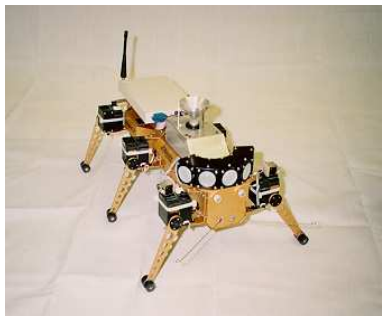
CS494/594:
Autonomous Mobile Robots

Fall 2008
Tuesday/Thursday 5:05-6:20 PM

Instructor: Dr. Lynne E. Parker

TAs (1/4-time each):
Yifan Tang
Yu ("Tony") Zhang



Note from Dr. Parker

Hi Future Roboticists!

Sorry I can't be with you today. I'm helping teach a week of summer school in a castle in Germany this week on the topic: "Monitoring and Coordination Across Networked Autonomous Entities" (see http://gkmm.de/summerschool/).

So, you get a short day in class today! I'll be back with you on Tuesday.

Cheers,
--Lynne Parker (parker@eecs.utk.edu)

Outline

- Overview syllabus and class policies
- Introduction to class
- Overview of assignment #1: Introduction to robotic simulator

Overview of Syllabus and Class Policies

(See handout)

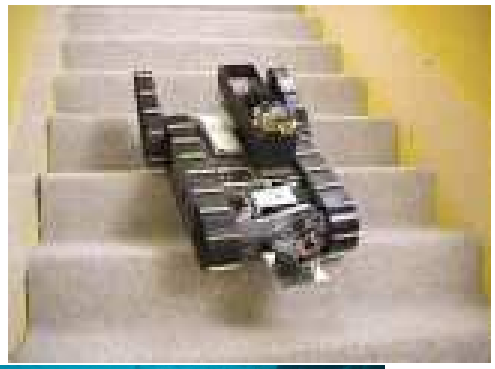
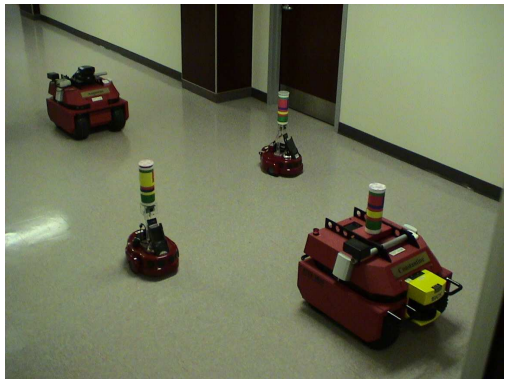
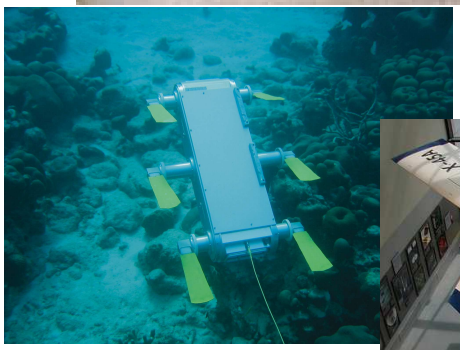
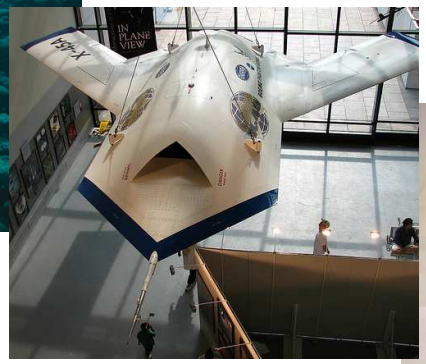
What is a Robot?

- Notion derives from 2 strands of thought:
  - Humanoids -- human-like
  - Automata -- self-moving things
- "Robot" -- derives from Czech word *robota*
  - "*Robota*" : forced work or compulsory service
- Term coined by Czech playright Karel Capek
  - 1921 play "R.U.R" (Rossum's Universal Robots")
- Current notion of robot:
  - Programmable
  - Mechanically capable
  - Flexible
- Our working definition of *robot:* physical agent that generates "intelligent" connection between perception and action

We'll be studying *mobile* robots

- What is a "mobile" robot?
  - One whose entire body moves with respect to the environment

- Examples of *mobile* robots:

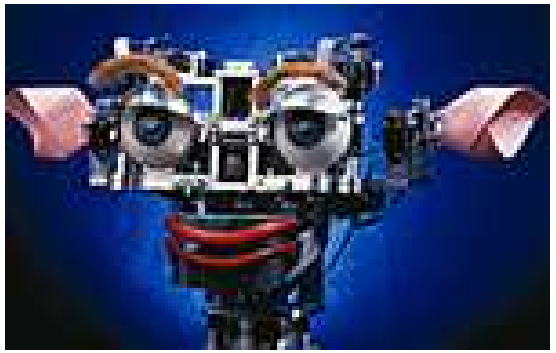

- Examples of *non-mobile* robots:


Strengths: What are mobile robots good at?

- Providing specialized access – hazardous environments (no air, etc.), distance/time (Mars)
- Reducing operating costs – lower overhead, reduced maintenance costs (gentler treatment of the machinery)
- Increasing productivity – “permanent” availability, more hours, higher throughput
- Improved product quality – accuracy, consistency
- Inventing new human services! – human interactivity

State of Robotics Applications

- Moving from manufacturing, industrial manipulators to:
  - Entertainment robotics
  - Personal service robots
  - Medical robots
  - Industrial applications beyond factory (e.g., mining, agriculture)
  - Hazardous applications (e.g., military, toxic cleanup, space)
  - And others…



Purpose: What Could Mobile Robots Do? (i.e., applications)

- Space (Robonaut, Sojourner, Opportunity, Spirit, etc.)

- Cleaning (Roomba)

- Agriculture (Demeter harvesting robot)

Purpose: What Could Mobile Robots Do? (i.e., applications) (con't.)

- Medical service

- Mining/excavation (Groundhog robot)

- Entertainment robots

Purpose: What Could Mobile Robots Do? (i.e., applications) (con't.)

- Security (MDARS interior robot)

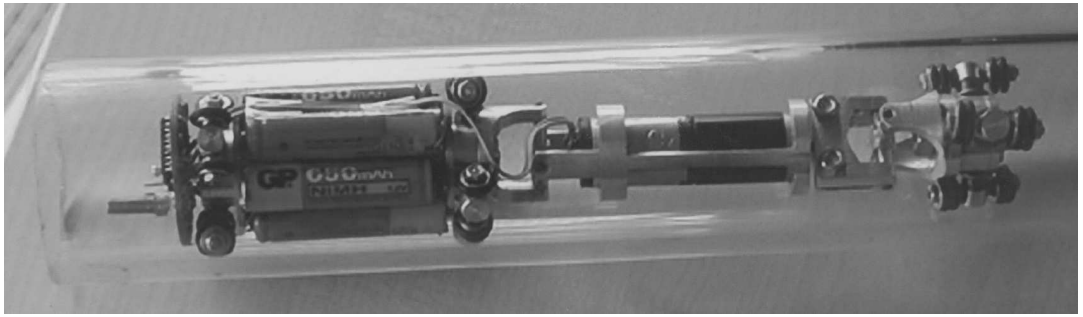
- Distance driving (Stanley)

- Military (Packbot)

Purpose: What Could Mobile Robots Do? (i.e., applications) (con't.)

- Handicapped Aides (Japan's WL-16RIII)

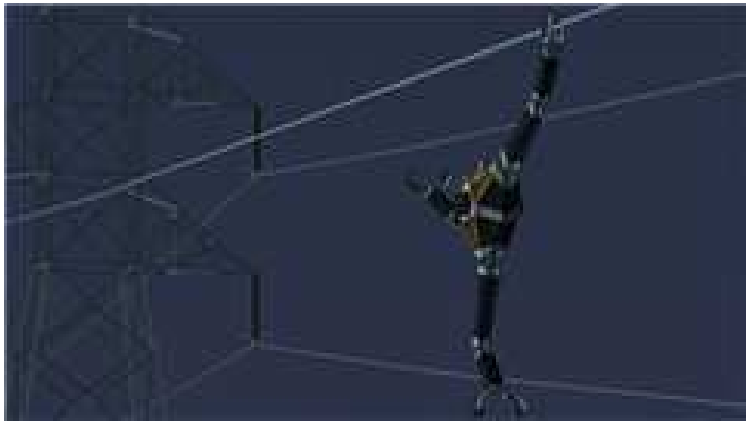
- Undersea (Oberon)



- Pipe inspection

Purpose: What Could Mobile Robots Do? (i.e., applications) (con't.)

- Lawn Care (Cyber Blue)



- Power Line Inspection (WireMonkey)

And many, many more applications!

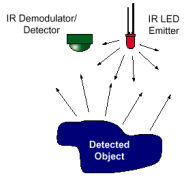
Example Robot Systems

(Movies)

- Hexapod1.mpg
- 3-robot-deploy-fast-clipped.wmv
- SwarmBot-followTheLeader.mpg
- OmniTread_UMich_Borenstein.wmv
- asimo2.mpg

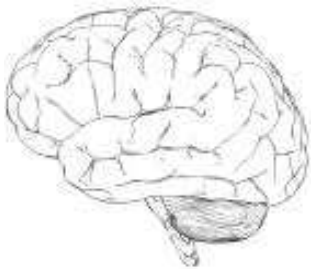
What is in a Robot?

- Sensors



- Effectors and actuators (i.e., mechanical)
  - Used for locomotion and manipulation

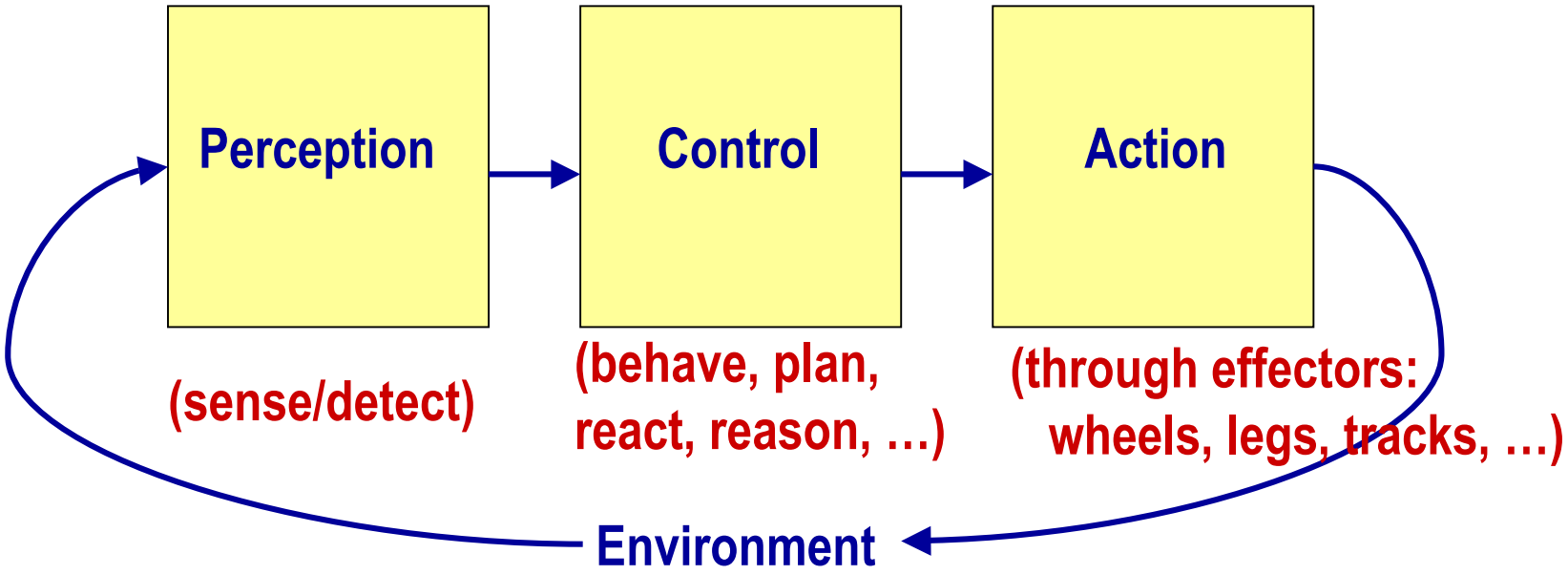
- Controllers for the above systems
  - Coordinating information from sensors with commands for the robot's actuators



- Power

- Robot = an **autonomous** system which exists in the **physical world**, can **sense** its environment and can **act** on it to achieve some goals

What are Basic Robot Software Issues?



- How do you perceive?
- How do you control?
- How to you generate action?

Challenges

- Perception
  - Limited, noisy sensors
- Actuation
  - Limited capabilities of robot effectors
- Thinking
  - Time consuming in large state spaces
- Environments
  - Dynamic, impose fast reaction times

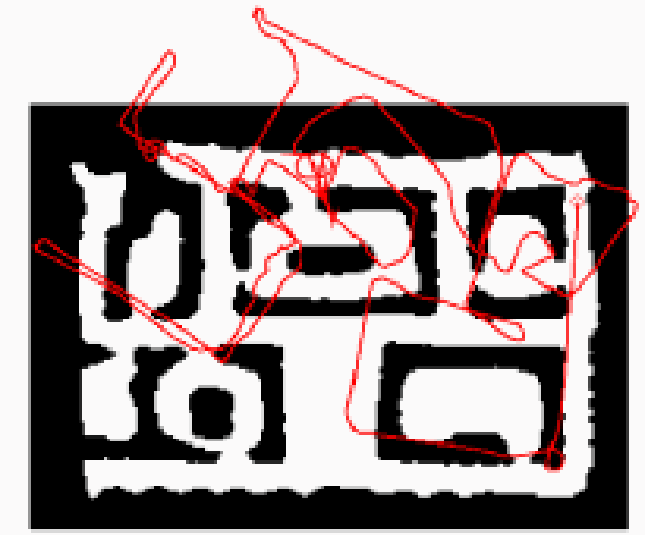
Uncertainty

- Uncertainty is a key property of existence in the physical world
- Environment is stochastic and unpredictable
- Physical sensors provide limited, noisy, and inaccurate information
- Physical effectors produce limited, noisy, and inaccurate action
- Models are simplified and inaccurate

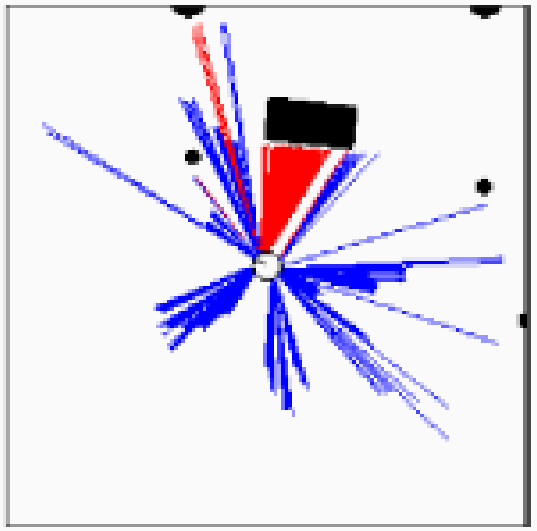
Uncertainty (cont.)

- A robot cannot accurately know the answers to the following:
  - Where am I?
  - Where are my body parts, are they working, what are they doing?
  - What did I just do?
  - What will happen if I do X?
  - Who/what are you, where are you, what are you doing, etc.?...

Example:



Odometry Data



Range Data

(pictures from Thrun, CMU)

This semester, we'll study various aspects of mobile robotics

Topics we'll cover:

- Robot control architectures
- Locomotion
- Representation issues
- Sensing/perception
- Adaptation
- Path planning
- Navigation
- Localization
- Mapping
- Multi-robot systems

Assignment #1: Getting familiar with Player/Stage Simulator

- The Player-Stage-Gazebo simulator (playerstage.sourceforge.net)
  - **Player** is a general purpose language-independent network server for robot control
  - **Stage** is a Player-compatible high-fidelity indoor multi-robot simulation testbed
  - **Gazebo** is a Player-compatible high-fidelity 3D outdoor simulation testbed with dynamics
  - **Player/Stage/Gazebo** allows for direct porting to Player-compatible physical robots.

- For high-level intro, read: "Most Valuable Player: A Robot Device Server for Distributed Control", by Gerkey et al, 2001.

Movie examples of Player/Stage

- Deploy_100_far.avi
- idn_interceptor1.mpg

See you Tuesday!

- Dr. Parker will be back

- We'll begin with Chapter 1 of text next time (i.e., Read Chapter 1!!), along with some other introductory material