Introduction to Robotics

CSE 461

Lecture 10: Introduction to Control System Theory

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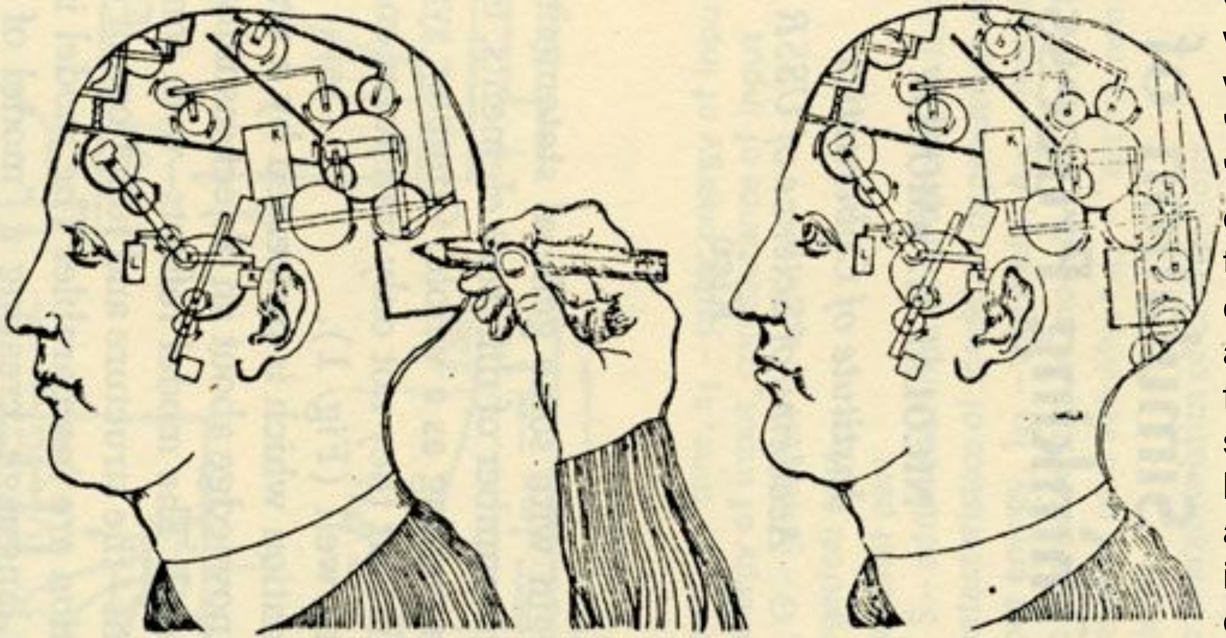
Cybernetics



The term "cybernetics" comes from the Greek word "kybernetes," which means "steersman" or "governor." In cybernetics, this refers to the process of controlling or regulating a system by providing feedback. It involves the study of how systems, both biological and artificial, process information, adapt to changes in their environment, and communicate with each other.

How things get controlled

Control Systems Example

Body temperature regulation

- If cold, shiver (muscles produce heat)
- If hot, sweat (evaporation takes away heat)

Maintaining social peace

- If a crime is found (sensor), the guilty party is punished (actuator).

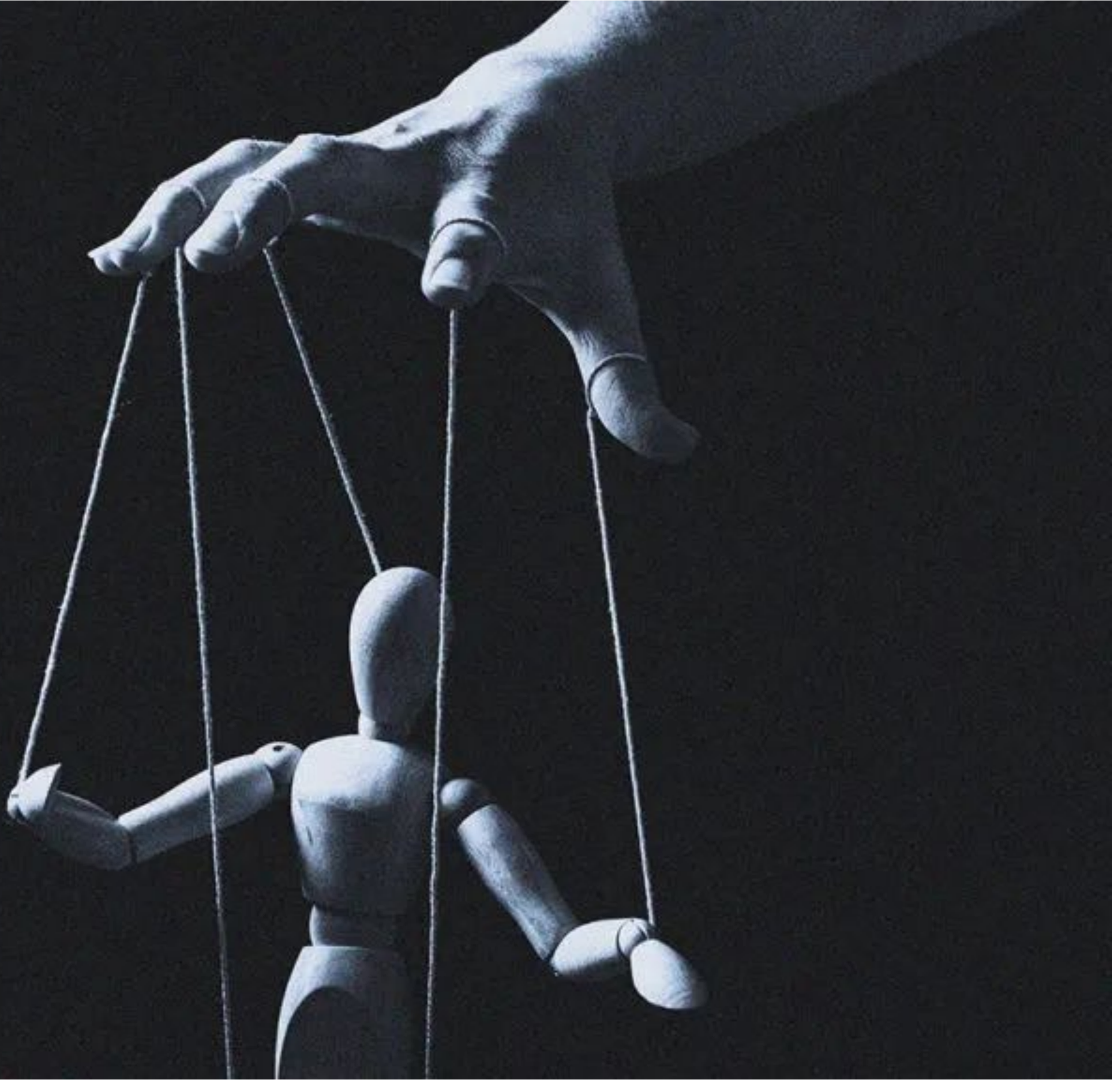
Cruise control in cars

- You set a speed, Cruise control will increase fuel intake uphill, and decrease it downhill.
- Etc...

Control System Goal

- Regulation
  - Thermostat
- Tracking
  - robot movement, adjust TCP window to network bandwidth
- Optimization
  - best mix of chemicals, minimize response times

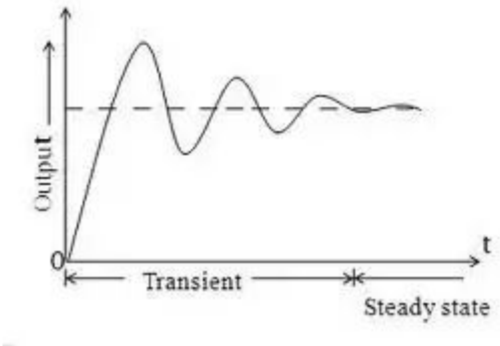
Control Theory



Why Control Theory

Systematic approach to analysis and design

- Transient response
- Consider sampling times, control frequency Taxonomy of basic controllers (PID, open-loop, Model-based, Feedforward...)
- Select controller based on desired characteristics



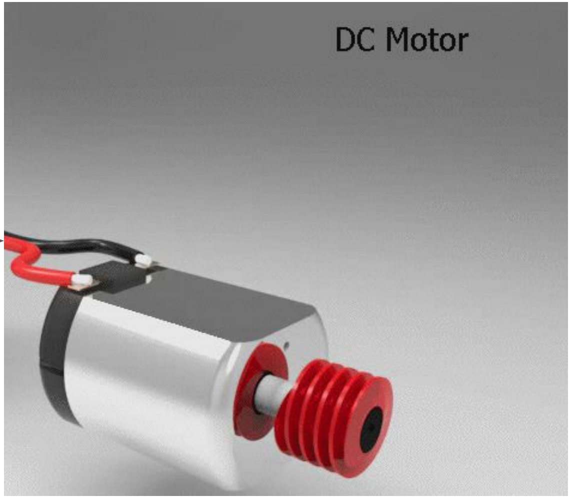
Predict system response to some input

- Speed of response (e.g., adjust to workload changes)
- Oscillations (variability)

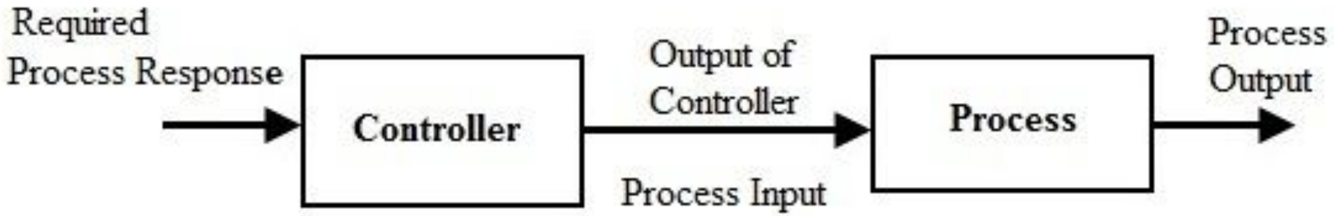
Assessing stability of system

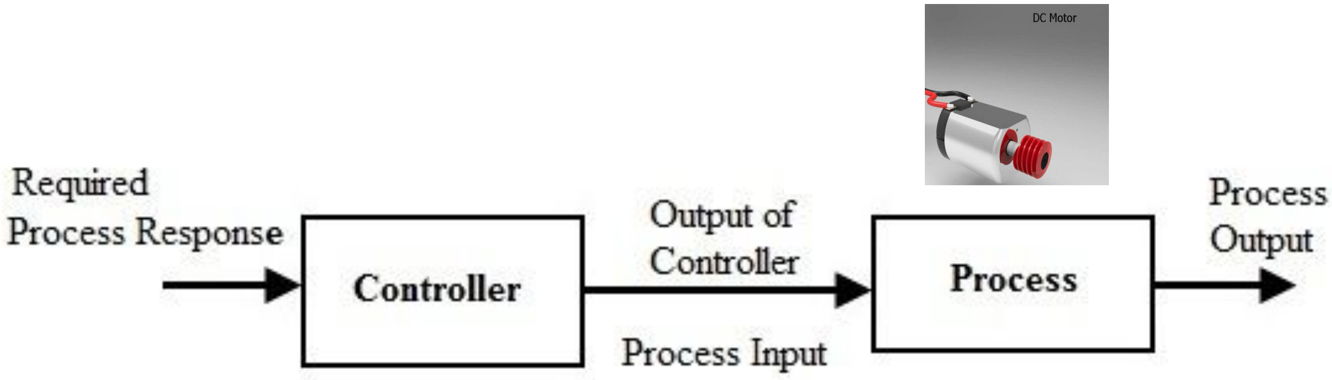
Control System

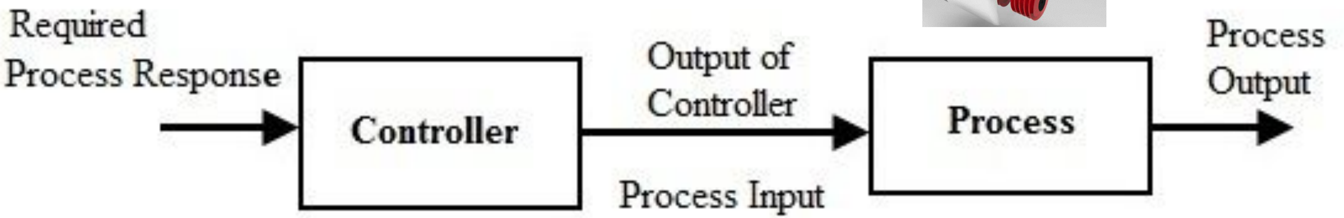
3 rad/sec → Controller →



2.2 rad/sec

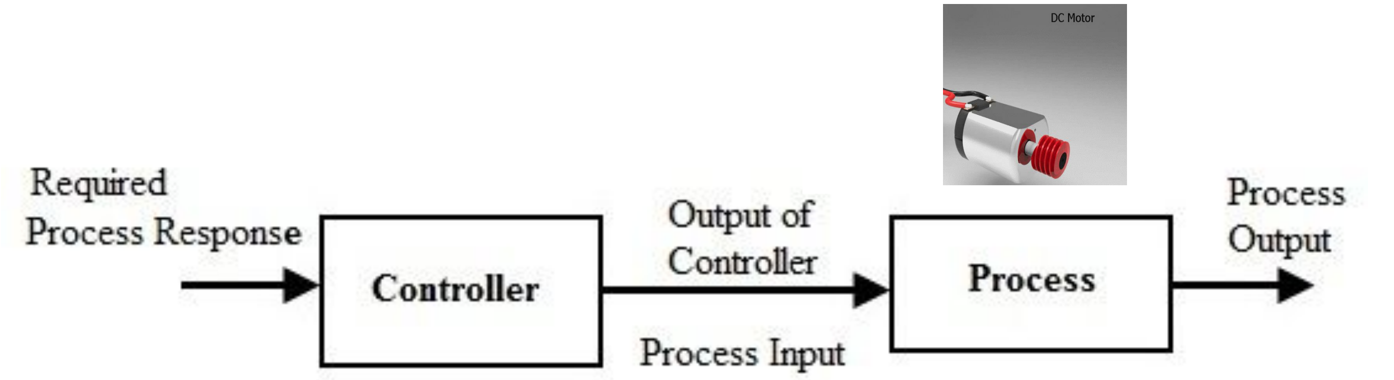

Required
Process Response
Controller
Output of
Controller
Process Input
Process
Process
Output


DC Motor
Required
Process Response
Controller
Output of
Controller
Process Input
Process
Process
Output



3 rad/s

2.2 rad/s



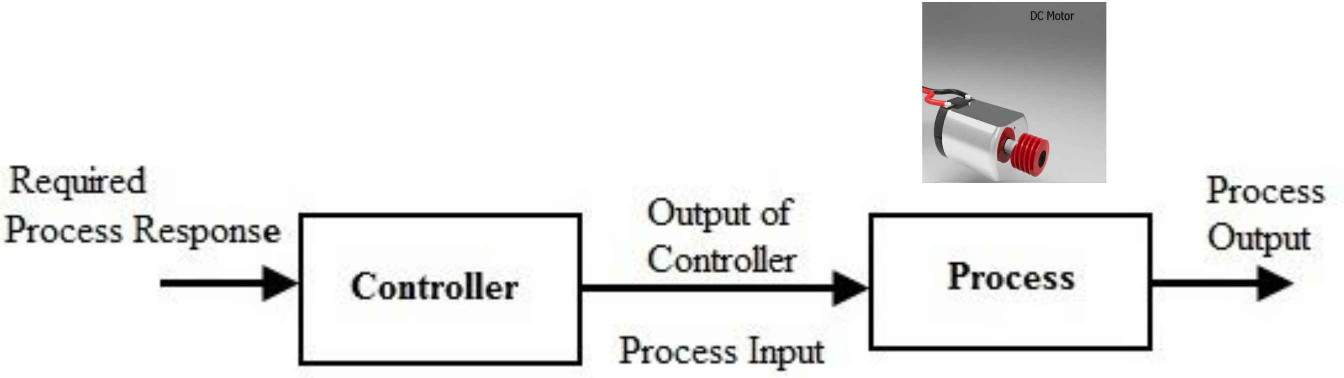
Required
Velocity

3 rad/s

Output
Velocity

2.2 rad/s

Open Loop Control



Required
Velocity

3 rad/s

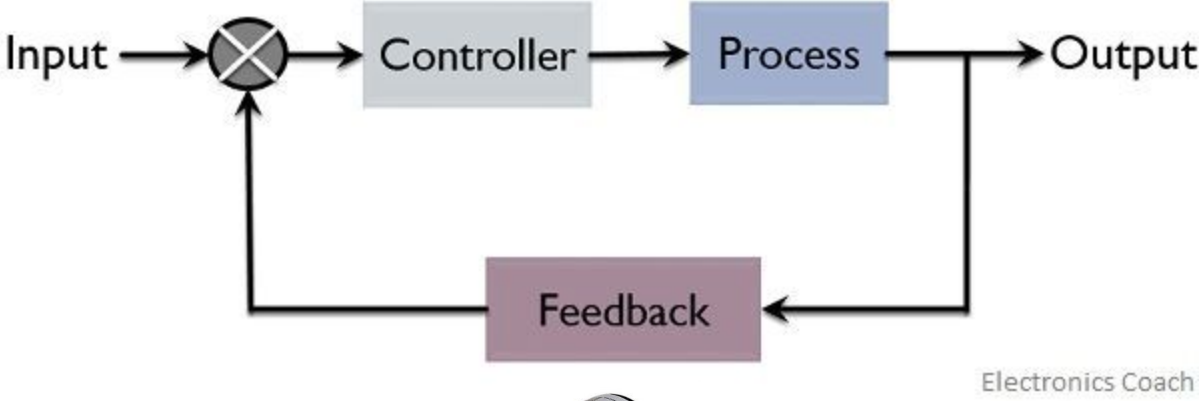
Output
Velocity

2.2 rad/s

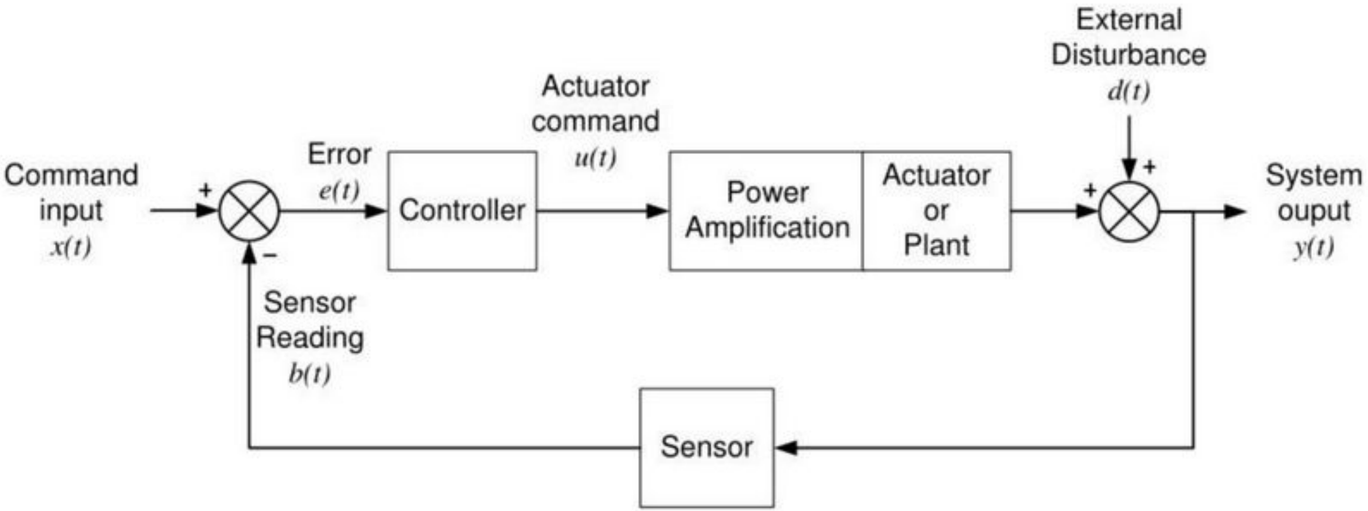
Let’s measure the actual angular velocities.

Now we can compensate for changes in load by feeding back some information.

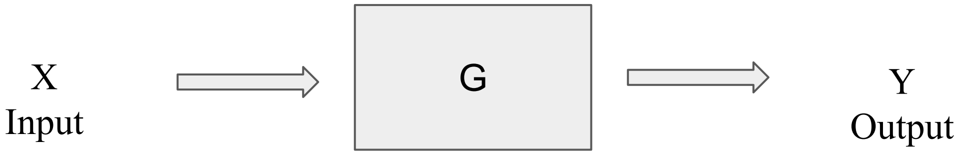
Closed Loop Control



Feedback Diagram



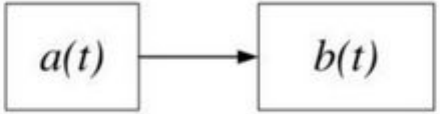
Block Diagram



$$Y = X*G$$
$$Y/X = G$$
$$\text{Gain} = Y/X = \text{Output}/\text{Input}$$

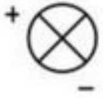
Block Diagram

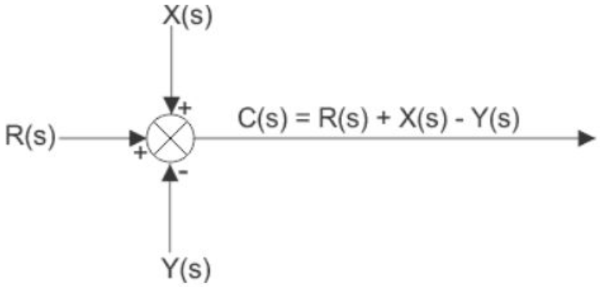
- Rules
  - Cascaded elements: convolution



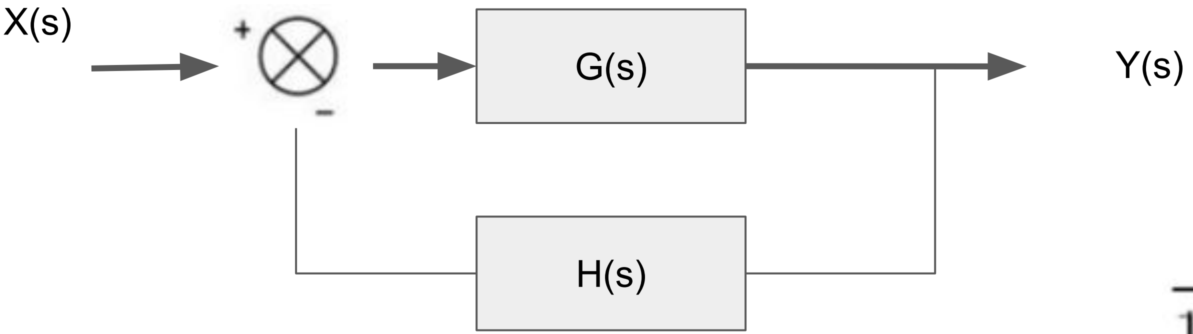
$$= a(t) * b(t)$$

  - Summation and deference elements





- Feedback Connection



$$\frac{G(s)}{1 \mp G(s)H(s)} * X(s)$$

Next Class

How to design a control system

How to solve a block diagram

PID Control

Thank You