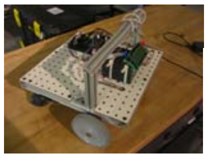
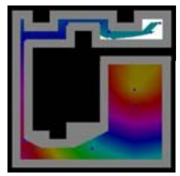
6.141J / 16.405J: Robotics Science and Systems Spring 2010



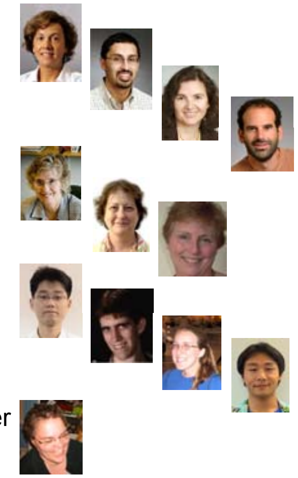
L1: Introduction
Wed 3 Feb 2010
Prof. Seth Teller
EECS / CSAIL / MIT



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

RSS Staff

- Instructors
  - Dr. Una-May O'Reilly (CSAIL)
  - Prof. Nick Roy (Aero/Astro)
  - Prof. Daniela Rus* (EECS)
  - Prof. Seth Teller (EECS)
- CI-M Lecturers
  - Ms. Jennifer Craig
  - Ms. Mary Caulfield
  - Ms. Jane Connor
- TA & LAs
  - TA Seungkook Yun (EECS)
  - LA Evan Iwerks (EECS)
  - LA Kim Jackson (Aero/Astro)
  - LA Andrew Sugaya (EECS)
- Class secretary & webmaster
  - Ms. Bryt Bradley (CSAIL)



* 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…
  - Occasionally, students from Courses 4, 7, 8, 9, 18 …
  - We urge you to become generalists, not specialists
- Communication
  - Verbal briefings; written reports; static & live graphics
  - Individual and team opportunities to communicate
  - Tackle real issues arising in team-based engineering
- Open-ended design and implementation challenge
  - Explore area, collect raw materials, build structure

Structure of RSS

- Theory in lecture; practice in lab (in small teams)
  - Also demos and short "labtures" for each lab module
- Foundational material (weeks 1-9):
  - Lectures and intensive labs covering 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

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)

Grading

- Lab quality, wikis, and briefings 35%

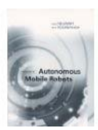
- Team challenge design and proposal 10%
- Challenge implementation 30%

- 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

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

My Research Focus

- **Machine situational awareness**
  – Integrating experience, models of the environment, and sensor data to plan and carry out useful behaviors
- **Natural interfaces** involving speech, gesture
  – References to shared surroundings
- **Fielded robots** for real-world utility
  – Engagement with user communities

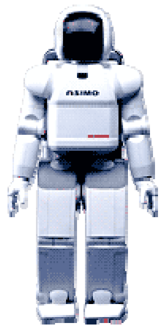
DARPA Urban Challenge: Self-driving passenger vehicle

Agile Robotics for Logistics: Gesture-commandable forklift

Voice-commandable autonomous wheelchair

Motivation

Robots: people have long sought to build them.
Why? And what exactly is a robot?


Robots: Conceptions and Precursors

3000BC	Anubis
1000BC	Talos
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


Talos (ΤΑΛΩΝ)

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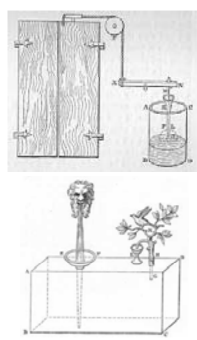
Hero of Alexandria

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

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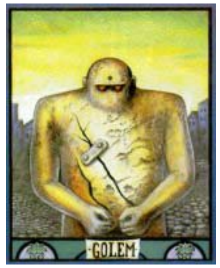

Golem (גלמ)

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Writing automaton

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Duck automaton

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Difference engine models

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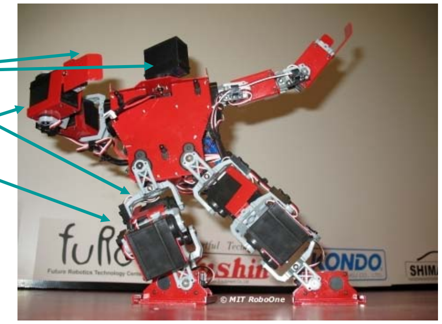
Unimate
(note controller!)

What is a Robot?

- A "programmable mechanical device that can exert forces" ?
- Essential ingredients:
  - Sensors
  - Computation
  - Actuators
    - Mobility
    - Manipulation
  - State (memory)
- Difference from an automaton?



- RSS focuses on autonomous mobile navigation & manipulation

Other Workable Definitions

- A robot is a reprogrammable, multi-functional manipulator designed to move material, parts, or specialized devices though variable programmed motions for the performance of a task
(Robotics Industry Association)
- A robot is a system which exists in the physical world and autonomously senses its environment and acts in it
(USC)
- 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
(Typical dictionary entry)
- Robotics is the intelligent connection of perception to action
(Mike Brady)

Current Robots and Applications

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

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

Research and Development Challenges

INDUSTRIAL

- Manipulation
- Perception
  - Visual, haptic, aural
  - Rich world models
- Development
  - Design, packaging, power
  - Safety
  - Product cost
- **Mobile manipulation**
- **Human-robot interfaces**
- **Task-level autonomy**

PERSONAL and PERVASIVE



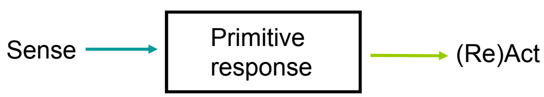

Structured / prepared (known) versus unstructured / unprepared (unknown) environments

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; they exhibit noise, and are subject to error
- Communication of intent often requires rich existing knowledge of the world

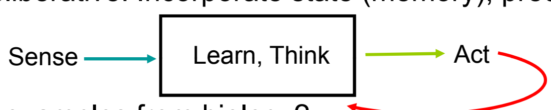
Reactive vs. Deliberative Architectures

- Reactive: Integrate sensing, computation, action



- … examples from biology?

- Deliberative: Incorporate state (memory), prediction



- … examples from biology?

- Differences? Is this a hard distinction?

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