ME451: Control Systems

Lecture 1
Introduction

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Instructor

- Class Instructor: Dr. Jongeun Choi,
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- Office Hours
  - 2459 EB, MWF 10:10-11:00am, Extra hours by appointment
- Laboratory Instructor: Dr. C. J. Radcliffe,
  - 2445 Engineering Building
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Course information

- Lecture:
  - When: MWF: 12:40pm-1:30pm,
  - Where: 2245 Engineering Building
- Class website: http://www.egr.msu.edu/classes/me451/jchoi/2010/
- Laboratory website: http://www.egr.msu.edu/classes/me451/radcliff/lab
- Required Text:
  - Feedback Control Systems, C. L. Phillips and R. D. Harbor, Prentice Hall, 4th edition, 2000

Main components of the course

- Lectures (about 40 lectures)
- Old Math Quiz
- Midterm1, Midterm2
- Final (Final exam period)
- Laboratory work
- Grading:
  - Homework (10%), Math Quiz (5%), Exam 1 (17.5%), Exam 2 (17.5%), Final Exam (comprehensive) (25%), Laboratory work (25%)
  - Homework will be due in one week from the day it is assigned

Tips to pass this course

- Come to the lectures as many times as you can.
- Print out and bring lecture slides to the lecture.
- Do "Exercises" given at the end of each lecture.
- Do homework every week.
- Read the textbook and the slides.
- Make use of instructor's office hours.
- If you want to get a very good grade…
  - Read the textbook thoroughly.
  - Read optional references too.
  - Do more than given "Exercises".
  - Use and be familiar with Matlab.

What is "Control"?

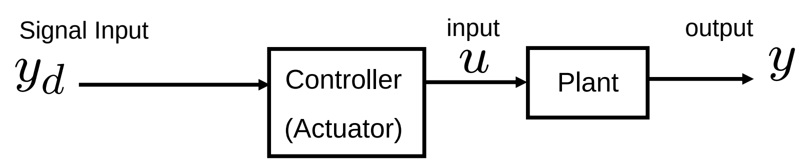
- Make some object (called ***system, or plant***) behave as we desire.
- Imagine "control" around you!
  - Room temperature control
  - Car/bicycle driving
  - Voice volume control
  - "Control" (move) the position of the pointer
  - Cruise control or speed control
  - Process control
  - etc.

What is "Control Systems"?

- Why do we need control systems?
  - Convenient (room temperature control, laundry machine)
  - Dangerous (hot/cold places, space, bomb removal)
  - Impossible for human (nanometer scale precision positioning, work inside the small space that human cannot enter)
  - They exist in nature. (human body temperature control)
  - Lower cost, high efficiency (factory automation), etc.
- Many examples of control systems around us

Open-Loop Control

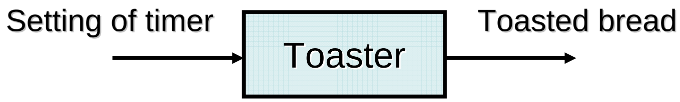
- Open-loop Control System
  - Toaster, microwave oven, shooting a basketball



  - Calibration is the key!
  - Can be sensitive to disturbances

Example: Toaster

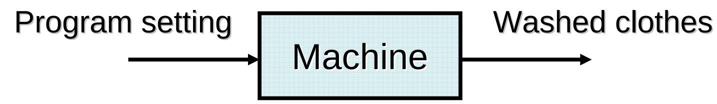
- A toaster toasts bread, by setting timer.



- Objective: make bread golden browned and crisp.
- A toaster does not measure the color of bread during the toasting process.
- For a fixed setting, in winter, the toast can be white and in summer, the toast can be black (Calibration!)
- A toaster would be more expensive with sensors to measure the color and actuators to adjust the timer based on the measured color.

Example: Laundry machine

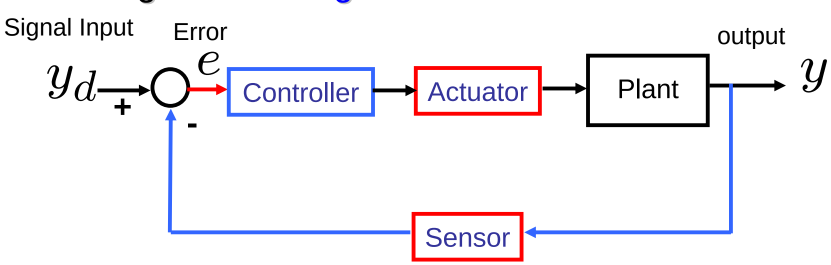
- A laundry machine washes clothes, by setting a program.



- A laundry machine does not measure how clean the clothes become.
- Control without measuring devices (sensors) are called ***open-loop control***.

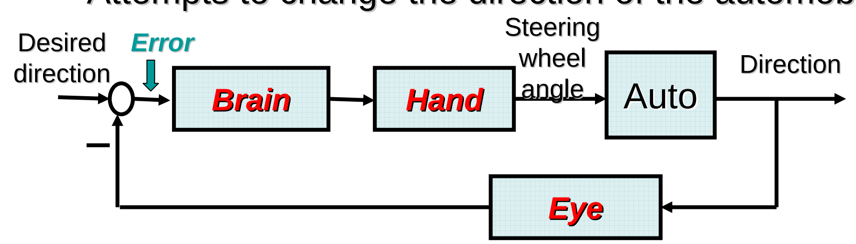
Closed-Loop (Feedback) Control

- Compare actual behavior with desired behavior
- Make corrections based on the error
- The sensor and the actuator are key elements of a feedback loop
- Design control algorithm



Ex: Automobile direction control

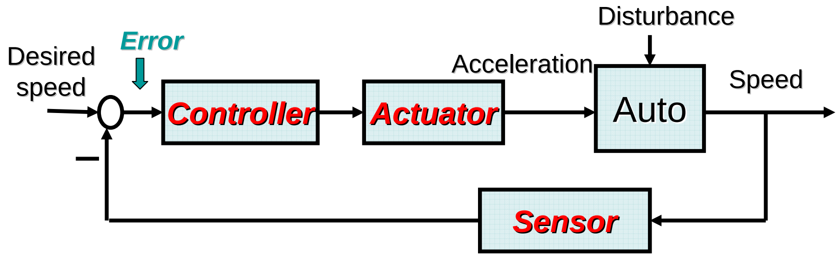
- Attempts to change the direction of the automobile.



- Manual closed-loop (***feedback***) control.
- Although the controlled system is "Automobile", the ***input*** and the ***output*** of the system can be different, depending on ***control objectives***!

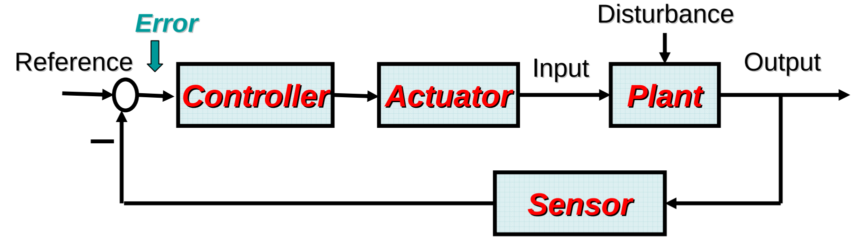
Ex: Automobile cruise control

- Attempts to maintain the speed of the automobile.



- Cruise control can be both manual and automatic.
- Note the similarity of the diagram above to the diagram in the previous slide!

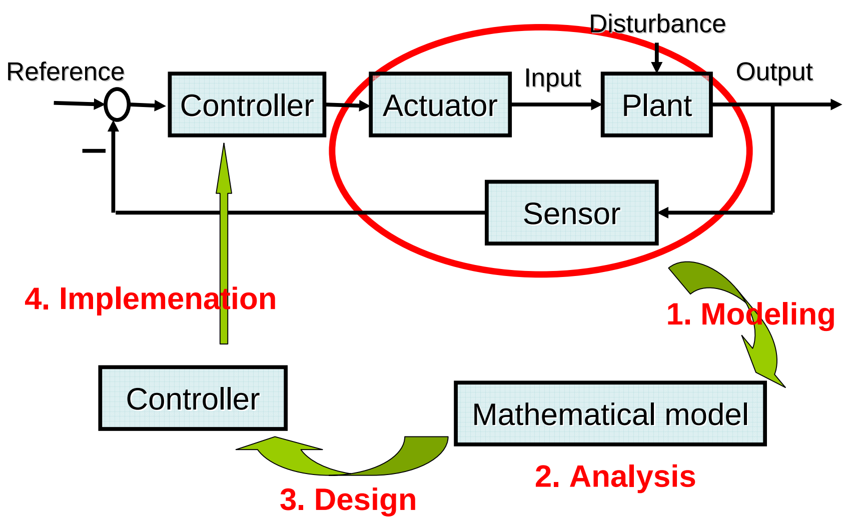
Basic elements in feedback control systems



Control system design objective

To design a controller s.t. the output follows the reference in a “satisfactory” manner even in the face of disturbances.

Systematic controller design process



Goals of this course

To learn basics of feedback control systems

- Modeling as a transfer function and a block diagram
  - Laplace transform (Mathematics!)
  - Mechanical, electrical, electromechanical systems
- Analysis
  - Step response, frequency response
  - Stability: Routh-Hurwitz criterion, (Nyquist criterion)
- Design
  - Root locus technique, frequency response technique, PID control, lead/lag compensator
- Theory, (simulation with Matlab), practice in laboratories

Course roadmap

Modeling

- Laplace transform
- Transfer function
- Models for systems
  - mechanical
  - electrical
  - electromechanical
- Linearization

Analysis

- Time response
  - Transient
  - Steady state
- Frequency response
  - Bode plot
- Stability
  - Routh-Hurwitz
  - (Nyquist)

Design

- Design specs
- Root locus
- Frequency domain
- PID & Lead-lag
- Design examples

(Matlab simulations &) laboratories

Summary & Exercises

- Introduction
  - Examples of control systems
  - Open loop and closed loop (**feedback**) control
  - Automatic control is a lot of fun!
- Next
  - Laplace transform
- Exercises
  - Buy the course textbook at the Bookstore.
  - Read Chapter 1 and Apendix A, B of the textbook.