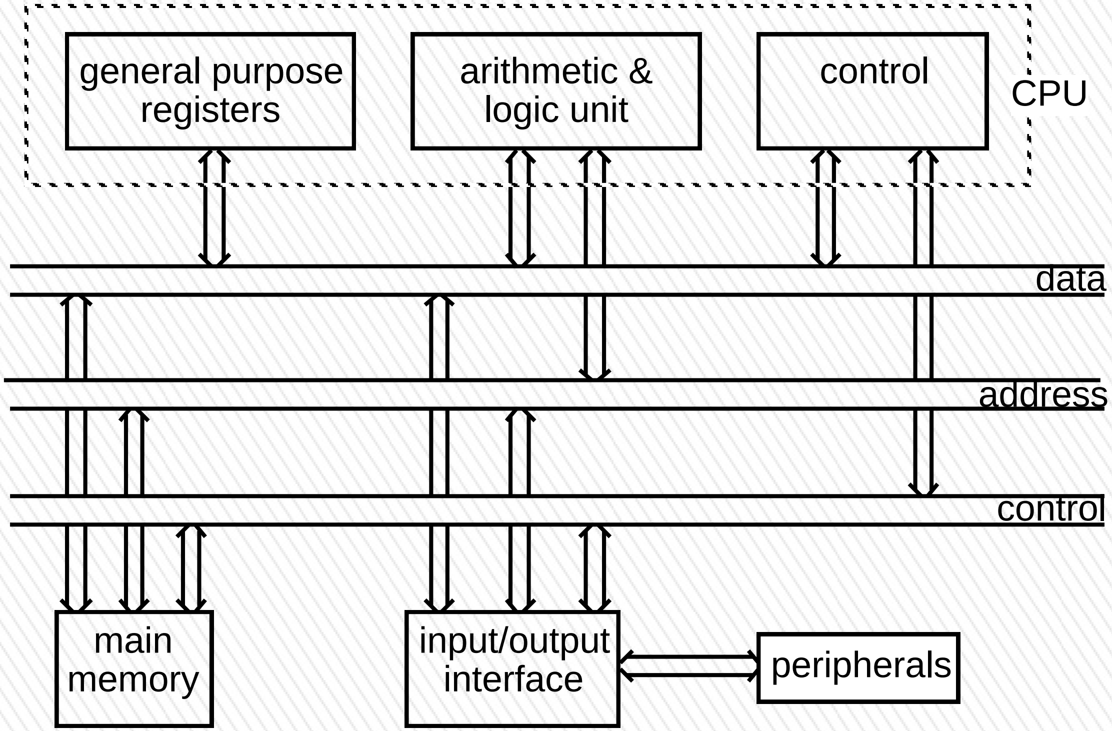
» Complex and highly uncertain systems traditional methodologies based on a single controller do not provide satisfactory performance.
» Use of multiple controllers
» Switch between them

» Applications in Factories
» Large Chemical and Process Industries



Supervisory Control

» e.g. 680xx, i86



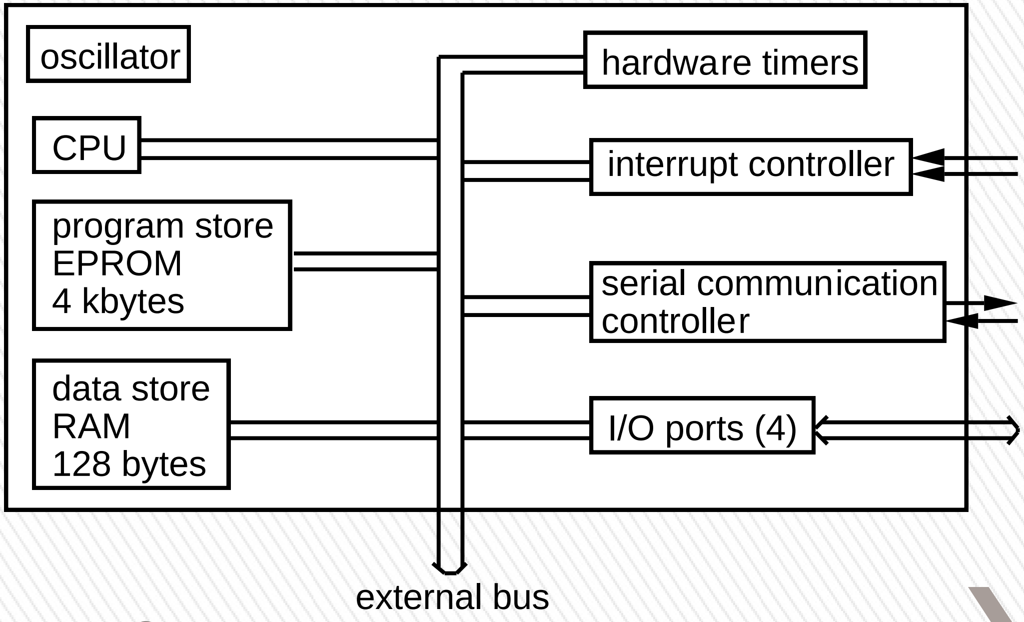
Hardware requirement

Single-chip microcomputers & microcontrollers

- include all functions necessary for complete computer on single chip (suitable for small systems)
- microcontroller is specially designed for embedded control
- typically includes on-chip ADC, process output (e.g. Pulse Width Modulator)

  Note: PWM is used to control of the power supplied to electrical devices especially for inertial loads such as motors

- and real-time clock generator



Hardware requirement

» specialised processors for very high speed calculations (developed for speech/video processing & telecoms)
» used for complex control algorithms that need to be executed quickly (e.g. robotics)
» best known is the Texas Instruments TMS320xx series
» require fast interfaces for optimum performance

Digital Signal Processors

Solving the difference equation

$$\frac{U(z)}{E(z)} = D(z) = \frac{D_n(z)}{D_d(z)} = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2} + K}{1 + a_1 z^{-1} + a_2 z^{-2} + K}$$

$$\therefore \quad \frac{U(z)}{E(z)} = \frac{D_n(z)}{D_d(z)}$$

$$\therefore \quad D_d(z)U(z) = D_n(z)E(z)$$

$$\therefore \quad u(k) = -a_1 u(k-1) - a_2 u(k-2) - K$$
$$+ b_0 e(k) + b_1 e(k-1) + b_2 e(k-2) + K$$

So require past values of control signal + present and past values of error signal.

note: at the present sample, *u*(*k*) is the present output value
- next time the controller code is executed this value is *u*(*k*-1)
similarly for *e*(*k*), *e*(*k*-1), *u*(*k*-1) etc

Implementing the controller