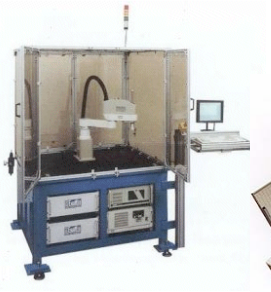
Lecture 1:
Introduction to the Course

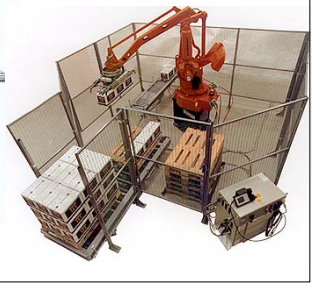
CS 344R: Robotics
CS 393R: Autonomous Robots
Benjamin Kuipers

CS 344R: Robotics
CS 393R: Autonomous Robots

- Professor Benjamin Kuipers
  - 471-9561, kuipers@cs.utexas.edu
  - Office hours: TTh 10:00 - 11:00, CSA 1.120A
- TA: Jeremy Stober (jstober@cs.utexas.edu)
  - Office hours: TBD, ENS 19N
- Robot lab: ENS 19N
- Wiki: http://z.cs.utexas.edu/wiki/cs344r.wiki

Are these robots?



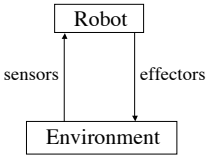


Are these robots?

Are these robots?

What is a robot?

- A robot is an intelligent system that interacts with the physical environment through sensors and effectors.
  - Program module?
  - Web crawling 'bot?



Is a human a robot?

- By our definition, yes.
  - Humans interact with a complex physical environment via sensors and effectors.
  - We are not artificially manufactured, of course!
- Does this diminish humans? No!
  - Understanding the difficulties of robotics helps us appreciate how amazing humans are.

Robbie

- from *Forbidden Planet*, 1956.

We will study robots that …

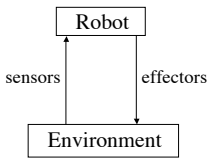
- … function in (mostly) unmodified human environments.
  - (Well, in soccer fields, anyway.)
- … that use, and perhaps even learn, useful *models* of the environment.
  - They have *knowledge*, and act on it.

What makes a good model of the environment?

- A good model is a *simplified* description of the environment such that …
  - If the robot orients itself in the *model*,
  - and makes a plan using the *model*,
  - and executes that plan in the *real environment*,
  - then the plan has its intended effect.

What will we do in this course?

- Our goal is to learn some methods for implementing this interactive loop.
- We will spend a few weeks each on topics that often get entire graduate courses.



Subject Material Areas

- Artificial Intelligence
- Computer Vision
- Control Theory
- Bayesian Probability Theory
- Mechanical Engineering
- Cognitive and Developmental Psychology

Major Topics and Projects

- What is robotics?
- Control laws
- Behavior architectures
- Observers and tracking
- Local metrical mapping
- Topological mapping
- Social implications

- "Hello, World!" (9/16)
- Motor control (10/7)
- Learning skill (10/28)
- Metrical maps (11/13)
- Localization (12/2)

- Grad student projects

Control Laws and Behaviors

- Rules for behaving in a qualitatively uniform environment.
  - Following walls, seeking open space or targets.
- Rich theory based on differential equations and dynamical systems.
- Reality outside the model is treated as noise.
- Compose multiple control laws to make behaviors.
- Task: Approach and kick a ball to a target.
  - Learn to do it more accurately.

Observers

- Sensors don't sense the world directly.
  - They just respond to its stimulation.
- By gathering lots of sensor input over time, we can estimate what the world is like.
- Assumes models of the nature of the world, and of sensor properties, such as error types.
- Task: Implement Kalman Filters to track and block a rolling ball.

Local Metrical Mapping

- A map of the local environment is useful for local motion planning.
- Range sensors give distance to obstacles.
  - Laser rangefinder is more accurate than sonar
- Combine sensor returns to find obstacles.
- Robot must localize itself.
- Tasks: Implement occupancy grid mapping.
  - Next: Implement localization and SLAM.

Topological Mapping and Planning

- Abstract local regions to "places".
- Abstract travel actions to "paths".
- Model the environment as a graph.
- Transforms action planning to graph search.
- Plans can be translated back to actions, and to control laws.

Social Implications

- Robots may change our world dramatically
  - How? For better? Or for worse?
- Science fiction writers have thought about a lot of important possibilities.
- We will watch and discuss relevant clips from movies and television shows.
  - Brief discussions. Few conclusions.
  - Questions are more important than answers.

Robot Lab Assignments

- There are five robot lab assignments.
  - Due about every three weeks.
  - (Once, it was six, due every two weeks!)
- You demonstrate the techniques taught in class.
  - "*In theory, there's no difference between theory and practice, but in practice, there is.*"

Robot Assignments 1, 2, 3

- Students will work in teams.
  - Each team has three people (10 teams).
  - A single grade for each team.
- Each team has one physical robot.
  - These are expensive, fragile, and *irreplaceable*!
  - Take care of them!

Robot Assignments 4, 5

- Students will work individually.
  - Each person gets their own grade.
- The "robot" is a recorded sensor trace.
  - A robot explores an area, using laser range-finder and measuring odometry.
- Build a map, given correct odometry.
  - Then do simultaneous localization and mapping.

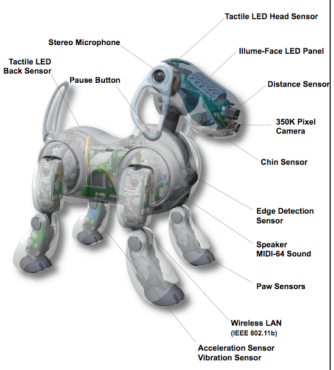
Previous robot: the Amigobot

- Sonar sensors: front (6), back (2)
- Camera
- Passive gripper
- Differential drive (right/left wheel)
- Odometry
- Wireless communication

Demo in the old Robot Lab

This year: the Sony AIBO

- Better sensors
- More degrees of freedom
- Onboard computing



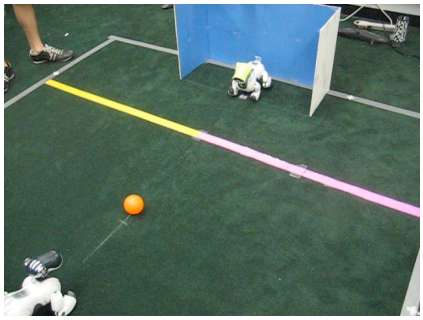
Entertainment Robot System 7

- Sony designed the AIBO as an entertainment robot, with sophisticated built-in behaviors.
  - We won't be using those.
  - You are welcome to explore them, but that's not part of the course.
- We are using the AIBO as a platform for implementing robotic capabilities.

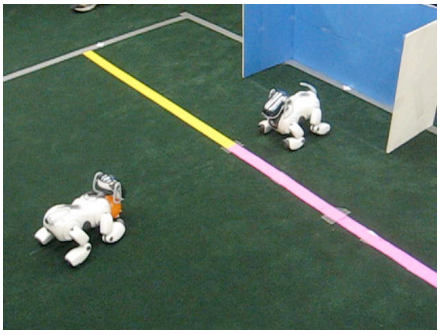
Technical Details

- CPU: 64 bit RISC
  - 64 mb RAM
- LAN: 802.11b
- Degrees of freedom:
  - Head: 3 dof
  - Mouth 1 dof
  - Legs: 3 dof x 4
  - Ears: 1 dof x 2
  - Tail: 2 dof
- Image input:
  - 350,000 pixel CMOS camera
- Stereo microphones
- Infrared distance x 2
- Acceleration
- Vibration
- Touch: head, back, chin, paw

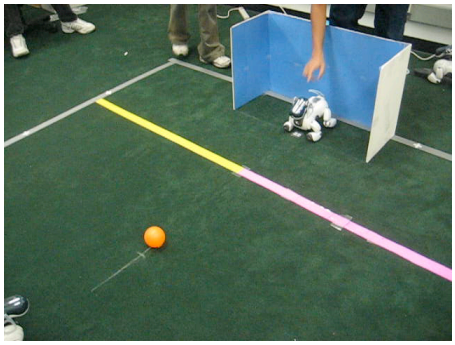
Shooting and Blocking



Shooting and Blocking



An Illegal Strategy



What Assignments Require

- The point of the assignments is to implement the methods taught in class.
- To turn in an assignment:
  - Demonstrate the behavior to Jeremy *before* the due date.
  - Each team hands in a clear, concise memo describing the problem, your approach, and your results.
    - Append the code.
  - The memo describes the role of each individual on the team in accomplishing this assignment.
- We will discuss each assignment in class on the due date.
  - Some teams will be selected to demonstrate the robots.
  - No assignments accepted after that class meeting.

Working in Teams

- One of the goals of this course is to give you experience at working in teams.
  - Robot assignments 1, 2, and 3.
- Your team can be stronger than any one individual, but it is also vulnerable.
- You are responsible for working effectively with your team
  - not just for doing your own job, but also
  - for helping the team work well together.

Term Projects (CS 393R only)

- Research one topic in greater depth.
- Select a topic (suggestions to be provided).
- Survey the related literature.
- Describe the alternate approaches
  - Discuss their strengths and weaknesses.
- *Design and justify* a project to advance the field.
  - A novel experiment to discriminate approaches
  - A novel approach (and experiment)
  - A toolkit to build on mature successful methods

Grading (344R/393R)

- Robot Assignments
  - Hello, World! (12/8%)
  - Motor control (12/8%)
  - Learning skill (12/8%)
  - Metrical maps (12/8%)
  - Localization (12/8%)
- **These are *never* accepted late!**
- Participation (10/10%)
- Exams (individual)
  - Mid-term 1 (15/15%) **October 14**
  - Mid-term 2 (15/15%) **November 25**
- Projects (0/20%)
  - CS 393R only
  - Proposal (9/30)
  - Literature (10/21)
  - Methods (11/6)
  - Research plan (12/4)

Grading (344R/393R)

	344R	**393R**
Assignments	12%	8%
	12%	8%
	12%	8%
	12%	8%
	12%	8%
Project		20%
Midterm exam 1	15%	15%
Midterm exam 2	15%	15%
Participation	10%	10%
Total	100%	100%

This class is a **lot** of work.

- Robotics includes many different concepts.
  - Control theory, logic, probability, search, etc.
- Abstraction barriers are very strong in most of Computer Science, but weak in Robotics.
  - Programs are vulnerable to sensor and motor glitches.
- Plan ahead, to put the time in to this course.
  - Your team will be depending on you.

Robotics

- The topic is fundamentally important scientifically and technologically.
  - Building intelligent agents
  - Modeling the phenomenon of mind
- It will be very demanding on all of us.
  - Be prepared, and start work early.
- It's also very exciting and lots of fun!