EGN 4060c: Introduction to Robotics

Lecture 1: Introduction

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Announcements

- **No lab this week!**
- **Reading** for week 1: Chapter 1 in Introduction to AI Robotics
- **Homework 1** (due Aug 27): Writeup on current robotics research (2 pages)
- **TA:** Astrid Jackson
- **Sukthankar office hours:** MW 10-11:30am HEC 232 (but please just send email if you experience problems)
- **Jackson office hours:** by appointment HEC 201

Course History

- Your feedback is important and welcome!
- Derived from a course at Carnegie Mellon
  - Mobile Robot Programming (Nourbakhsh)
- Course objectives:
  - Learn core principles of robotics
  - Hands-on programming experience
  - Future robotics research directions
- Less emphasis on:
  - Building robots from parts (we don't have the lab space and the equipment)
- This course was formerly listed as EGN3060C.

Prerequisites

- COP 3223 (C Language) or COP 3330 (Object Oriented Programming)
- EEL 3657 (Linear Control Systems) or EEL 4742C (Embedded Systems) or COP 3503C (Computer Science II) or EGN 3321 (Dynamics)
- Practically speaking:
  - Knowledge of programming (Java especially useful)
  - Linear algebra
  - Probability/statistics
  - Experience working as a team
  - A sense of adventure
- If you have questions about this, send email to gitars@eecs.ucf.edu.

Intelligent Robotic Systems

- This is a required course for this minor along with EEL 4660 Robotic Systems (to be offered Spring 2015)
- Programming language: COP 3223 or EGN 3211
- Select 4 courses from:
  - Computer Science (computer vision, AI, algorithms): CAP 4053, CAP 4453, CAP 4630, CAP5415, CAP 5512, CAP 5610, COP 3503C.
  - Electrical/Computer Engineering (control, machine learning, pattern recognition): EEL 3567, EEL 4612C, EEL 4750, EEL 4818H, EEL 4872, EEL 5669, EEL 5173, EEL 5513, EEL 5625, EEL 5630, EEL 5820, EEL 5825, EGN 3321
  - Mechanical Engineering (kinematics, dynamics, MEMS): EML 3217, EML 3262, EML 4225, EML 4312C, EML 4313, EML 4264, EML 4804C, EML 5311, EML 5290

Course Topics

- Robot Architectures
- Path Planning
- Reactive systems/Control
- Sensing/Computer Vision
- Machine Learning
- Localization and mapping
- Cooperative Robotics
- Human-Robot Interaction
- Manipulation
- Locomotion
- Future directions: humanoid robotics

What you will learn:
•What problems are hard/unsolved
•A cookbook of useful techniques that people have used to solve common robotics problems

Labs

- Completed in teams of 3 students
- iRobot Create
  - Qwerk controller (Linux system)
  - Logitech camera
  - TeRK: Telepresence Robot Kit
  - Java and the Eclipse IDE
- Laptop (**bring your own**)
- Each team needs one laptop

Webcourses

- Please update your email forwarding settings so we can use webcourses to contact you as needed.
- All lectures will be posted as pdfs and will form the major component of what appears on the exams.

Evaluation

- Homework/labs (50%)
  - Research overview
  - Scripting/odometry
  - Path planning
  - Line following (vision & control)
  - Reinforcement learning
- Midterm/final exam (30%)
  - Questions based on material covered in lectures
- Project (20%):
  - Develop a robotics application of your choice
  - Complete a demo video, presentation, and writeup describing your application

Example Lab Task

This is an example of the type of task you will be doing in lab:

https://www.youtube.com/watchv=Uqh3Co1YPgk&feature=youtu.be

Grading Policy

- Lab writeups will include:
  - individual questions related to the lecture
  - team questions describing the overall implementation.
  - A demo where you are graded on the robot's performance.
- One student should submit the team writeup and everyone should submit their own answers to individual questions.
- Writeup should be submitted in a timely fashion via webcourses by midnight on the due date.
- You are expected to abide by UCF's plagiarism and cheating policies.
- Any code sharing or code obtained from other sources **must** be documented appropriately.

Textbook

- R. Murphy, Introduction to AI Robotics
- Additional research papers
- Reading for week 1: Chapter 1: From Teleoperations to Autonomy
- Textbook is optional; all the material you are required to learn will be covered in the lectures.

Teams

- At the end of the week, you should self-organize into teams of 3 people that you will be working with for the whole semester.
- Learning to work in teams is important---and possibly the most valuable skill that you'll learn in this course.
- Take turns doing things, listen to each other, and don't make one person responsible for doing everything!
- Demos are performed by the team and every team member should be present to receive their grade.
- Each team needs one member with a laptop that can run and compile Java.
- **Tip:** it is useful to have one person who is a confident programmer on each team.

Lab Details

- New lab space in HEC 302.
- Current times
  - Tuesday 6-9pm
  - Thursday 6-9pm
  - Extra lab time: by appointment
- All labs involve programming in Java.
- Questions:
  - Is there anyone here who can't make one of those times?
  - Who is interested in attending a Java tutorial?

Introductions

- Introduce yourself:
  - Your name
  - Year, major, and minor
  - Favorite project that you have ever done for a course at UCF

Robots in the Media

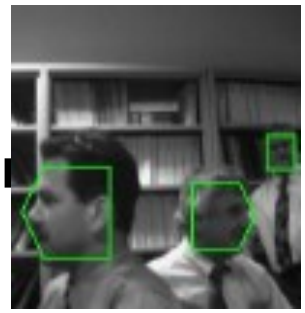
Background

- What is a robot?

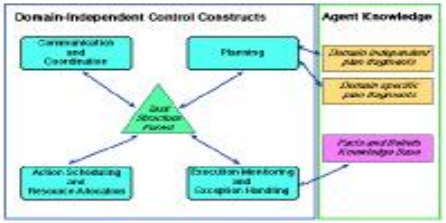
(or what did you think you would be learning about in this course)

Robotic Systems

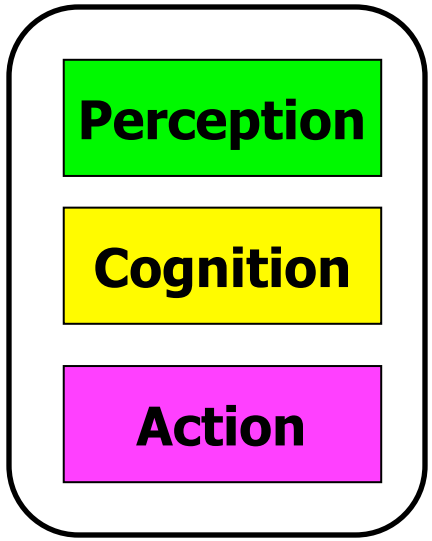
Camera
Sonar
Laser range-finder



Planning
Scheduling
Machine Learning



Manipulation
Locomotion
Navigation



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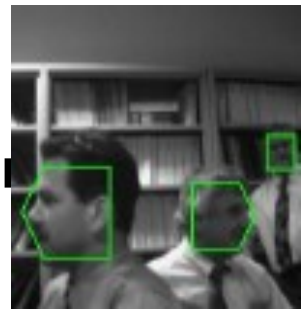

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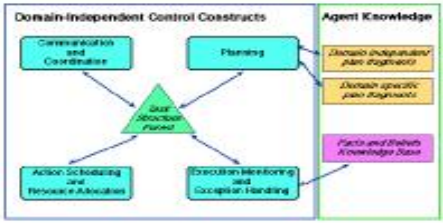

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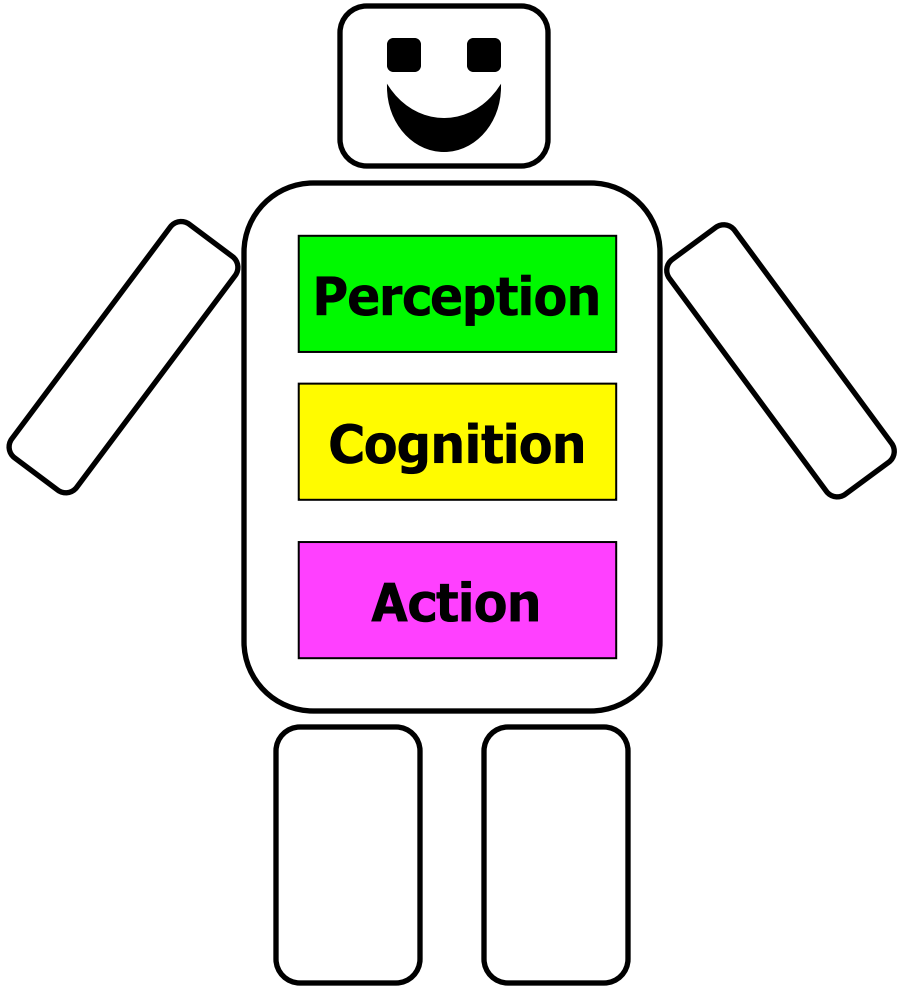


Background

- What is a robot?
  - Physically-embodied (rather than a software agent or a bot)
  - Autonomous
  - Empowered with higher-level decision-making capabilities
- But…
  - Most robotics research actually focuses on one aspect of the problem (e.g. vision or locomotion).
  - Robotics technology is useful for other problems like software agents, graphics, simulation systems, user interfaces.

Challenges

- What makes building a robot difficult?

Challenges

- What makes building a robot difficult?
  - Sensor noise
  - Dynamic environments
  - Real-time system issues
  - Material and power issues
  - Limited processing power and bandwidth
  - Reproducing and debugging errors
  - Integrating multiple subsystems
  - Robot breakage
  - Interfacing with humans
- KISS Principle: Keep it Simple, Stupid
- Strive for design simplicity and avoid unnecessary complexity

Homework 1: Robotics Research

- Due Aug 27th;
- More details will be discussed in class on Wed
- Writeup on current robotic research (1-2 pages) to be done as an individual writeup
- Find a research group on the web
- Read their web page, look at their videos, browse some of their papers.
- Describe their robot platform, what problem they are trying to solve, applications for the technology
- The assignment will be graded on research content, writing style, and references.
- You are allowed images/schematics as part of your writeup.
- Please cite all sources (including images) that you use.
- 6 pts (2 on research content, 2 on writing style, 2 on references)

Research

- What makes research different from other kinds of hardware/software development work?

Thoughts about Research

- Research: doing something new that no one has done before
- Important aspects of research are:
  - Novelty
  - Soundness
  - Verifiability
  - A product (paper, software, hardware) that communicates the ideas to the community
  - Solving some problem that someone has characterized
  - Research builds upon what came before.

Personal vs. Global

- Personal research: you experience a problem, you find a workable solution to your problem, and communicate it to others. Both the problem and the solution have been proposed by other people but are new to you.
- Global research: you propose a solution or a introduce a problem that is different in several ways from what has been solved or implemented before. The problem is sufficiently general such that it can be generalized to other problems that other people have experienced.
- The discovery process is largely the same, so being good at one helps at being good at the other.

What you are doing in this course counts as personal research.

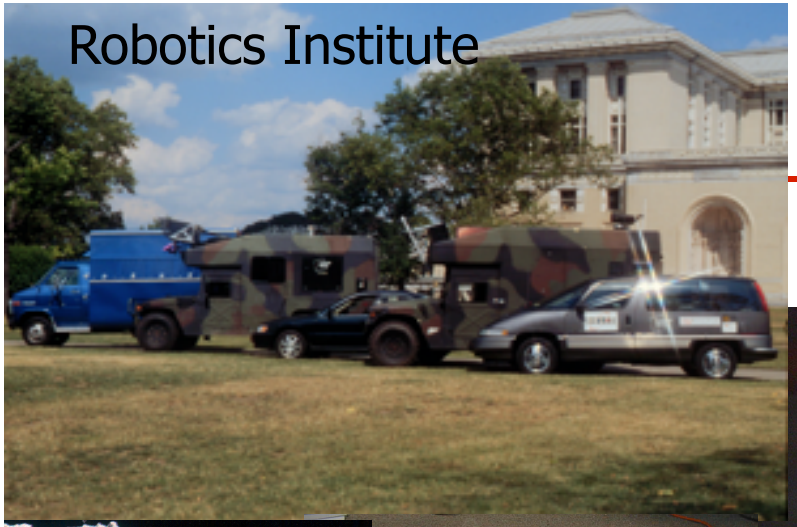
Research Assignment

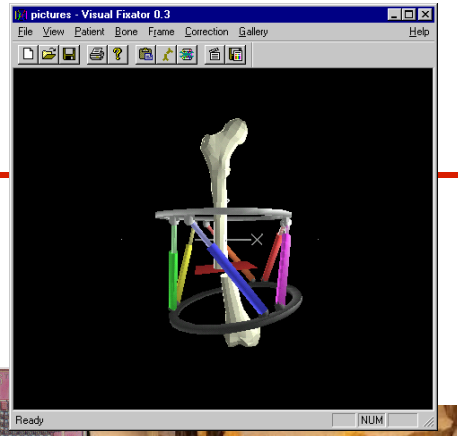
- Think about what the researchers were trying to solve
- Think about the technique they used to solve it
- What prototype or software implementation did they use to prove their point?
- How did they evaluate their results
- Does their solution generalize to other problems?
- Be prepared to discuss it in class next Wed

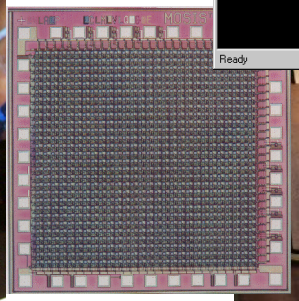
Applications

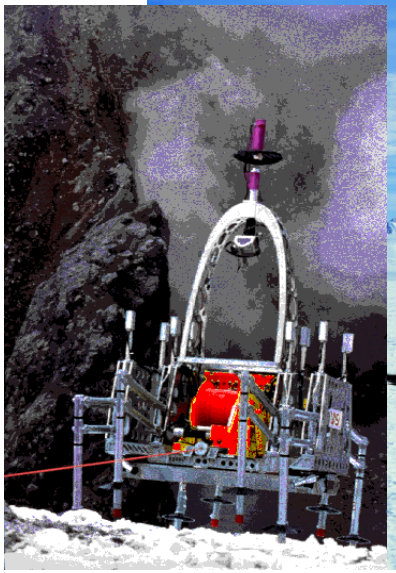
- What type of applications are robots used for?

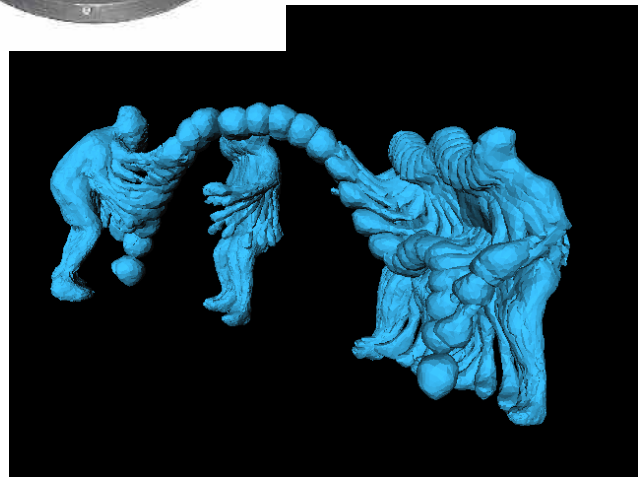
Robotics Institute











Application Areas

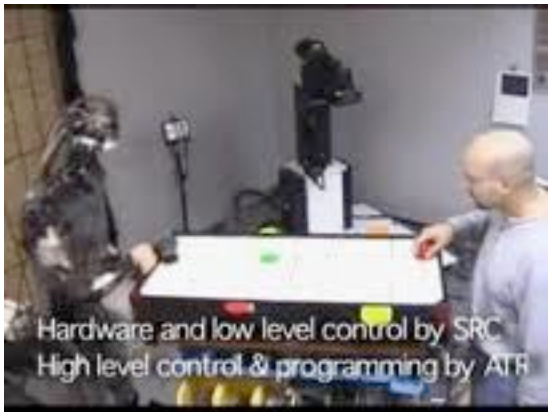
- Repetitive tasks
  - Manufacturing
  - Farming
- Hazardous environments
  - Space
  - Military
  - Urban search and rescue (USAR)
- Autonomous vehicles (cars, helicopters)
- Household tasks

Other Application Areas

- Games and simulations
  - Similar software, no hardware
- Humanoid animation
- Medical robotics
- Social/companion robotics
- Smart matter/swarm robotics/reconfigurable robots

Game-Playing Robots

- Robots have been taught how to play a variety of games
- Why would you want to teach a robot to play a game?
- (why do you play games?)



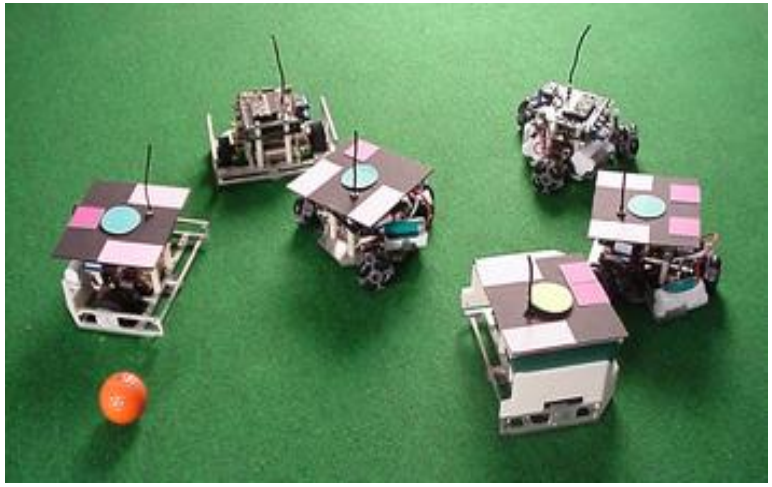
Game-Playing Robots

- Games allow us to teach a specific set of skills and form a simpler more contained world.
- There is a relatively simple evaluation/reward function in many games which facilitate skill acquisition.
- Games can be made to designed to emphasize different properties
- Ideas like the Serious Games Initiative have shown that people learn well doing games.

Tom Sawyer principle: the line between games and work is blurry

Robocup

- Goal: by year 2050 develop a team that can win against the human world soccer champion team
- 3000 researchers in 39 countries; 321+ teams over all the leagues



Robotics: Now

Soft-object manipulation: Berkeley towel folding demo on Willow Garage PR2 platform

Robotics: Now

https://www.youtube.com/watch?v=-KxjVlaLBmk

Ishikawa Komuro Lab: High-Speed Robot Hand (Dynamic Grasping)

Robotics: Now

https://www.youtube.com/watch?v=2Gp3E7IwLRQ

Better cheap sensors: the Kinect enables cheaper depth sensing

Robotics: Now

https://www.youtube.com/watch?v=cNZPRsrwumQ

Big Dog (Boston Dynamics): rugged terrain legged locomotion

Robotics: Now

https://www.youtube.com/watch?v=MOEjL8JDvd0

Better cheap sensors: the Kinect enables cheap reliable depth sensing

Robotics: Now

https://www.youtube.com/watch?v=Sbwq5GEvB9M

The rise of the quadcopter: multi-robot coordination

Robotics: Now

https://www.youtube.com/watch?v=cdgQpa1pUUE

Self-driving cars come out of the research lab: Google car

Robotics: Now

https://www.youtube.com/watch?v=WijMCSfX0RA

Clone robots: Hiroshi Ishiguro's lab Geminoid robotic telepresence

Conclusion

- Robots come in a variety of shapes and sizes besides the traditional humanoid and mobile robot form factors.
- Summer REU projects along with the EXCEL program can be a great way to get involved with research.
- http://www.nsf.gov/crssprgm/reu/list_result.cfm?unitid=5049