ME7752: Mechanics and Control of Robots

Lecture 1

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(PDF posted. In the PDF, if there are no links to videos, do a google video search)

What movie(s) does this story remind you of?

"... a factory builds robots, meant to relieve humans of the drudgery of work.

The robots are built in great numbers and with increasing intelligence.

Soon, the robots are used as soldiers in wars.

Eventually, a robot revolt wipes out the human race!"

Story quoted from the book Robo sapiens (2000)

When was this story written?

"Rossum's Universal Robots"
a czech play by Karel Čapek, 1920!

"... a factory builds robots, meant to relieve humans of the drudgery of work.

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First use of the word "robot"

Robotics

- Kinematics (How to describe the possible motions of objects = geometry)
- Dynamics (How to compute motion of objects given forces on the objects)
- Control (How to move objects in a desired manner under different environments)
- Sensing (Forces, Position, etc) incl. Computer Vision ...
- Artificial Intelligence (Similar to control, but can involve more high-level stuff, like cognition and learning)
- Electronics, Micro-controllers, and Computers
- Actual building expertise, Mechanical Engineering, ...
- etc

This course ...

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Student presentations ...?

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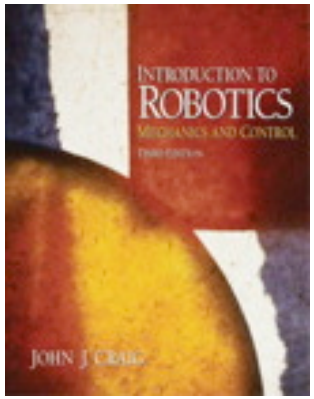
Text chapters

Introduction to robotics: Mechanics and Control Third Edition, John J. Craig



1. Introduction
2. Spatial descriptions and transformations
3. Manipulator kinematics
4. Inverse manipulator kinematics
5. Jacobians: velocities and static forces
6. Manipulator dynamics
7. Trajectory generation
8. Manipulator-mechanism design

Mechanics and Math

9. Linear control of manipulators
10. Nonlinear control of manipulators
11. Force control of manipulators

Control theory

12. Robot programming languages and systems
13. Off-line programming systems

Computers

departments involved ...

Electrical Engineering

Mechanical Engineering

Computer Science

Mathematics?

Biology
(biomimetic robots, etc)

Material Science
(smart materials, etc)

Let's consider an analogy

How do you pick up a piece of fruit?

How do you write on a piece of paper?

What parts of your body are involved?

Parts of the human body relevant to moving and manipulating its environment

Actuators

Muscles

Sensors

Touch, Vision,
Hearing, Force sensing,
position sensing, etc
(sensory neurons)

Mechanisms

Arms, legs, fingers, etc.

Computers

Brain, spinal cord,
nervous system

(energy systems, circulation, breathing, etc, etc)

Robot components

Actuators

(Motors, pneumatic, hydraulic, smart materials, etc)

Sensors

(for force, angles, position, orientation, etc)

Mechanisms

(links, joints, gears, cam, etc)

Computers

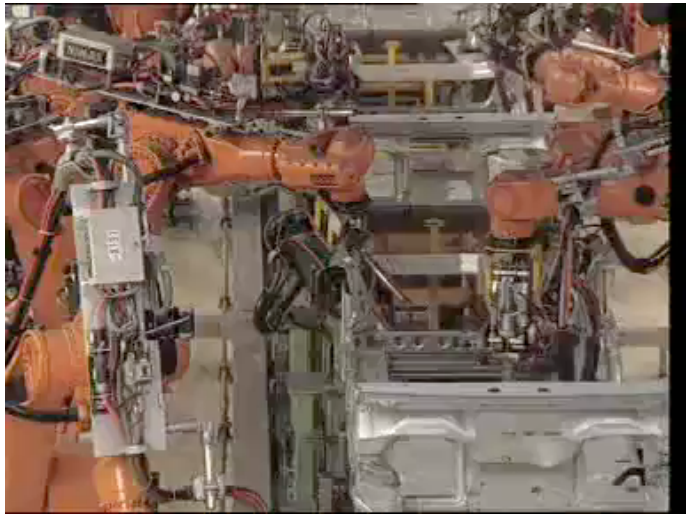
(various micro-controllers, chips ...)

Some robot examples

Industrial robots

(for manufacturing, etc)

http://www.youtube.com/watch?v=v5eR0eHknZk



Kuka Industrial Robots
Car assembly -
spot welding ...
http://www.youtube.com/watch?v=1-J_EzKm_70

Adept
Technology, Inc.
SCARA robot.

Fluid Research
Corporation.
Gantry robot
for dome labeling

http://www.fluidresearch.com/movies/dome_label.wmv

Robot surgeon

da Vinci Surgical System
Intuitive Surgical Inc.

http://www.intuitivesurgical.com/corporate/newsroom/videos/index.aspx

Robot semantics

Should the da Vinci surgical system be called a robot?

(How is it qualitatively different from a car?)

So we may be vague about what qualifies for a robot

Prosthetic devices

Prosthetic arms / legs ...

Hugh Herr
MIT Biomechatronics Lab
http://biomech.media.mit.edu/index.html

Steve Collins
CMU Biomechatronics Lab

Exoskeletons

Berkeley Bionics

Cleaning robots

iRobot®

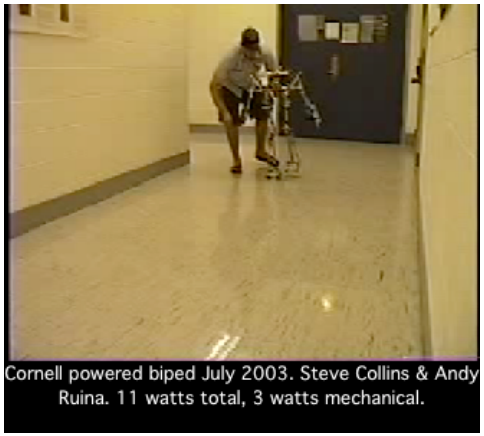
iRobot roomba demo

http://www.youtube.com/watch?v=LQ-jv8g1YVI

Miscellaneous legged robots

Cornell biped

http://ruina.tam.cornell.edu/research/topics/robots/



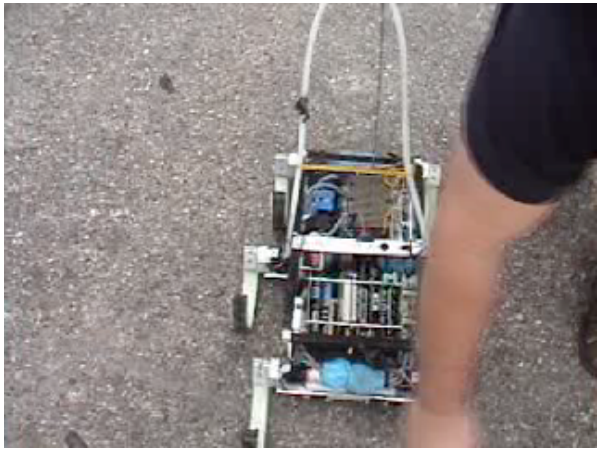
Cornell powered biped July 2003. Steve Collins & Andy Ruina. 11 watts total, 3 watts mechanical.

Big Dog (by Boston Dynamics)

http://www.youtube.com/watch?v=W1czBcnX1Ww

Honda Asimo

RHex
Upenn
UMich
McGill
BD
etc



http://www.youtube.com/watch?v=wIuRVr8z_WE

More recent developments

DARPA robotics challenge.
VRC
and the Atlas robots.

http://www.theroboticschallenge.org

Recent developments

- the President's National Robotics Initiative
    - a collaboration between NASA, National Institutes of Health, United States Department of Agriculture, Department of Defense.
    - to support research in new robotics research, especially aimed at creating robots that will work in concert with humans: "co-robots", "soft robots"

Recent developments

A revitalization of home-made robotics
and do-it-yourself (DIY) projects

Make magazine

Other robotics clubs, etc.

Other applications ...

Self-driving cars
Flying & swimming robots, etc

(We might do a robot video of the week)

Robot toys (incl. robot kits)
Search and rescue,
Military robots, etc ...

CBS - Late Show, David Letterman
http://www.youtube.com/watch?v=9oUWCLBKK3E

The end