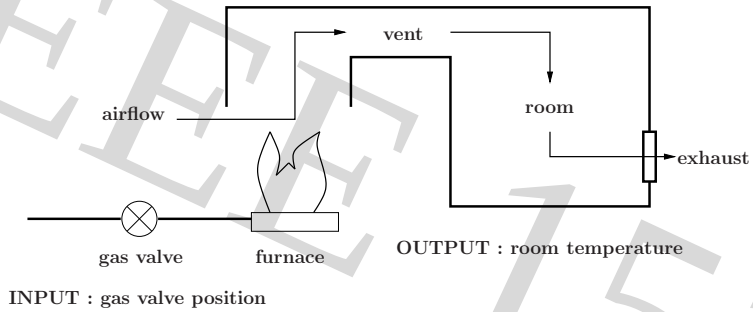
Today's EEE 151 Lecture

- Open-loop vs. closed-loop.
- Advantages and disadvantages of a closed-loop system.
- Control system design overview.

Why Feedback?

- Example. Room heating



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

Why Feedback?

- How can we control the system?
  - for different actions (at the input), determine the effects (at the output) on the system.
  - we have a input to output map of the system.
  - we want the output behave a specific way.
  - invert the input to output relationship, i.e., determine for a given output what the necessary input is.
- For the room heating example, we want the output temperatures for different valve settings.

  We then set the valve to the corresponding temperature we want.

Why Feedback?

- This control solution is termed inversion.
- Problem :
  - what if the number of people in the room increases?
  - what if somebody opens a window?
- Result : temperature change.
- Even though our valve is at the "right" setting, the room temperature is not at the desired level.

  $\Rightarrow$ The model changed.

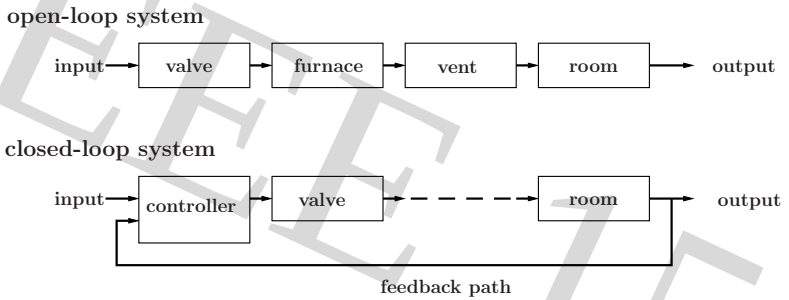
Why Feedback?

- In general, inversion does not usually lead to a satisfactory solution unless
  - we have a very good representation of the plant,
  - the plant model and its inverse are stable, and
  - disturbances and initial conditions are negligible.
- We need to find an alternative solution to inversion.
- Solution: monitor the room temperature.

  Change the gas valve position such that
  - LOW TEMP ⇒ more gas.
  - HIGH TEMP ⇒ less gas.

Open-loop vs. Closed-loop

- Comparison.



- We will see later that a properly designed closed-loop system works similar to inversion but without the problems.

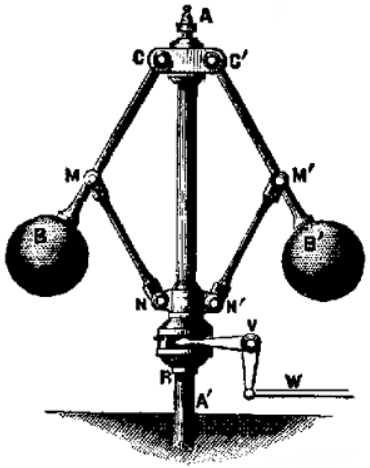
Open-loop vs. Closed-loop

- Advantages of a closed-loop system.
  - output is less sensitive to DISTURBANCES (e.g. more people in room, window opens).
  - output is less sensitive to PLANT CHANGES (e.g. aging furnace, improved insulation).
  - output is more accurate with respect to desired value.
- Disadvantages of a closed-loop system.
  - controller and sensor cost money.
  - system may become unstable if improperly designed (e.g. steam governor, Mars rover).

Open-loop vs. Closed-loop

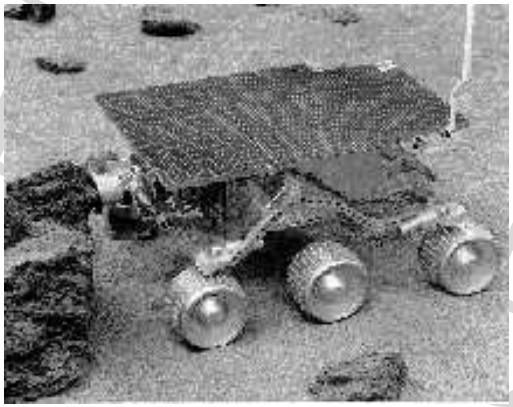
- Steam governor.

  Becomes unstable if mechanisms are too smooth.



Open-loop vs. Closed-loop

- Mars rover - too much delay leads to "instability."



Control System Design Flowchart

control objectives	experience, dialogue
⇓	
modeling	system identification, science, math
⇓	
model verification	simulation
⇓	
control architecture	experience
⇓	
control design	root locus, Bode, Nyquist, simulation
⇓	
control verification	simulation, prototyping

Control System : Objectives

- What do you want the control to achieve?
  - enhance quality.
  - energy reduction.
  - increase yield.
- What variables need to be controlled to achieve the objectives?
- What level of performance is necessary?
  - accuracy (error $<$ 5%).
  - speed (system needs to settle in 1 minute).

Control System : Modeling

- Gaining understanding of how the process operates.

  The model is usually expressed in mathematical form.
- Finding the right model is key to proper design.
  - the model must be simple enough so as not to complicate the controller design.
  - the model must also be accurate enough to provide a good undestanding how the process works.
- Example. Diode model.

  You need to determine the appropriate model for the circuit you are designing.

Control System Design

- It is often necessary to go back one or more steps and repeat the process.

- What controller?
  - classical, fuzzy, neural.
  - does it take into account modeling errors?
  - how does it react to disturbances and noise?
  - cost and complexity.

Summary

- What is a closed-loop system?
  How is it different from an open-loop system?

- Advantages and disadvantages of a closed-loop system.

- Control system design.

- Homework. Text P{ 1.1, 1.2, 1.6, 1.8 }, DP{ 1.1, 1.2 }