Introduction to Robotics
CSE 461

Class 11: Introduction to Control System Theory

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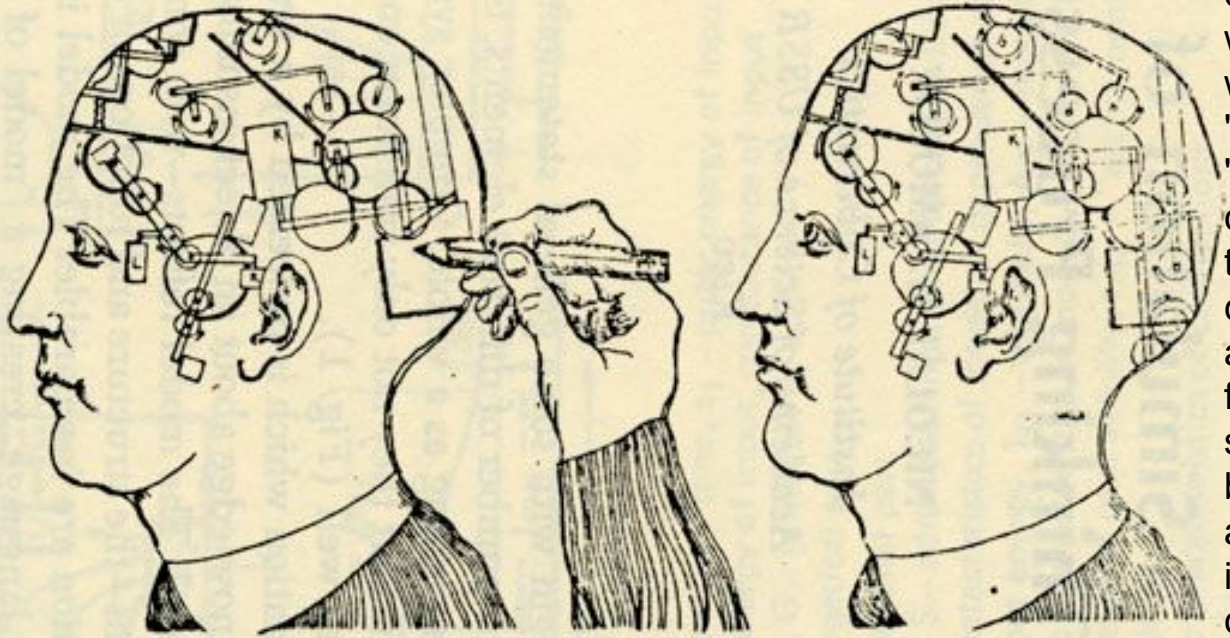
Cybernetics



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 the 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...

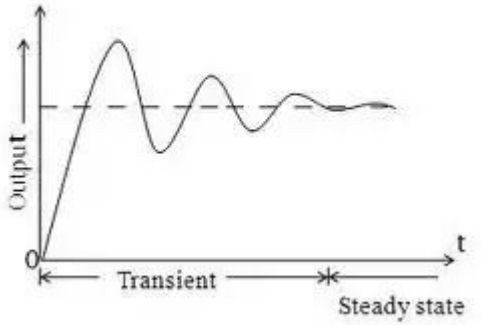
Control Theory

Why Control Theory

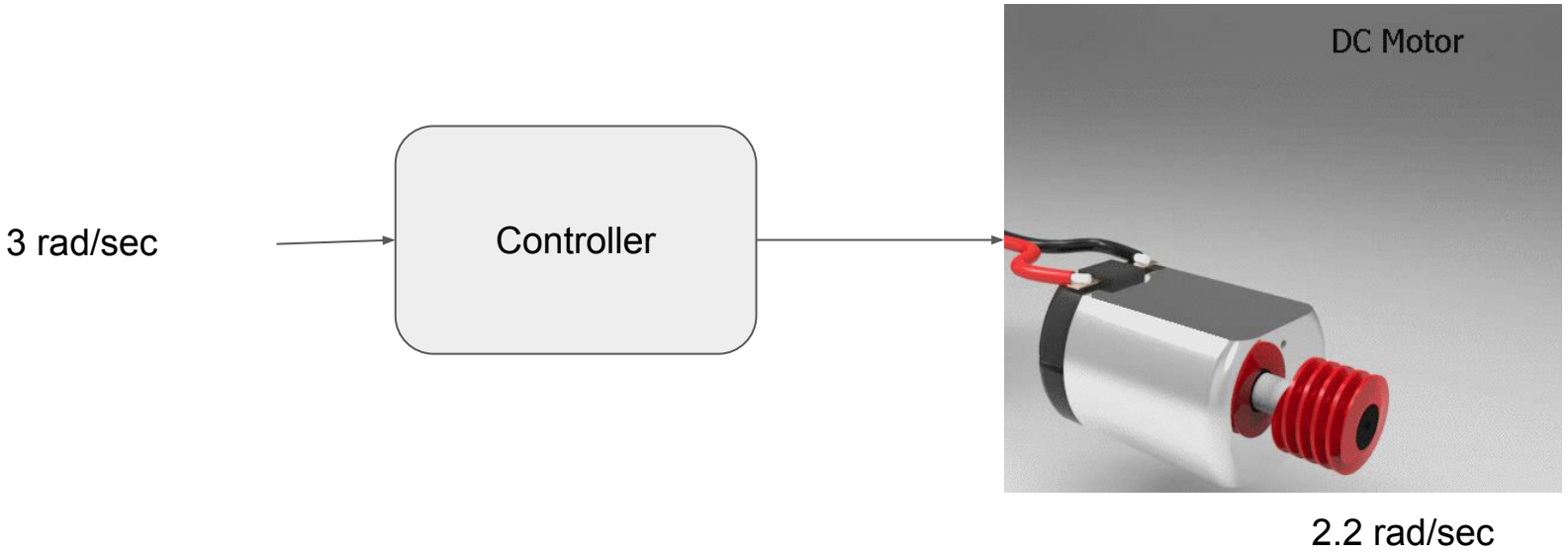
Systematic approach to analysis and design

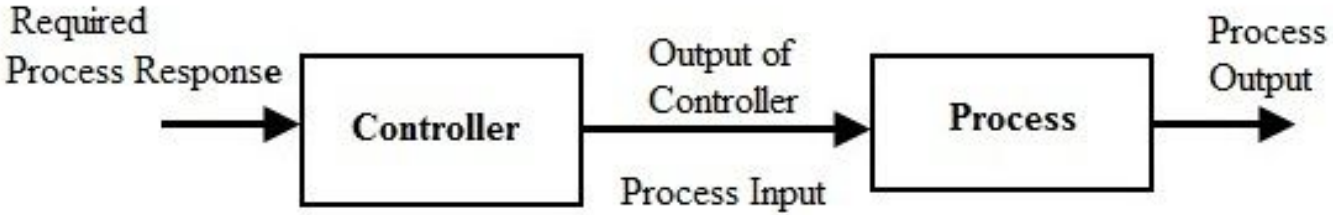
Predict system response to some input

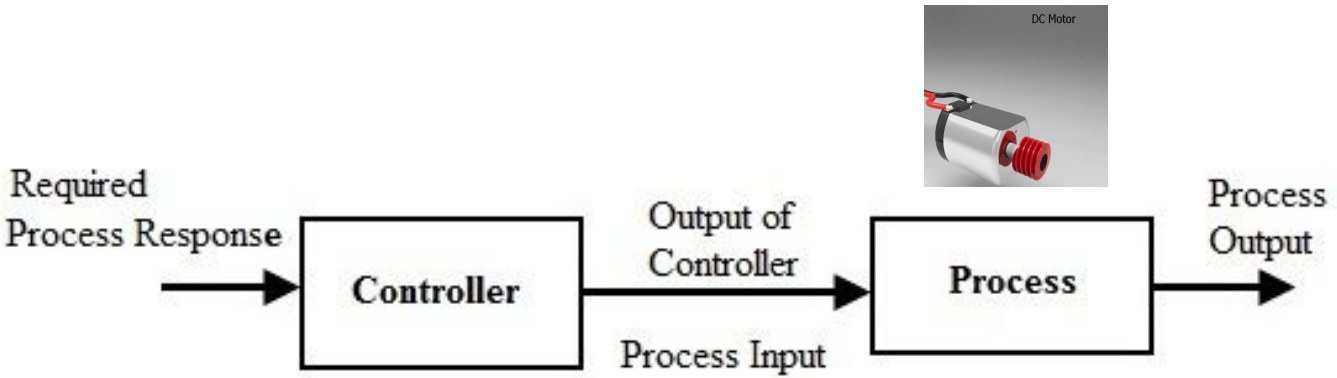
Assessing stability of system

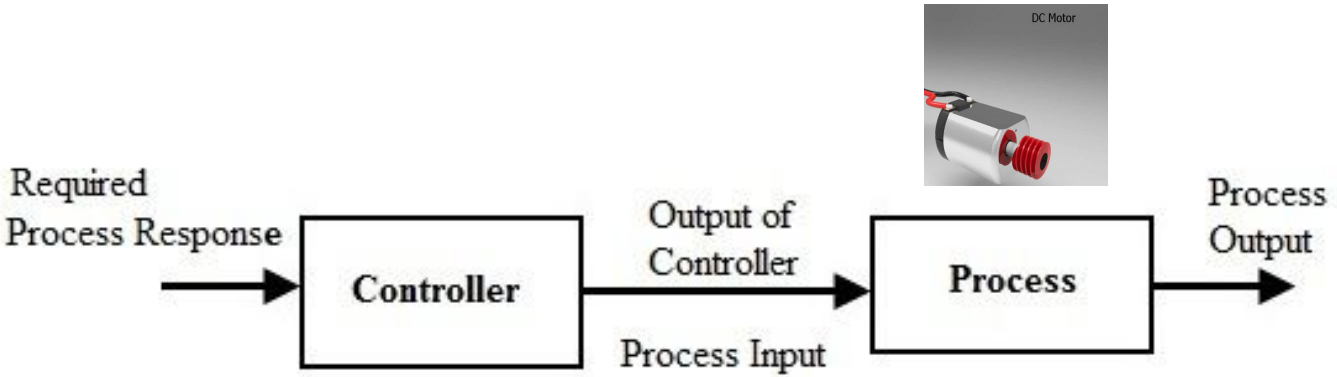


Control System




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
Process Response

Controller

Output of
Controller

Process Input

Process

Process
Output

Required
Velocity

3 rad/s

Output
Velocity

2.2 rad/s

Open Loop Control

Required
Process Response

Controller

Output of
Controller

Process Input

Process

Process
Output

Required
Velocity

3 rad/s

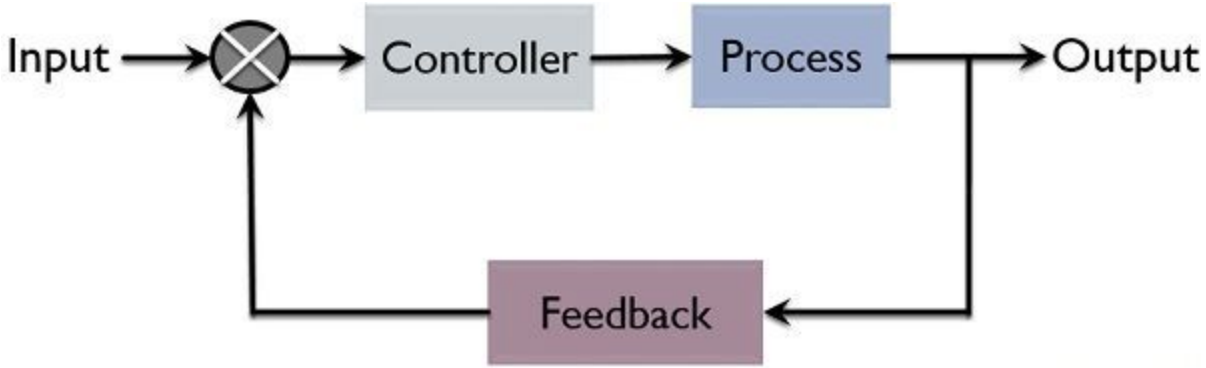
Output
Velocity

2.2 rad/s

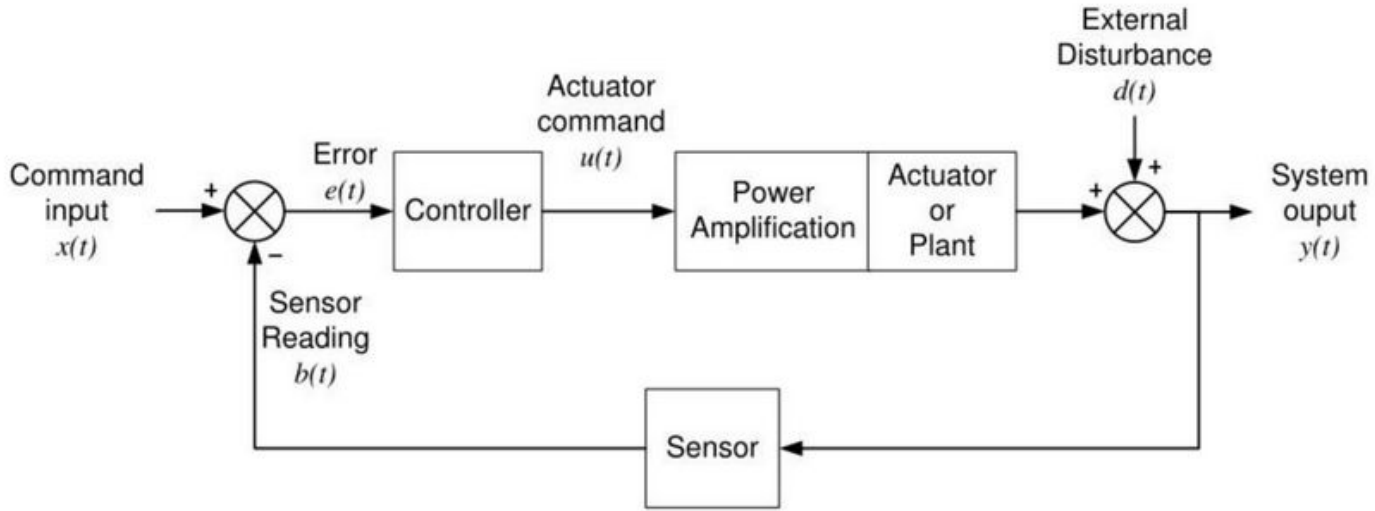
Let’s measure the actual angular velocities.

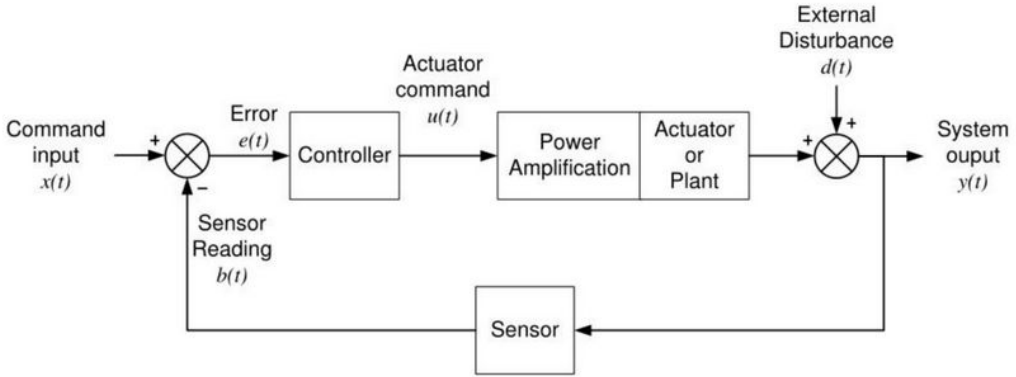
Now we can compensate for changes in load by feeding back some information.

Closed Loop Control



Feedback Diagram





Characteristics of Feedback System

- Power amplification
- Actuator
- Feedback
  - measurement (sensor)
- Error signal
- Controller

Control System Goal

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

Block Diagram

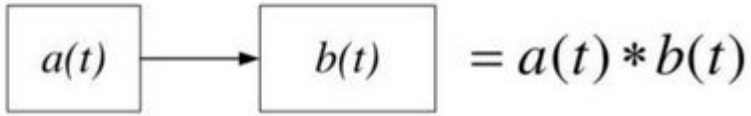
$$Y = X*G$$

$$Y/X = G$$

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

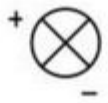
Block Diagram

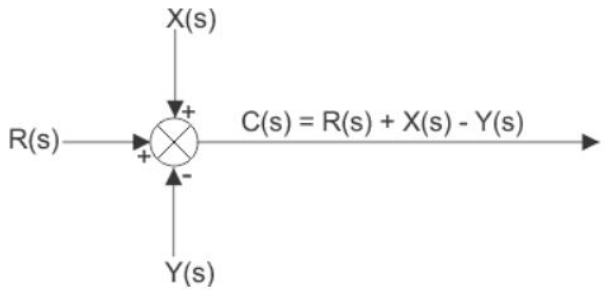
- Rules
  - Cascaded elements: convolution



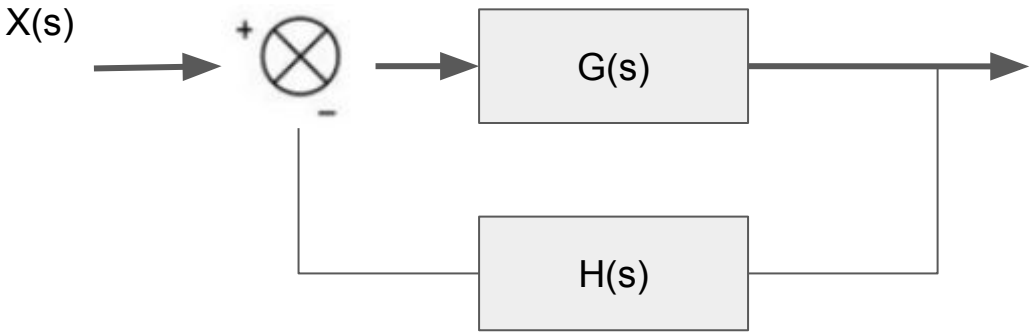
$$= a(t) * b(t)$$

  - Summation and deference elements





- Feedback Connection



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

Next Class

How to design a control system

How to solve a block diagram

PID Control

Thank You