Instrumentation of an Engineering System

Chapter 1

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What is the need for mechatronics?

- Mechatronics are multi-domain (i.e. real) systems involving electrical, mechanical, computational, and control theory components:
  - actuators, sensors, controllers, signal conditioners, power sources, mechanical structure, user interface

- A mechatronic approach considers *all* of the systems, and in particular, how they will be interconnected.

- Components designed separately may behave differently when interconnected.
Control System Fundamentals

Goal: Cause the output to follow, or “track”, the reference input.

Examples:
- Cruise control system for a car
- Autopilot for an airplane
- Oven thermostat

Control system types:
- Open-loop (“feed-forward”)
- Closed-loop (“feedback”)
Open-Loop Control System

(ME593)

Reference Input → Controller → Actuator → Plant → Output

Goal: Cause the output to follow, or “track”, the reference Input.

Advantage: Simple, low-cost configuration

Disadvantage: Controller has no knowledge of the output
Closed-Loop Control System

Goal: Cause the output to follow, or “track”, the reference Input.

Advantage: Controller has a measurement of the output
  • Reject disturbances
  • Good performance even without an accurate model

Disadvantages:
  • Comparatively complex, costly configuration
  • Possibility of instability, or even self destruction if there is a sensor failure
A well-designed mechatronic feedback system

- is stable:
  - response to an initial condition asymptotically decays to a steady state
  - a bounded input leads to a bounded output (BIBO stability)
- responds quickly to a control signal (is high-bandwidth)
- is not significantly affected by sensor noise and disturbances
- is robust to small changes in the characteristics of the plant
- low error

These specifications are often in conflict, e.g. a fast response requires high feedback gain, which can drive the system to instability
Figure 1.6 Key components of a feedback control system.
ME 477 Lab 8: Control of Angular Velocity of DC Motor

Proportional + Integral Controller:

\[
u(t) = K_p \left[ v_{\text{ref}}(t) - v_{\text{actual}}(t) \right] + K_i \int_0^t \left[ v_{\text{ref}}(\lambda) - v_{\text{actual}}(\lambda) \right] d\lambda
\]