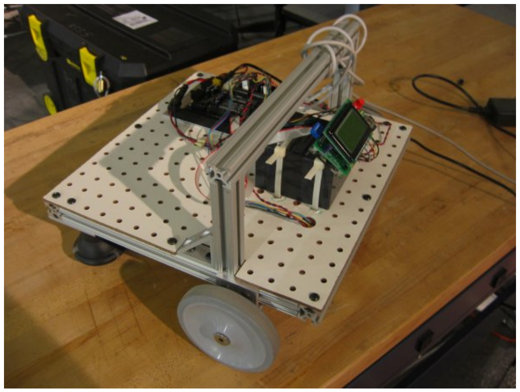
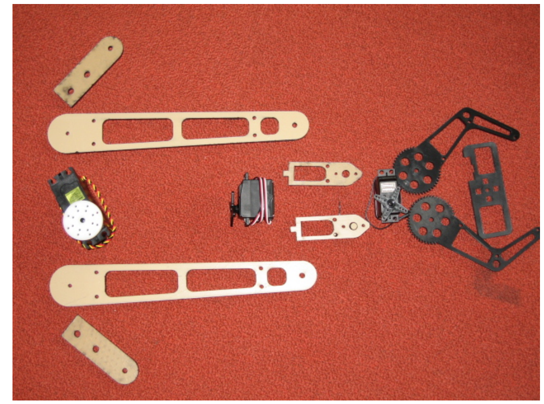
6.141J / 16.405J: Robotics Science and Systems Spring 2011



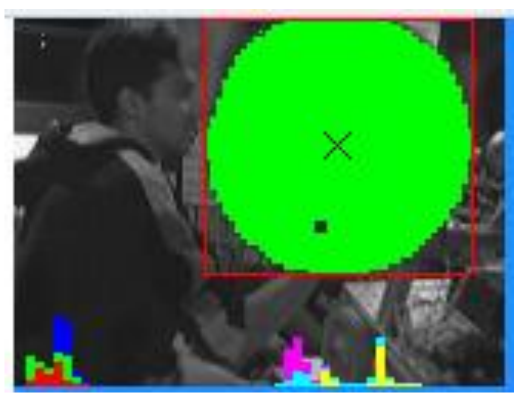


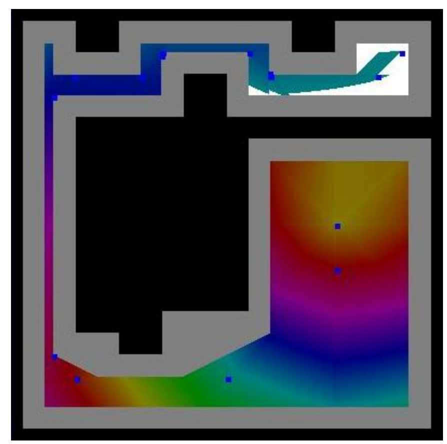
L1: Introduction

Wed 2 Feb 2011

Prof. Daniela Rus

EECS / CSAIL / MIT





http://courses.csail.mit.edu/6.141/

Today

- Introductions of course staff
- Goals and structure of the class
- Administrative items
- Technical

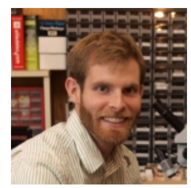
RSS Staff

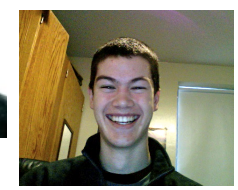
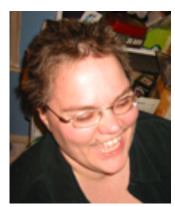
- Instructors
  - Prof. Nick Roy (Aero/Astro)
  - Prof. Daniela Rus (EECS)
  - Prof. Seth Teller* (EECS)
  - Dr Cagdas Onal (EECS)
- CI-M Lecturers
  - Ms. Mary Caulfield
  - Ms. Jane Connor
- TA & LAs
  - TA Kenny Donahue (EECS)
  - TA Kyle Gilpin
  - LA Clark Davenport
  - LA Zeke Flaton (EECS)
- Class assistant & webmaster
  - Ms. Bryt Bradley (CSAIL)
  - Ms. Kathy Bates








* On sabbatical

Goals of RSS

- Intensive introduction to theory and practice
  – Hands-on application of fundamental ideas
- Experience with inherently interdisciplinary area
  – EE, CS, MechE, Aero/Astro: sensing, estimation, control, system architecture, implementation, validation…
- Communication
  – Verbal briefings; written reports; static & live graphics
  – Individual and team opportunities to communicate
  – Tackle real issues arising in team-based engineering
- Design and implementation challenge
  – Explore an area, collect raw materials, build structure

What will you learn?

- What are robots, what is the science and technology behind building robots and programming them ?
- Why is robotics hard ?
- Hands-on experience building a robot of your own

Syllabus for RSS

- Theory in lecture; practice in lab (in small teams)
  - Also demos and short “labtures” for each lab module
- Foundational material (weeks 1-9):
  - robot architectures, motor control, sensing and machine vision, navigation, motion planning, kinematics, grasping and manipulation
  - Complex system design, development and test
- Debates (weeks 11-12):
  - Students, in small teams, debate ethical issues in class
- Course challenge (weeks 1, 3, 7, 9, 10-14):
  - Introduced first day of class, revisited throughout term
  - Individual and team written design proposals
  - Design reviews (including dry runs) with course staff
  - Five weeks of team-based work, with regular checkpoints

Course Challenge

- Build a Shelter on Mars
  - Explore region, given uncertain prior map
  - Gather prefabricated materials dropped from orbit
  - Transport materials to a selected building site
  - Assemble them into a wall or structure
- Eight teams, four students per team
- Challenge described in more detail on the web and will be presented in class and lab
- Warm-up for Fall subject (6.142, RSS II), NASA Grand Challenge, other future efforts

Communication Aspects of RSS

- CI-M lectures typically on Fridays at 1pm

- Lab team wiki (brief answers, plots, videos etc.)
- Lab team briefings (to course staff)
- Lab checkpoints (in lab, rolling basis)
- Written challenge design document (individual)
- Written challenge design (team), revision
- Challenge design review (to staff), with dry runs
- Debates (in pair teams, with class)
- Challenge overview presentations (in lab, to class)
- Reflective report (individual, at end of term)

Requirements Satisfied by RSS

- Institute Lab
- 12-unit subject worth 12 EECS EDPs
- CI-M subject in EECS
- Can be petitioned for use in lieu of 6.UAP
- Department Lab in EECS (6-1, 6-2, and 6-3)
- Aero/Astro students can petition to use it as a PAS

Required Work

- Weekly
  - Lab assignments given in lab
  - Lab reports (oral and one written) by beginning of specified lab period
  - First lab today
- Debate participation
- End of term paper (due last day of classes)
- Team Project with Challenge Run and project presentation

Grading

• Lab quality, wikis, and briefings	35%
• Team challenge design and proposal	10%
• Challenge implementation	30%
• Debate performance	10%
• Participation in lecture and lab	5%
• Initial ideas and reflective report	10%

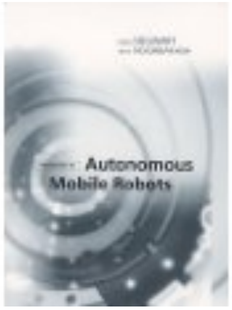
Team behavior, cooperation (qualitative factors)

Intermediate grade summaries Week 5, Week 10

Schedule

- Lecture **MWF 1-2p** in 32-155
  - Lectures start promptly at 105pm, end at 155pm
- Lab **MW 3-5pm**
  - 38-630
  - First lab is **this afternoon**
- Students expected to attend all lectures and labs
  - Very occasional absence OK; email staff beforehand
- Challenge Friday **May 6th**
  - Scheduled **3-5pm**; historically longer than 5pm

Text and Other Resources



- Textbook: Siegwart and Nourbakhsh,
  Introduction to Autonomous Mobile Robots (Intelligent Robotics and Autonomous Agents)
- Web Site:
  http://courses.csail.mit.edu/6.141
- Course staff:
  - Lecturers, TA, and LAs hold scheduled hours in lab
- Help after hours:
  email rss-help@csail.mit.edu

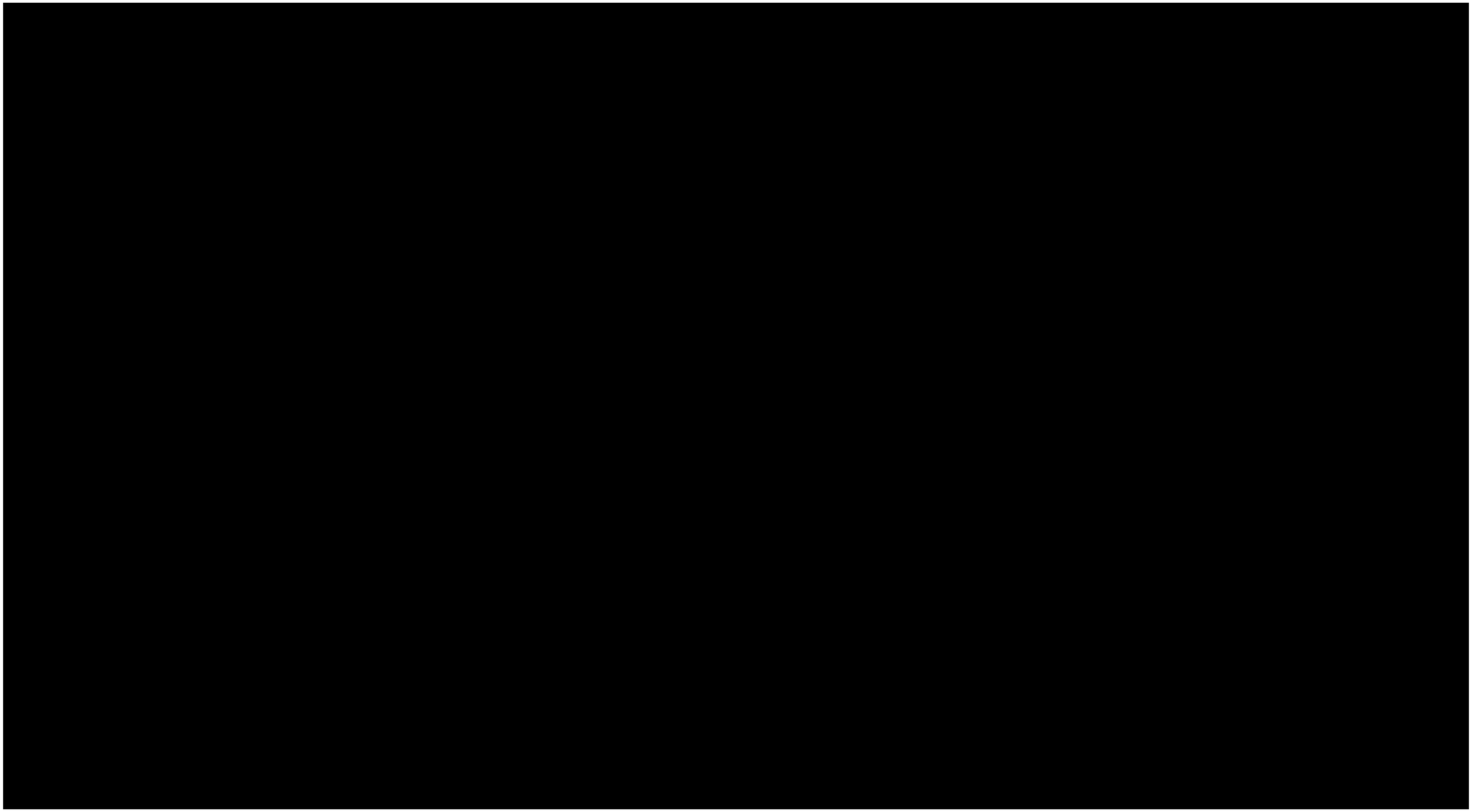
Lecture / Lab Etiquette

– Laptop use only for RSS note-taking
– No texting, music, email- or newspaper-reading, …
– All lectures start at 1:05pm (and end at 1:55pm)
– Please be on time for all activities: lectures, lab lectures, project presentations, etc.

Enrollment is Limited

- As many as we have room and supplies for
- Fill out questionnaire & **hand it to LA when it is done**
  - Your course and year
  - Relevant background (formal, independent etc.)
  - Whether you’ve previously tried to register for RSS
- We will email between 3pm - 3:30pm and post class list on lab door (38-630)
  - You must reply with your acceptance by 4pm
- We will make waitlist offers after 4pm

Movie: 50 years of Robotics (thanks to Prof. Khatib, Stanford)



6.141:
Robotics systems and science
Lecture1: what is a robot?

Outline

- A Brief History of Robots
- What is a Robot?
- Current Robot Trends
- Robot Methodology

Robots: Conceptions and Precursors

3000BC	Anubis
100AD	Early automata
1500s	Leonardo da Vinci
1580s	Rabbi Loew: Golem
1700s	Pierre Jaquet-Droz
1738	Jacques de Vaucanson
1816	Mary Shelley
1833	Babbage’s difference engines
1926	Metropolis’s Maria
1960	George Davol’s Unimate

Anubis

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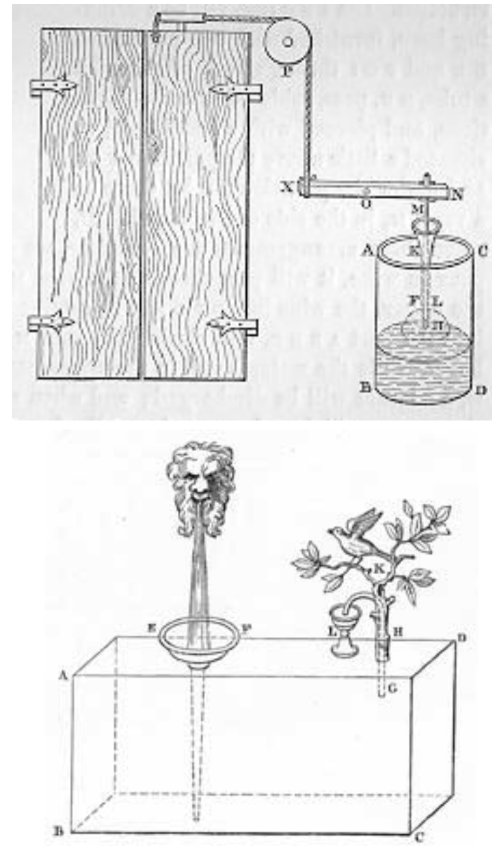

Hero of Alexandria

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Developed mechanical principles of automata
Built mechanical lion to entertain King Louis XII

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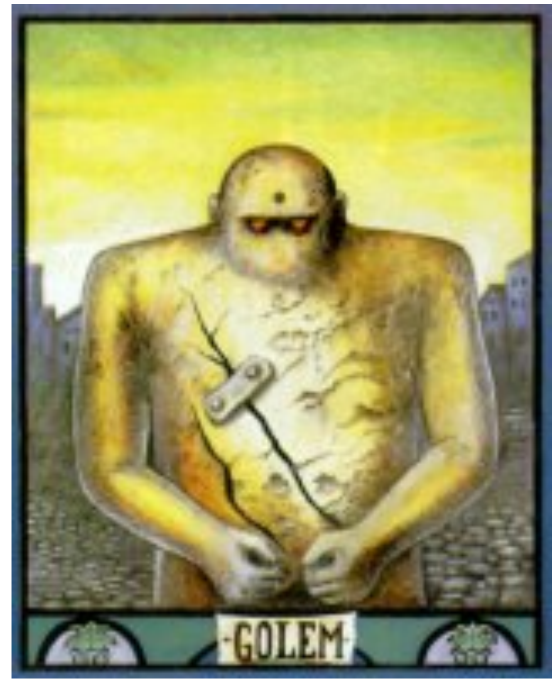

Golem (גלמ)

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Writing automaton

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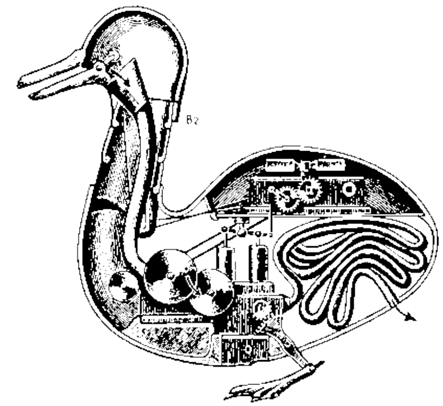

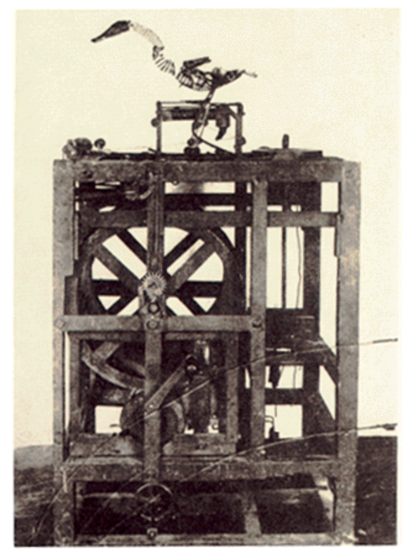

Duck automaton

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Frankenstein's Monster

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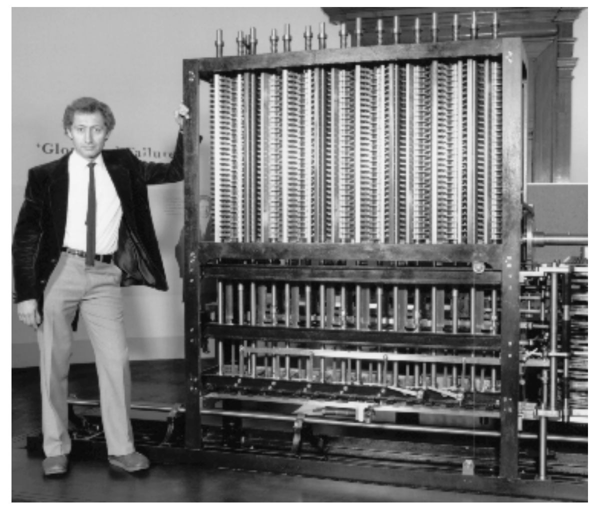

Difference engine models

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Maria

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Unimate
(note controller!)

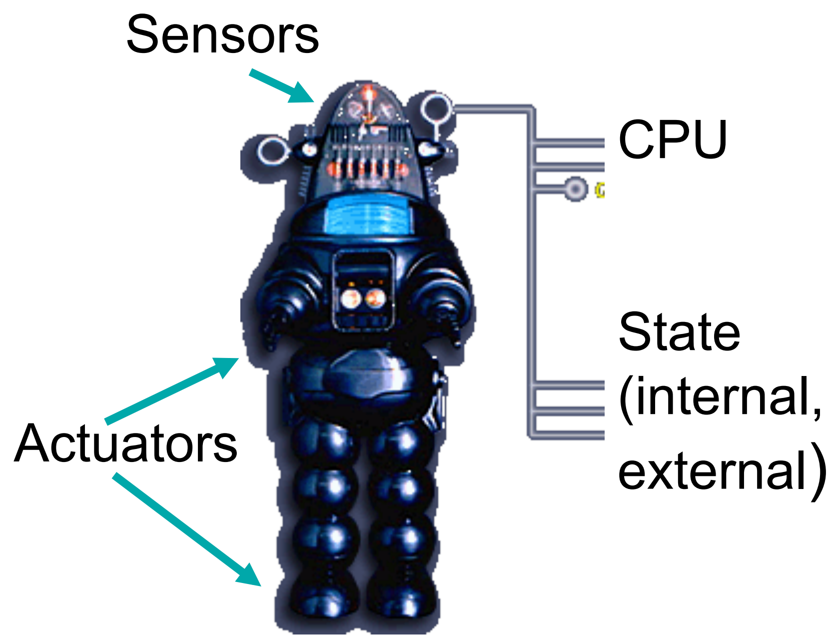
What is a robot?

- Science fiction robots make autonomous decisions
- Automata are hard coded and do not
- Robot:

What is a robot?

- Science fiction robots make autonomous decisions
- Automata are hard coded and do not
- Robot: programmable mechanical device that can exert forces

Input from sensors
Effects with actuators



Other Definitions

- An intelligent robot is a machine able to extract information from its environment and use knowledge about its world to move safely in a meaningful and purposeful manner.
- A robot is a system which exists in the physical world and autonomously senses its environment and acts in it (USC).
- A robot is a re-programmable, multi-functional, manipulator designed to move material, parts, or specialized devices though variable programmed motions for the performance of a task (Robotics Industry Association)
- Robotics is the intelligent connection of perception to action (M. Brady)

Current Robots and Applications

- Manipulators
- Mobile robots
- Humanoid robots
- Bio-inspired robots

Inspection, Surveillance (Field), Transportation, Construction, Health Care, Agriculture, Manufacturing, Entertainment, …

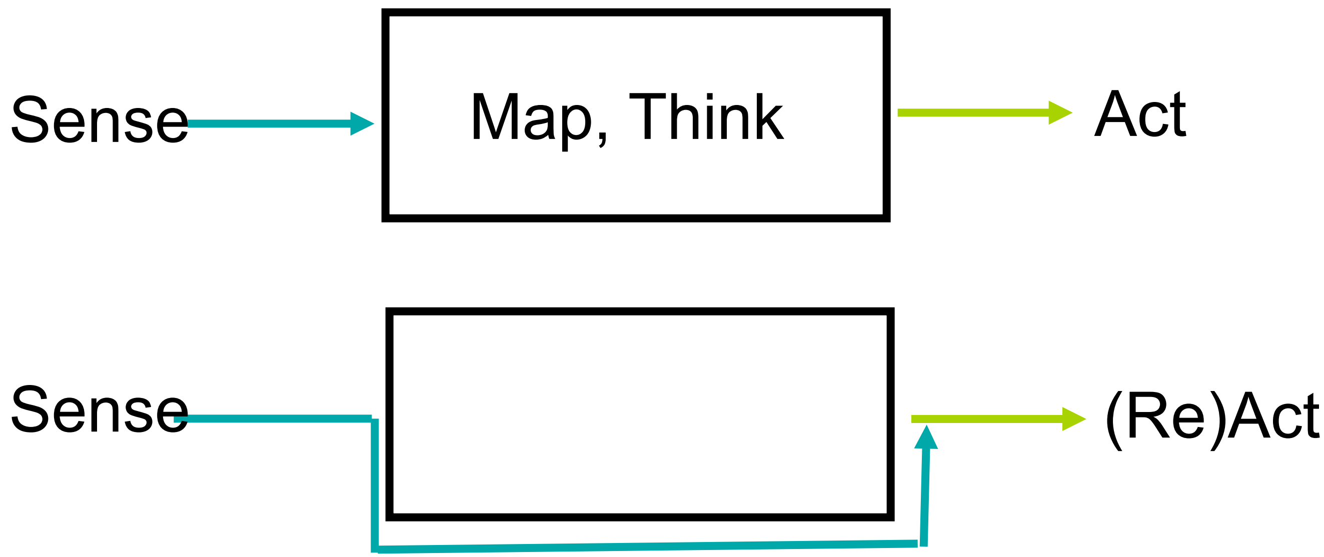
Why is Robotics Difficult?

Why is Robotics Difficult?

- Actions in the world must be coordinated with perceptions (and models) of the world
- Physical world is continuous, dynamic, and accessible only through sensing
- Sensors and actuators are uncertain, noisy, and subject to error
- Communication of intent requires rich existing knowledge of the world

Motion Planning

- How do we command the robot to move from A to B despite complications?



How does a robot sense?

- Depends on the sensors on the robot
- The robot exists in its perceptual space
- Robot sensors are very different from biological ones
- We have to imagine the world in the robot's sensor space

The Robot State

- A description of the system in terms of what is known internally and externally about the robot
- Can be:
  - Observable: robot always knows its state
  - Hidden/inaccessible/unobservable: robot never knows its state
  - Partially observable: the robot knows a part of its state
  - Discrete (e.g., up, down, centered)
  - Continuous (e.g., 25 km/hour)

Internal and External State

- External state: state of the world
  - Sensed using the robot's sensors
  - E.g.: night, day, at-home, sleeping, sunny
- Internal state*:* state of the robot
  - Sensed using internal sensors
  - Stored/remembered
  - E.g.: maps, paths, velocity, mood
- The robot's state is a combination of its external and internal state.
- State Space: all possible states for the robot

How does a robot move?

- A robot acts through its actuators (e.g., motors), which typically drive effectors (e.g., wheels)
- Robotic actuators are very different from biological ones, both are used for:
  - locomotion (moving around)
  - manipulation (handling objects)
- This divides robotics into two areas
  - mobile robotics
  - manipulator robotics
- Control: coordination of sensing and action

Questions:

- Is HAL a robot?
- Are Battlebots robots?
- Are exo-skeletons robots?
- Are internet crawlers robots?
- Is Stanley a robot?

Next in 6.141:

- Lab today at 4pm
  - Introduction to μORC board (used in MASlab, RSS)
  - Multimeters, oscilloscopes, battery safety
  - Admission decisions in lab, via email by early evening
- Lecture Friday at 1pm
  - Electric Motors
- Lecture Monday at 1pm
  - Motor Control
- Lab Monday at 3pm
  - Building and Controlling the Chassis
- CI-M Lecture Wednesday at 1pm
  - Expectations for wiki materials, technical briefings