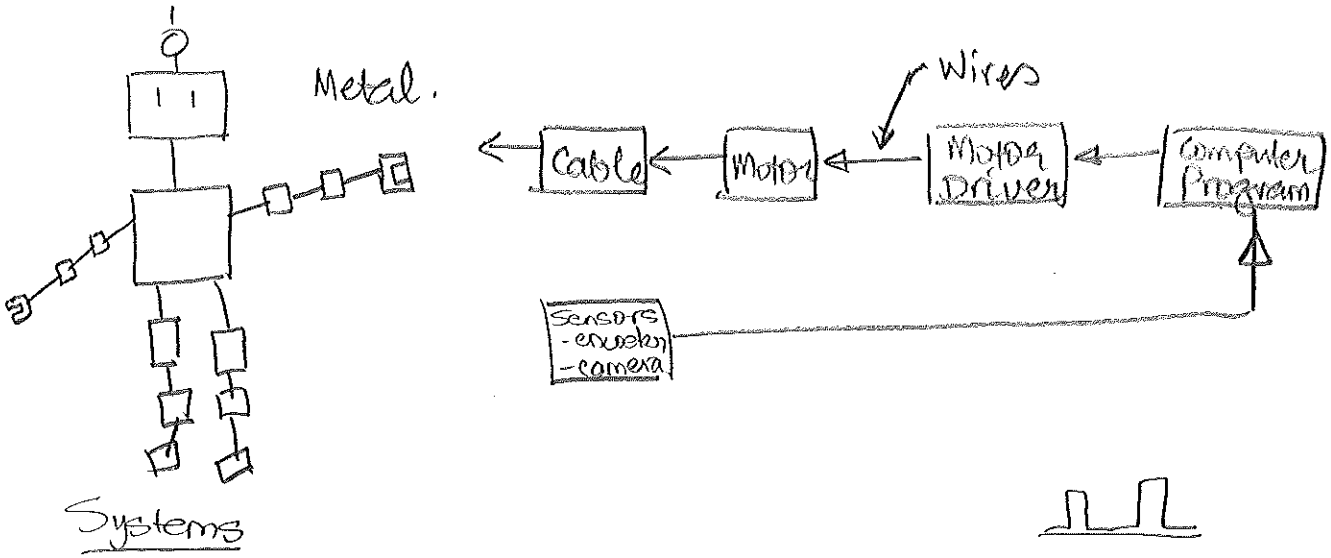
Lecture 1



Systems

Cable - moves joints by displacement

Motor - Spins (rotary) w/ elec. signal (PWM)

Larger motors require more current

" " produce more force.

Motor driver - converts high-level commands to motor signals (amp, PWM)

Sensors - measure pressure, angle change, etc

Computer program - Computes motor output

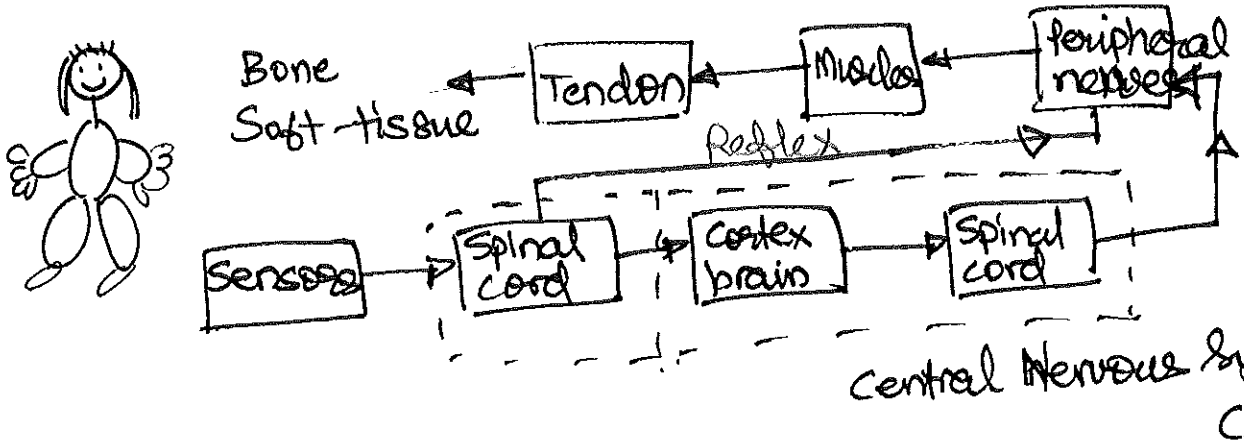
- forward kinematics: computes movement from robot inputs (motor/force)
- inverse kinematics: process motor commands/robot internal from desired task (position of end-effector coordinates)
- process error signals to correct error.

Robotic control

Open-loop control - many industrial robots
- cheaper, faster
- requires tedious programming, frequent calibration

Closed loop Control - used to calculate error (actual - desired)
- control signal = error correction signal
- But, introduce instability if not done properly
- Variety of strategies (PD, PID, etc.)
- Useful to overcome internal mechanical instability (inertia) (vibration), (gravity)
- instability due to environment
- Requires a model of robot & environment

Robot Vs Human



Systems

Tendon - moves the attached point 

Muscle - contracts (shortens) w/ electrical input signal to tug on tendons.

Peripheral nerves - conduct electrical signals (outside of CNS)

2 Divisions: Somatic : innervate skin, muscles.

Autonomic : controls guts, glands.

Spinal cord : conducts elec. signals to muscles from brain

- " from sensors to the brain
- in charge of reflexes (hardwired)
- neural delays are signals. So reflexes are important:

Brain :- computes motor output (motor cortex)

- computes " " from desired task (premotor areas)
  ↓ (position, force, velocity)
- " desired ?? from higher-level information
- processes sensory signals to computer higher-level info (sensory cortex)
- Uses error signal to correct motor output (cerebellum)
- Controls mechanical components } everywhere
- Adapt to the environment, task, etc. }

Control loops : Open loop (no sensors), closed loop (well-damped sys. but tremor is a disease)

- Similarities w/ robot system?
- Difference " " " ?
- Protection mechanism : } reflexes
  + compensation for large } neural delays

In this class: (1) Muscle physiology. { How does it work? What's the control signal like? What's its response?

(2) Tendon muscle behavior: multiple muscles + tendons per joint

(3) Sensory feedback: What are the signals? How are they integrated for spinal reflex, cortical control?

Brain is divided into many areas w/ varied functions

- Learn nervous system anatomy.
- Lesion studies / structural studies.

Movement Control Studies

- Crazy to do inverse dynamics for 400+ muscles
- So how are movements controlled?
- What is "desired" traj, pos, force?
- What is optimized during control? (cost?)
- What coordinate system does the brain use? (intrinsic, extrinsic)
- What are motor illusions? What role does it play in control?
- How do we adapt to create new movements? (Tennis, lifting empty milk carton)
  - long term short term.
- What is the adaptation structure?

Interaction w/ external Systems

- Link a limb to a robotic system
- What's its influence on control + adaptation?
- Can we predict how to influence motor control + adaptation for a given lesion?