CDS 101: Lecture 1
Introduction to Feedback and Control

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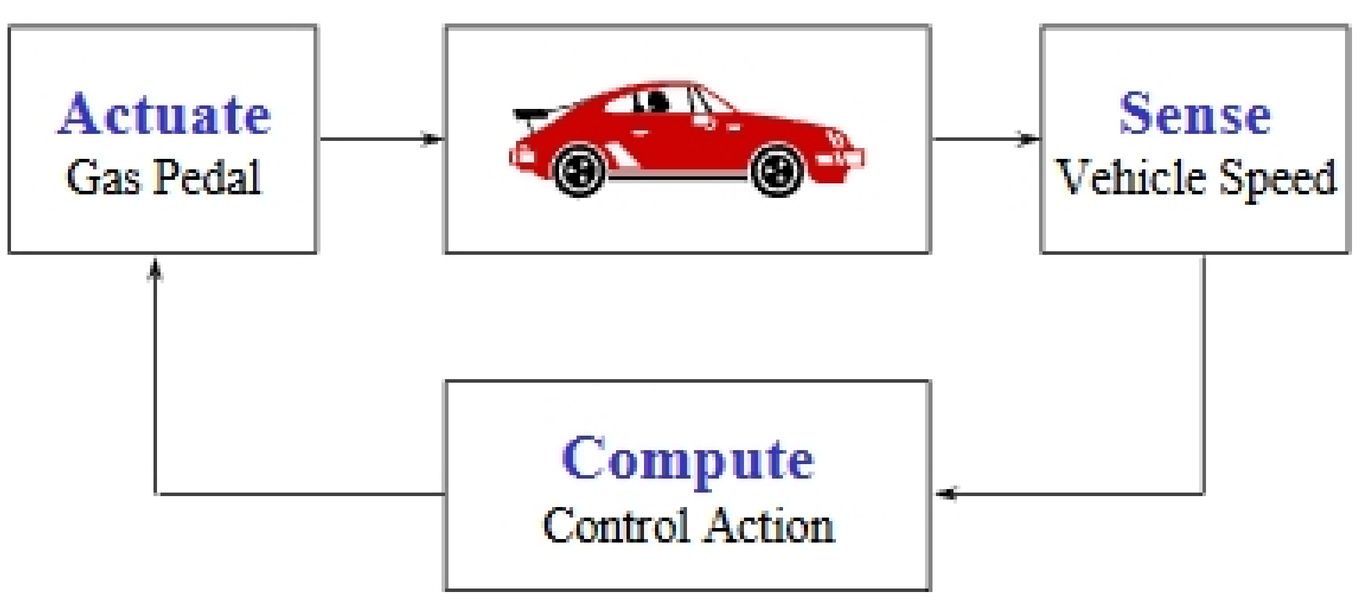
Goals:
- Define what a control system is and learn how to recognize its main features
- Describe what control systems do and the primary principles of control
- Give an overview of CDS 101/110; describe course structure and administration

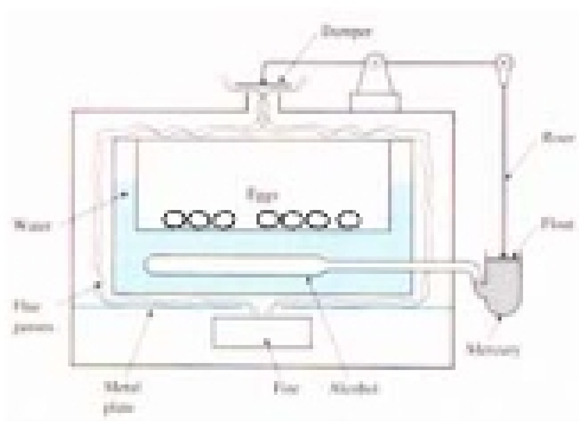
Reading (available on course web page):
- R. M. Murray (ed), *Control in an Information Rich World*, Chapter 2
- "For the Spy in the Sky, New Eyes", NY Times, June 2002.
- Optional: K. J. Astrom, *Control Systems Design*, Chapter 1

Control = Sensing + Computation + Actuation = *Feedback*



Goals: Stability, Performance, Robustness

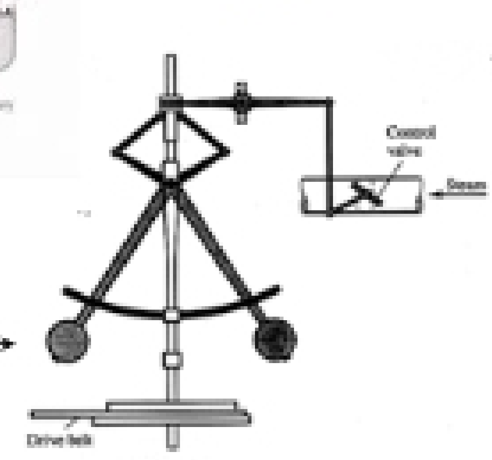
Early Uses of Feedback and Control



Pre-1700

- Water clock (~300 BC, Alexandria), float valves
- Egg incubator (Drebbel, 1620) - control temperature

Balls fly out as speed increases, closing valve

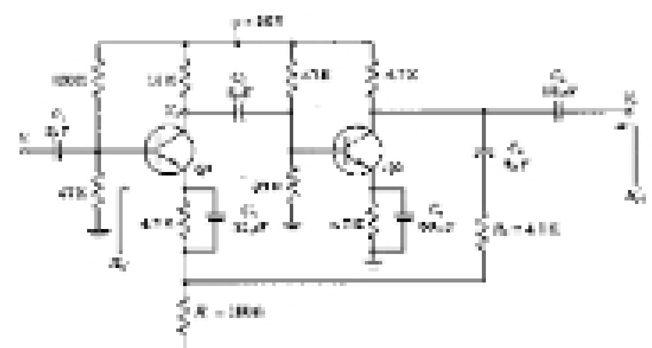


Watt Governor (1788)

- Regulate speed of steam engine
- Reduce effects of variations in load (disturbance rejection)

Feedback Amplifiers (1920s)

- Laid mathematical foundations for classical control
- Black's use of negative feedback to reduce uncertainty (robustness)



Modern Engineering Applications

Flight Control Systems

- Modern commercial and military aircraft are "fly by wire"
- Autoland systems, unmanned aerial vehicles (UAVs) are already in place

Robotics

- High accuracy positioning for flexible manufacturing
- Remote environments: space, sea, non-invasive surgery, etc.

Chemical Process Control

- Regulation of flow rates, temperature, concentrations, etc.
- Long time scales, but only crude models of process

Communications and Networks

- Amplifiers and repeaters
- Congestion control of the Internet
- Power management for wireless communications

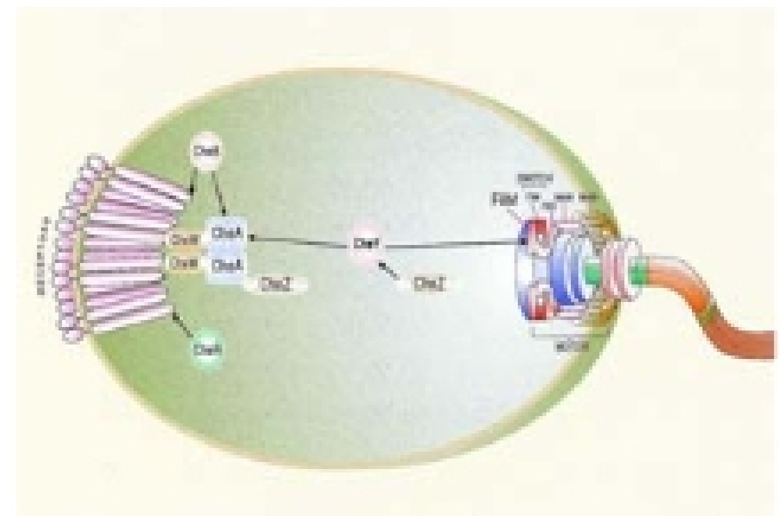
Automotive

- Engine control, transmission control, cruise control, climate control, etc
- Luxury sedans: 12 control instruments in 1976, 42 in 1988, 67 in 1991

AND *MANY* MORE...

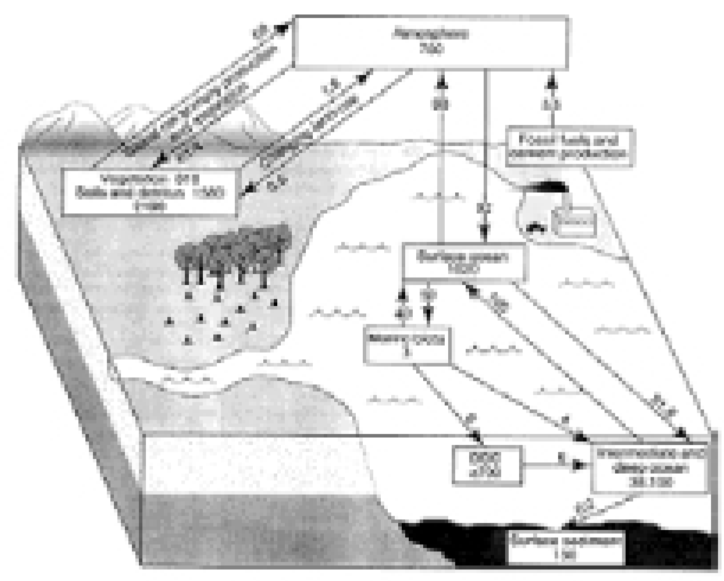
Other Applications of Feedback

Biological Systems
- Physiological regulation (homeostasis)
- Genetic regulatory networks



Environmental Systems
- Microbial ecosystems
- Global carbon cycle

Quantum Systems
- Quantum information processing
- Quantum measurement



Financial Systems
- Markets and exchanges
- Supply and service chains

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Two Main Principles of Control

Robustness to Uncertainty through Feedback
- Feedback allows high performance in the presence of uncertainty
- Example: repeatable performance of amplifiers with 5X component variation
- Key idea: accurate *sensing* to compare actual to desired, correction through *computation* and *actuation*

Design of Dynamics through Feedback
- Feedback allows the dynamics of a system to be modified
- Example: stability augmentation for highly agile, unstable aircraft
- Key idea: interconnection gives *closed loop* that modifies natural behavior

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