CSE 490i
Lecture 2
Robot Feedback Control

1/9/2007

Announcements

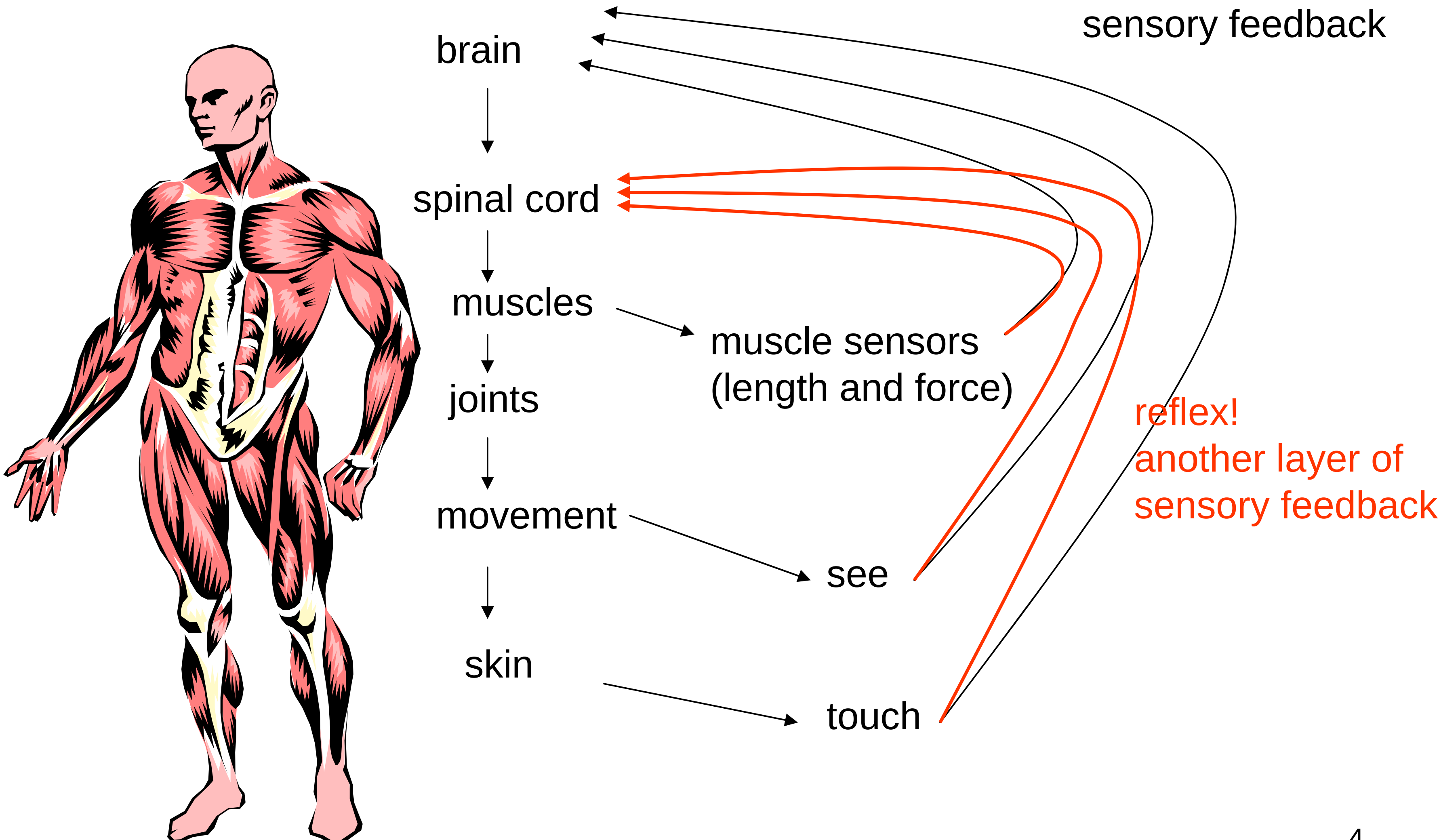
- PS1 was due before this class
- PS2 will be on the web by the end of today
- Lab1 this week
- If you haven't signed up for this class officially, you should let me know asap.
- Optional MATLAB tutorial lecture on Thursday in the lecture slot (will help you with the problem sets if you are not comfortable with it).
- Late assignment penalty: 3 free late days (for all lab writeups + problem sets, 1 day max per assignment). 10pts off per day thereafter.
- C programming experience concerns

Examples of Feedback Control System

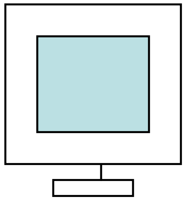
- Thermostat
- Airplane/car cruise control
- Inverse Pendulum
- Robots!!

Feedback Control = Closed Loop Control

Human Closed Loop System



Robot Closed Loop System

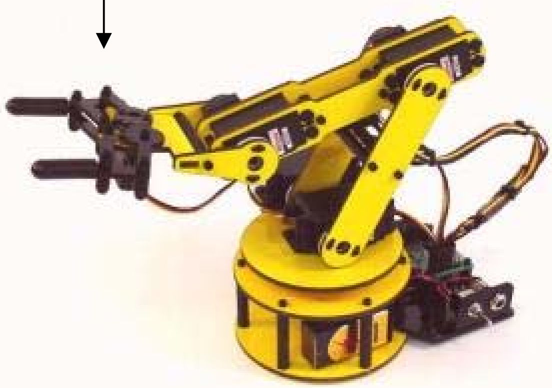


computer

sensory feedback

electronics (amplifiers, etc)

motors



joint angle sensors
touch sensors at gripper
force sensors

camera to see the position

robotics math gives gripper position
based on joint angles

This is what you have in the lab this week

How do the robots in the industry operate?

- Repeat the same task over and over
- Many do not use closed loop control.

WHY?

Pros: Require sensors --- expensive

Cons: Require calibration by hand
Not robust under perturbation or change in parameters

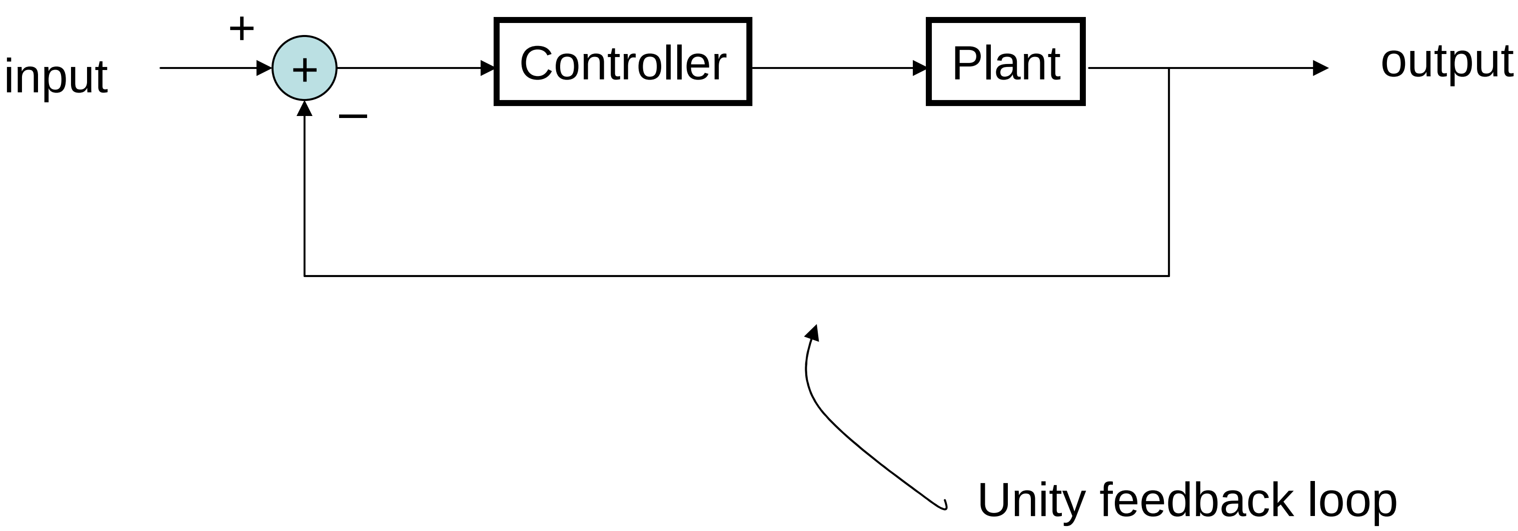
How can we build a better robotic system with feedback control?

Add
Touch/force sensors
Cameras
Joint/position sensors

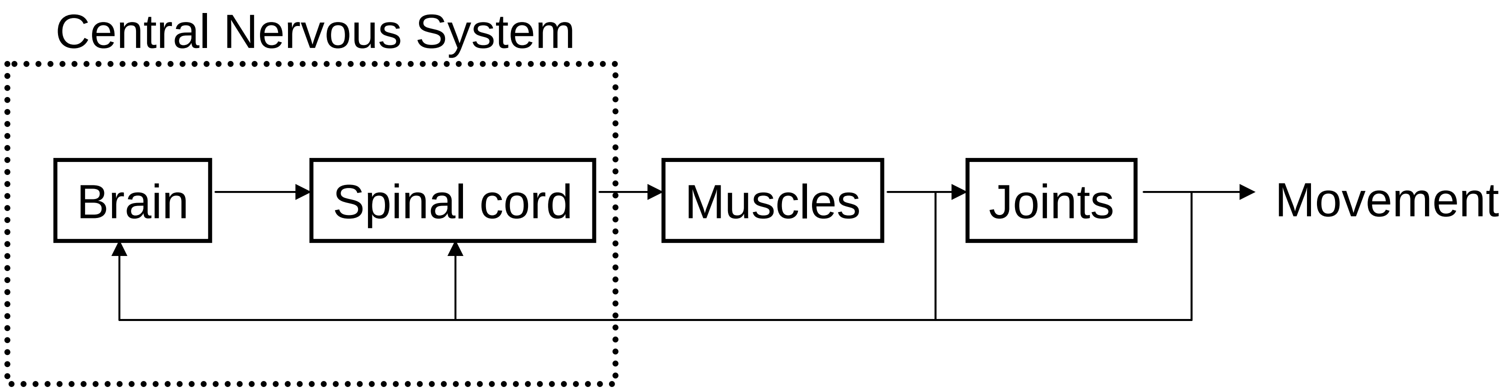
Position sensors can:
1. Tell position
2. Tell velocity/acceleration

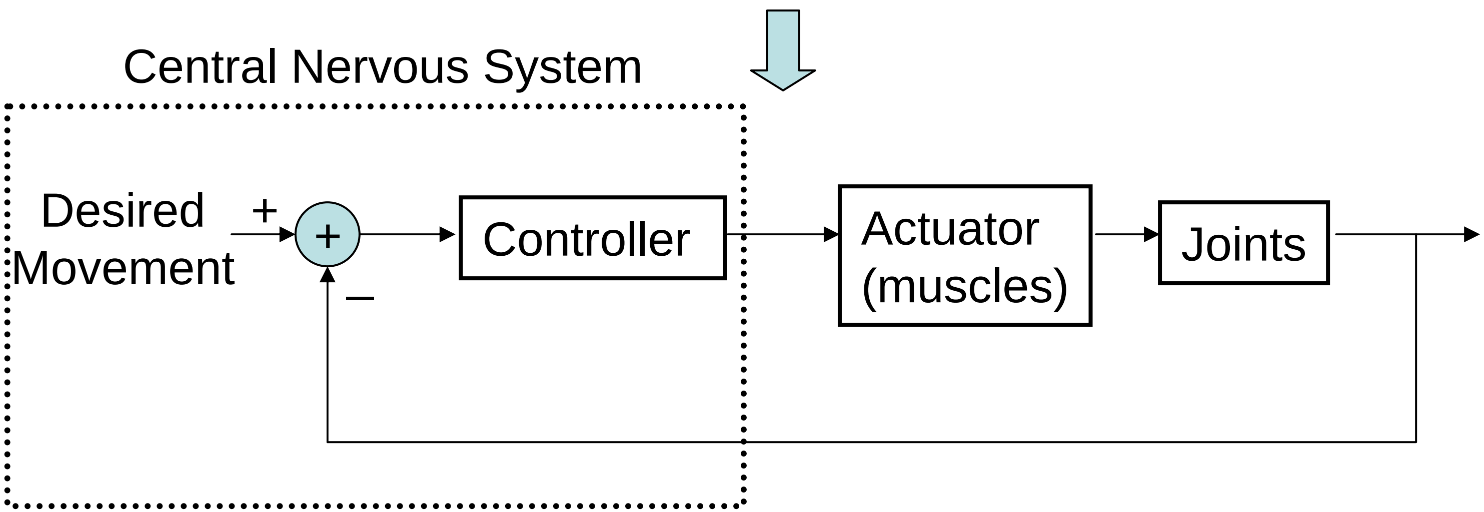
Typically robots care about positioning the gripper precisely
OR
Applying precise force at the gripper

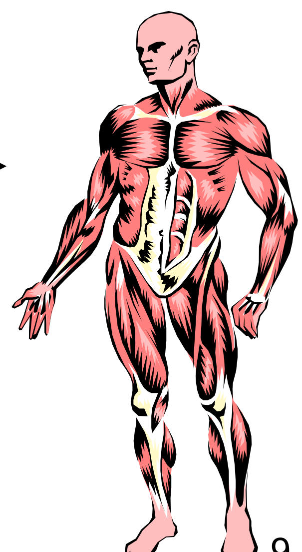
Box Diagram
(formal definition)



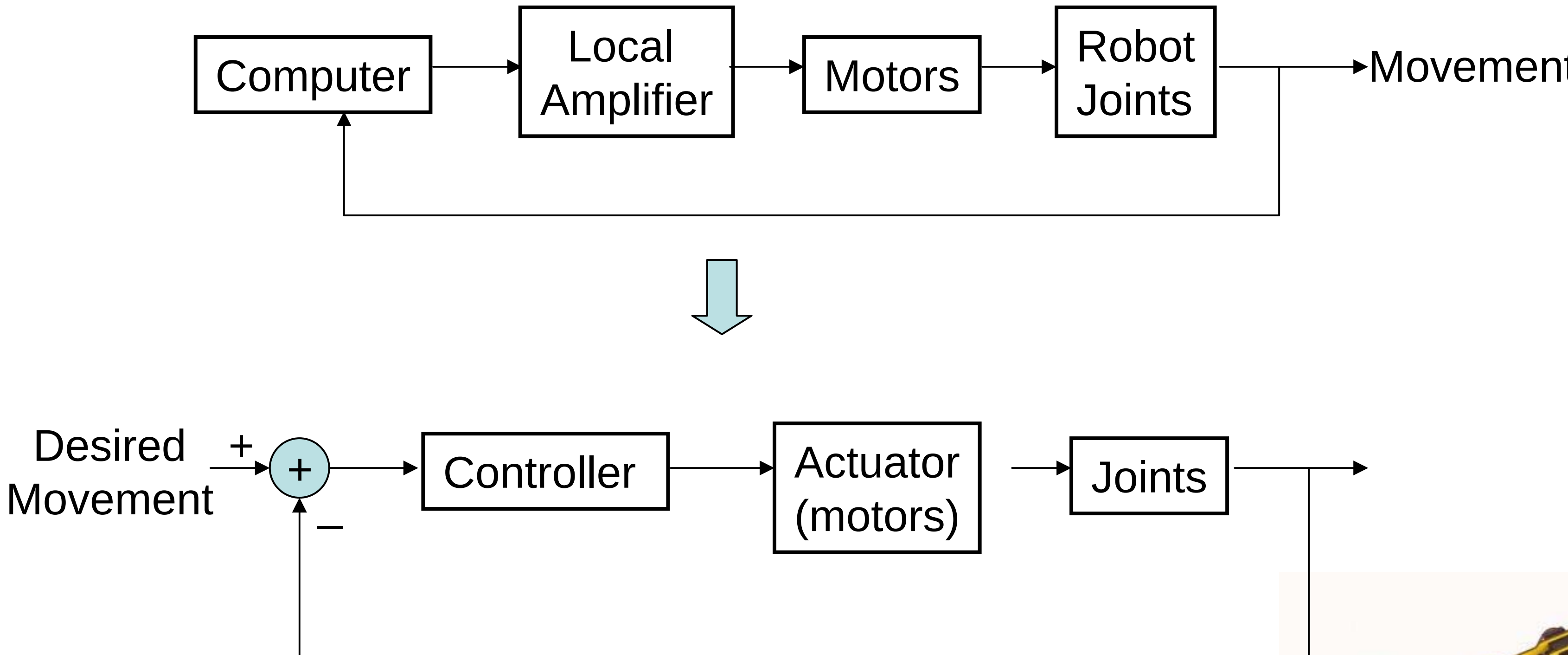
Human Closed Loop System Box Diagram



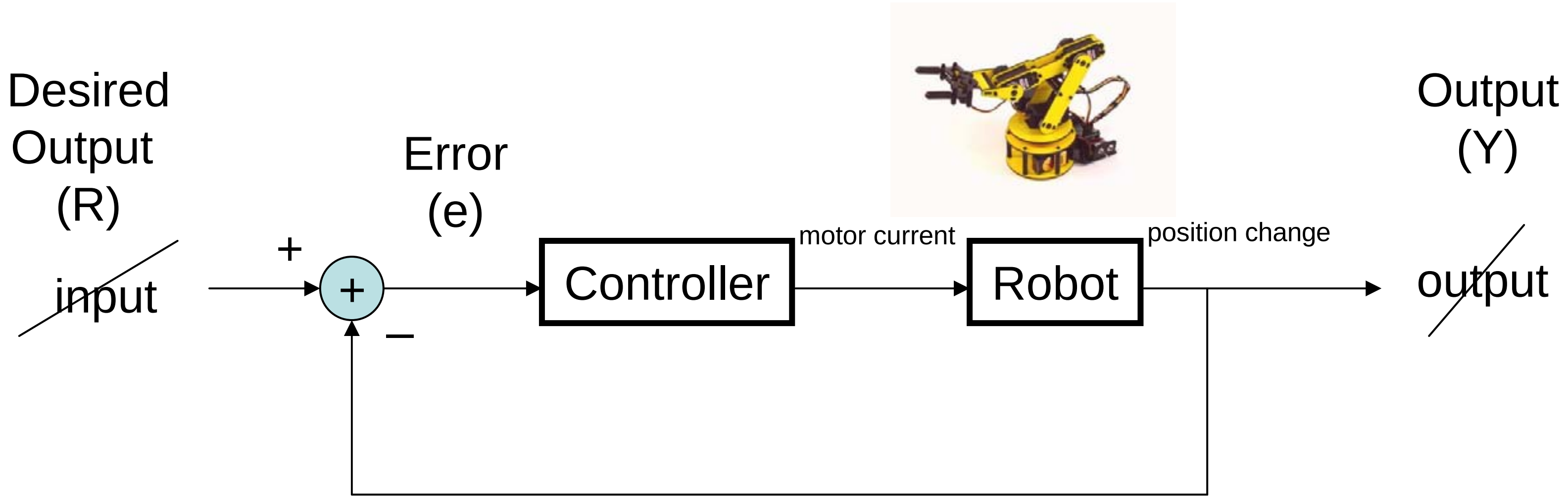




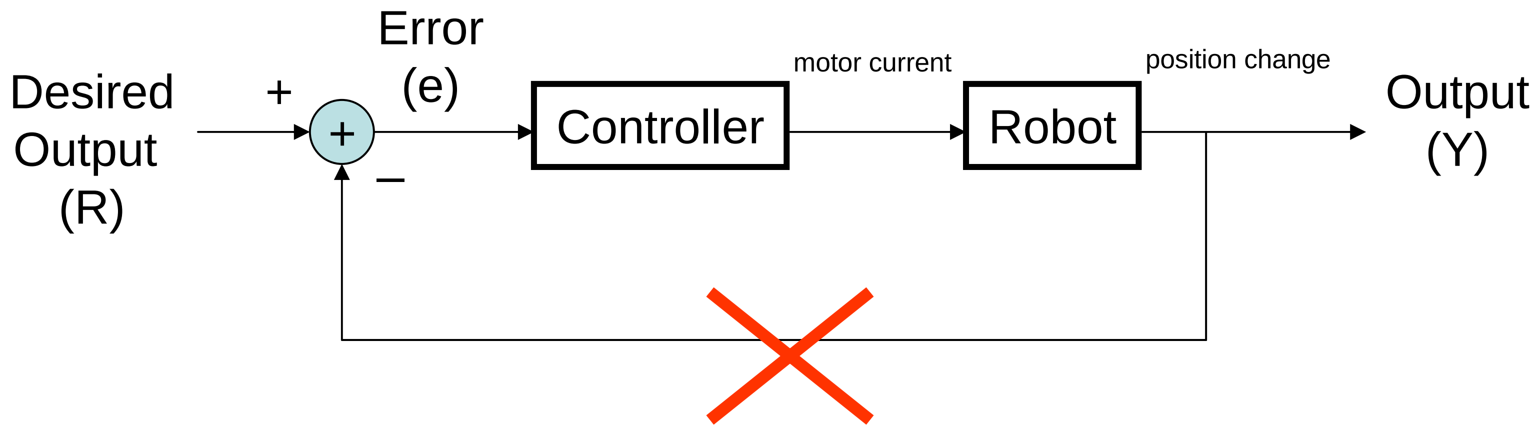
Robot Closed Loop System Box Diagram



More Formally:
Robotic Control Box Diagram



Example 1: Open Loop



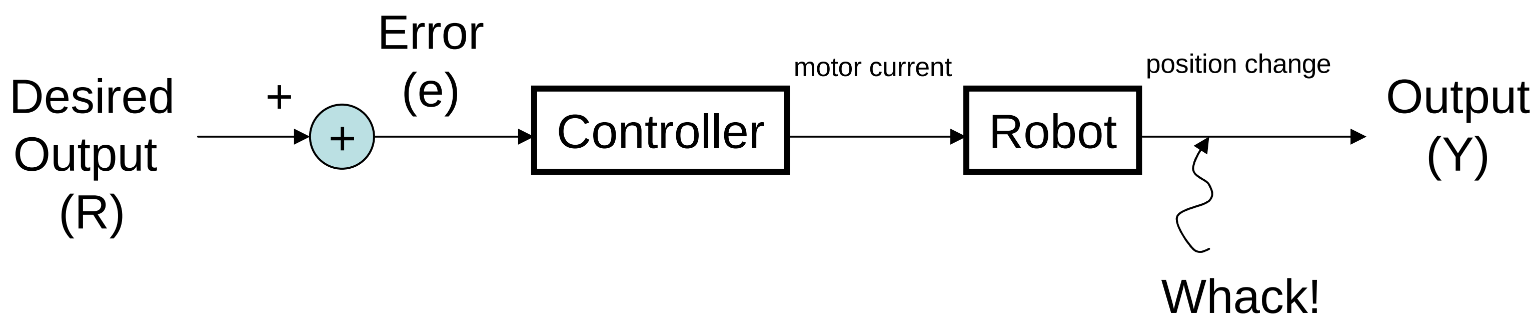
Initial condition: R = 0, Y = 0, e = 0
Controller gain = 1

At t = 0, R = 1

e = 1, e * gain = 1, Y = 1, and stays there

This is what you have in your lab this week
This is fine if you are sitting there making sure that everything is okay

Example 1: Open Loop
With perturbation



Controller gain = 1

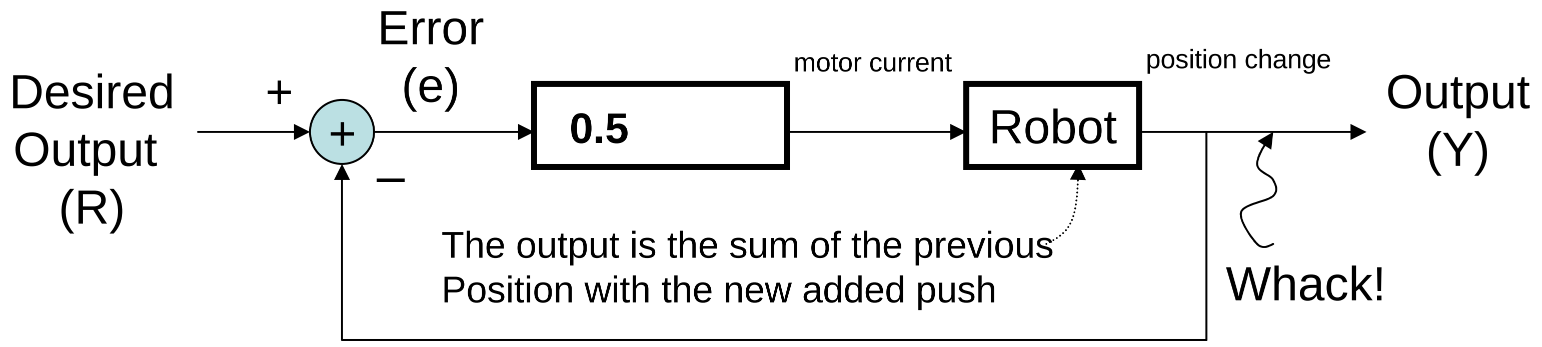
At t = 0, R = 1, Perturbation = 2

e = 1, e * gain = 1, Y = 1+2=3, and stays there

If you can predict the perturbation every time, then change the output.
But the perturbation, by definition, changes suddenly, and thus this system must be observed by someone at all time (or put the robot in an environment that nothing happens to it).

This is not too good…

Example 2: Closed Loop with proportional controller



Initial condition: R = 0, Y = 0, e = 0

Controller gain = 0.5

At t = 0, R = 1

Add perturbation = 2

e = 1, e * gain = 0.5, Y = 0.5+2=2.5

Next time step: e = -1.5, e * gain = -0.75, Y = -.75+2.5 = 1.75

Next time step: e = -.75, e * gain = -.375, Y = 1.375

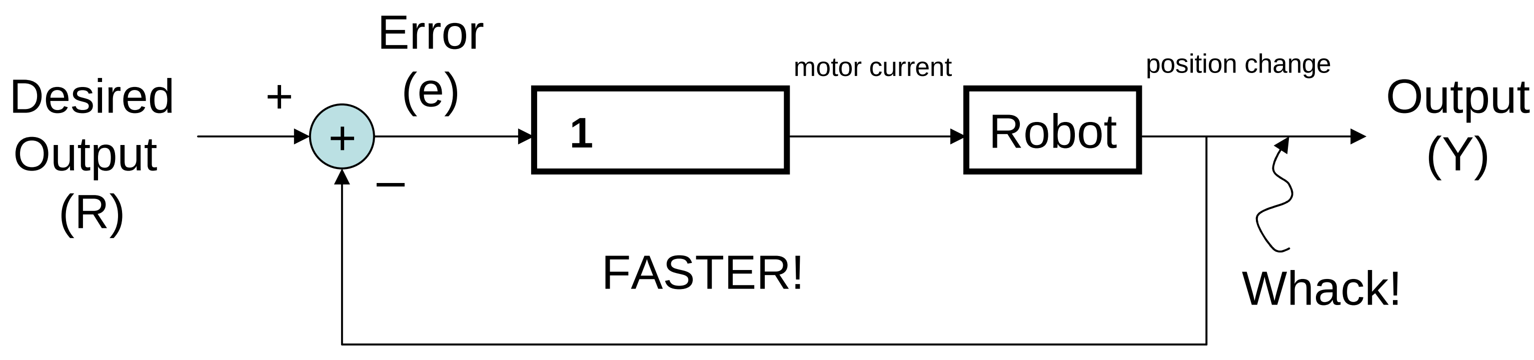
Next time step: e = -.375, e * gain = -.1875, Y = 1.1875, and so on

Gets closer and closer to 1 over time.

… so it gets closer to the desired output over time
Even with unknown perturbation to the robot

But it is slow at reaching the desired output with gain = 0.5. Let's make it faster.

Example 2: Closed Loop with proportional controller



Initial condition: R = 0, Y = 0, e = 0
Controller gain = 1

e = 1, e * gain = 1, Y = 1+2=3

Next time step: e = -2, e * gain = -2, Y = -2(+3) = 1!

Next time step: e = 0, e * gain = 0, Y = 0(+1)=1. and stays there.

At t = 0, R = 1

Great!

Add perturbation = 2

But there are other common problems with proportional controllers and
We will talk about them next time.