Today's EEE 151 Lecture

- What is control systems theory?
- Motivation for control.
- Examples of control systems.
- Basic feedback system.
- Why feedback?

What is EEE 151?

- Classical concepts of continuous-time feedback system.
  - modeling,
  - analysis and
  - compensation techniques.
- Stability of feedback systems.
  - root locus,
  - Bode diagrams and Nyquist plots.
- Introduction to computer-aided design tools.

Objectives of EEE 151

- Identify a system and mathematically model it.
- Design a controller to meet some given criteria.
- Time domain and frequency domain techniques.
- Verify your design.

Practical Use of EEE 151?

- Design control systems and know how they work.
- Understand other control systems and be able to say why they work (or do not work).
- More importantly,
  - read and review literature.
  - basic foundation for other control courses.
  - no blank faces when somebody mentions feedback, and poles and zeros, and Nyquist plots.

Motivation for Control

- Feedback control began with the human desire to harness the materials and forces of nature to their advantage.
- Early examples include water based regulating systems and mechanisms for keeping windmills point into the wind.
- Sophisticated control is crucial for the successful operation of many modern industrial plants.

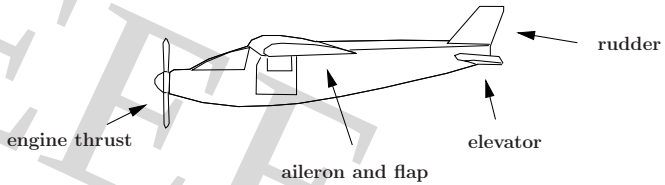
Motivation for Control

- Control has a major impact on society.

  For example, the fly ball governor had a major impact on the industrial revolution.
- Improved control is an enabling technology.
  - enhanced product quality.
  - less waste.
  - leads to environment friendliness.
  - greater throughput for a given installed capacity.
  - greater yield.
  - deferring costly plant upgrades.
  - higher safety margins.

Examples of Control Systems

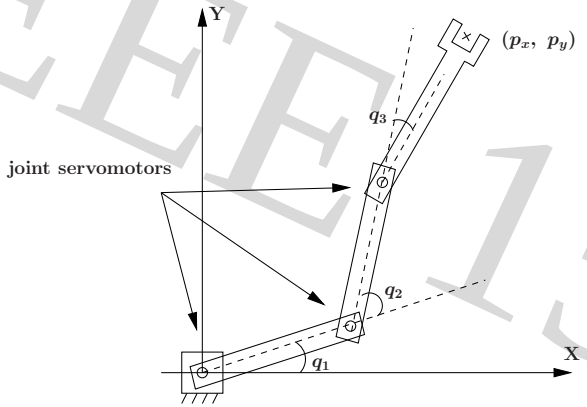
- Control of an aircraft.



  - engine thrust affects aircraft speed.
  - rudder controls aircraft yaw.
  - elevator controls the pitch.
  - aileron controls the roll of the aircraft.

Examples of Control Systems

- Robotic manipulator.
  - servomotors control the joint angles.



Examples of Control Systems

- Biological system.
  - nutrient flow controls bacteria growth.
  - input is nutrient material.
  - output is the bacteria concentration.

- Population system.
  - population depends on different factors.
  - inputs may be food supply and climate conditions.
  - output is population.

Basic Elements of a Control System

- Consider the problem of controlling the light intensity of a bulb.

- We have two light bulbs.
  - we set the intensity of one bulb (bulb A).
  - then we try to match the intensity of the other bulb (bulb B) to the intensity of bulb A.

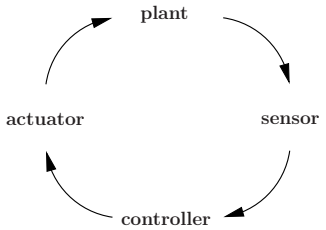
- Simple control system.

  What are the parts of the system?

Basic Elements of a Control System

- Plant.

  This is the process you want to control, i.e., drive to the desired state.



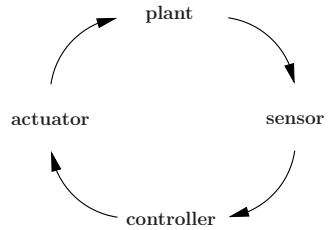
- You need to be familiar with the physics of the process in order to control it.

  Requires knowledge of basic energy balance, mass balance and material flows in the system.

Basic Elements of a Control System

- Sensor.

  Eye of the control. Enables the control to see what is going on. Reports on the state of the process.



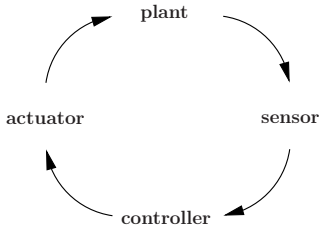
- Actuator.

  Moves the process from current state to the desired state. If the sensor is the eye, then the actuator is the muscle.

Basic Elements of a Control System

- Controller.

  Takes the sensor information and decides how to actuate the plant to achieve the desired state.



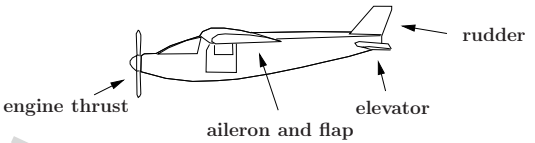
- In this course, we will concentrate on the design of a controller for a system.

  The sensor and actuator will usually be abstracted.

  In reality, the sensor and actuator are as much a part of the design as the controller is.

Basic Elements of a Control System

- Control of an aircraft.



- Actuators are
  - engine thrust.
  - rudder, elevator and aileron.

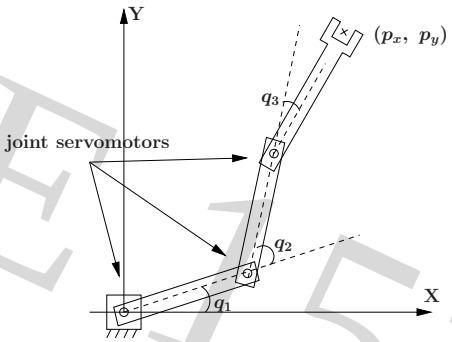
- Sensors could be
  - aircraft speed sensor.
  - pitch, roll, yaw angle sensors.

Basic Elements of a Control System

- Robotic manipulator.

- Servomotors are the actuators.

- Sensors are shaft encoders.



- No need for x, y end-effector position sensor. Why?

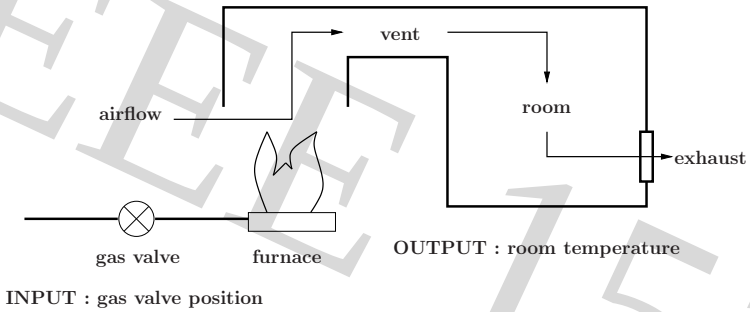
Basic Elements of a Control System

- Biological system.
  - the actuator is the nutrient material.
  - the sensor could be an image processing system coupled to a microscope.

- Population system.
  - the actuators are food supply and climate conditions.
  - the sensor could be random population sampling.

Why Feedback?

- Example. Room heating.



- This is an example of an OPEN-LOOP SYSTEM.

Why Feedback?

- Problem :
  - what if the number of people in the room increases?
  - what if somebody opens a window?
- Result : temperature change.
- Solution: monitor the room temperature.
  Change the gas valve position such that
  - LOW TEMP $\Rightarrow$ more gas.
  - HIGH TEMP $\Rightarrow$ less gas.

Summary

- Why EEE 151?
- Examples of control systems.
- Parts of a control system. Why feedback?
- Next time.
  - open-loop vs. closed-loop.
  - advantages and disadvantages of a closed-loop system.
  - control system design overview.