Lecture 1: 
Introduction to the Course

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

CS 344R: Robotics
CS 393R: Autonomous Robots

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• Wiki: http://z.cs.utexas.edu/wiki/cs344r.wiki

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.

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

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)

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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!