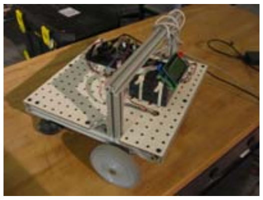
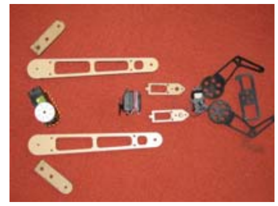
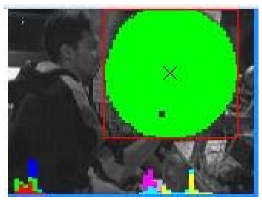
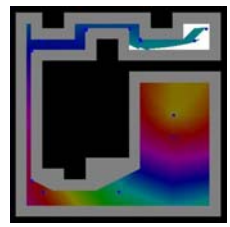
6.141J / 16.405J: Robotics Science and Systems Spring 2014



L1: Introduction
Wed 5 Feb 2014
Prof. Seth Teller
Prof. Daniela Rus*
EECS / CSAIL / MIT



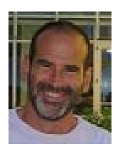




http://courses.csail.mit.edu/6.141

RSS Staff

- Instructor
  - Prof. Seth Teller (EECS / CSAIL)



Prof. Daniela Rus (EECS / CSAIL)

- Writing Program staff
  - Ms. Jane Connor

- TA & LA
  - TA Alec Poitzsch (EECS)
  - LA Alex Gutierrez (EECS)

- Class secretary & webmaster
  - Ms. Bryt Bradley (CSAIL)

Goals of RSS

- Intensive introduction to theory and practice
  - Hands-on application of fundamental ideas
- Experience with inherently interdisciplinary area
  - CS, EE, MechE, Aero/Astro: sensing, estimation, planning, control, system architecture, implementation, validation…
  - Occasionally, students from Courses 4, 7, 8, 9, 18 …
  - We urge you to become *generalists*, not specialists
- Improved technical communication ability
  - Verbal briefings; written reports; static & live visualization
  - Individual / team opportunities to communicate, persuade
  - 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 1-7):
  - Lectures and intensive labs covering motor control, robot architectures, sensing and machine vision, navigation, motion planning, kinematics, grasping and manipulation
  - Complex system design, development and test
- Debates (weeks 10-12):
  - Students, in small teams, debate ethical issues in class
- Course challenge (weeks 1, 3, 6, 8-14):
  - Individual and team-written design exercise, proposal
  - Seven weeks of team-based work, with real milestones
  - Final Challenge in week 14, with an audience (of friends)
- Communication threads through all aspects

Communication Aspects of RSS

- CI-M “Forum” held most Fridays at 1pm
  - Concrete strategies for effective writing, design, reporting
- Challenge Design Exercise (individual)
- Team wiki (brief answers, plots, images, videos &c.)
- Team briefings (to course staff) for each lab
- Lab checkpoints (in lab, rolling basis)
- Written challenge design (indiv. + team), revision
- Debates (in small groups, with class as audience)
- Reflective report (individual, at end of term)

Debates

- Argue a stance on an ethical-technical issue
  - All robots must obey Asimov’s three laws
  - Robots will eventually have civil rights
  - Robots should be allowed to use lethal force, autonomously
  - Etc.
- Instruction from an expert on rhetoric

Requirements Satisfied by RSS

- Institute Lab
- 12-unit **AUS** subject worth 12 EDPs in EECS
- CI-M subject in EECS for 6-1, 6-2, or 6-3
- Department Lab in EECS for 6-1 or 6-2
- Can petition for use in lieu of 6.UAP (not guaranteed)
- Aero/Astro students can petition to use it as a PAS

Prerequisites – some mix of:

- Relevant coursework from a variety of Departments
- Familiarity with Java (or C or C++)
- Bench/shop skills (electronics, machine shop, etc.)
- Independent experience (UROPs, competitions etc.)

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 summary in Week 11 (by drop date)

Schedule

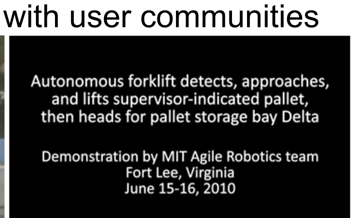
- Lectures **MW 1-2p** here in 32-155
  - Lectures start promptly at 105pm, end at 155pm
- Forums **F 1-2pm** here in 32-155 (but not every Friday)
  - Focus on communications aspect of class
- Both Lectures and Forums are **essential parts** of 6.141

- Lab **MW 3-5pm**
  - In 38-630 (accessible via 38-500 or 38-600)
  - Open M-R 9am-1145pm; F 9am-5pm; Sun 1pm-1145pm
  - First lab is **this afternoon**, but starts at **330pm**
- Students are expected to attend all lectures, forums & labs
  - Very occasional absence OK; email staff beforehand
- Challenge dry runs on **M May 5th,** final runs on **W May 7th**
  - Scheduled from **3-5pm**; historically run later than 5pm

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

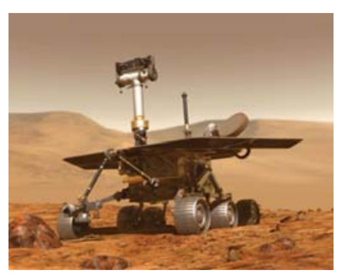
DARPA Robotics Challenge

- Motivation: Disaster Relief

BDI Petman

Motivation

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



Robots: Precursors and Conceptions

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
1961	George Devol's Unimate

Anubis

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Talos (Τάλως)

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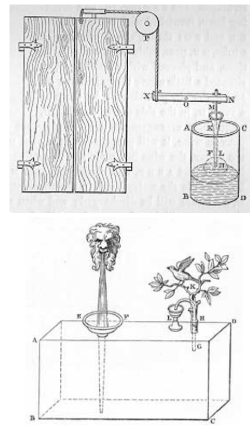

Hero of Alexandria

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

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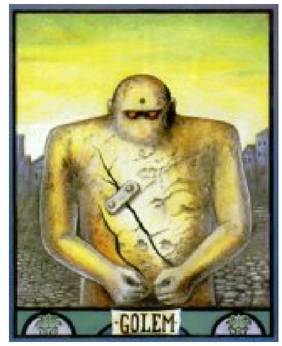

Golem (גלמ)

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Writing automaton

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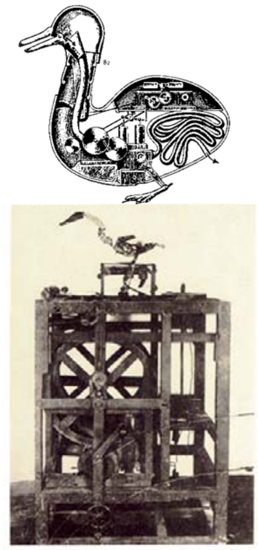

Duck automaton

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Frankenstein’s Monster

The Turk

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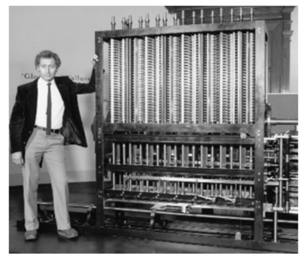

Difference engine models

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Maria

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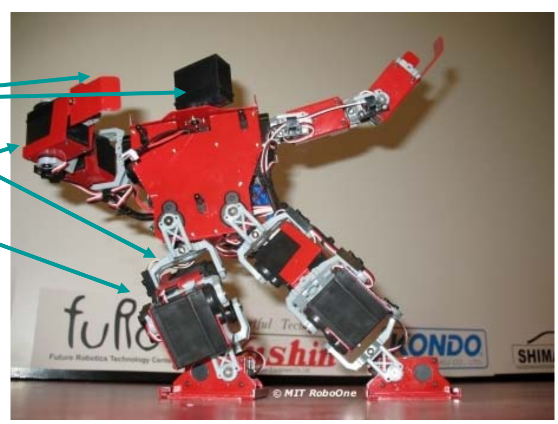
Unimate
(note controller!)

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

- 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)
- 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)
- Robotics is the intelligent connection of perception to action (Mike Brady)

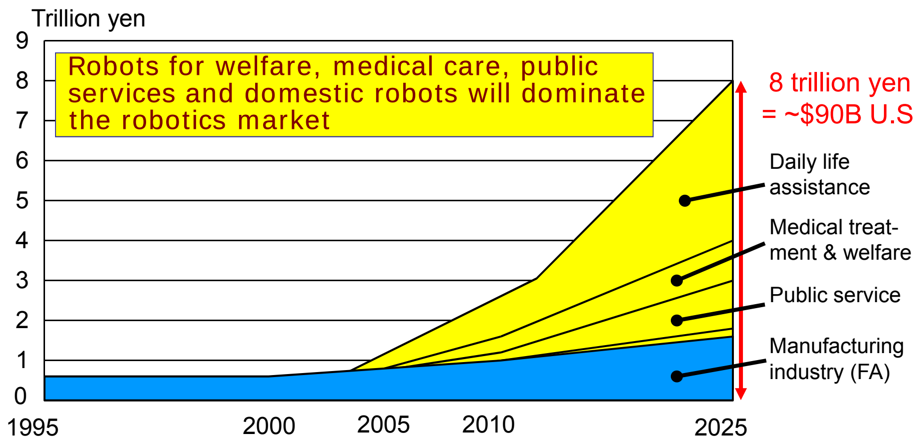
Drivers of Advances in Robotics

- Mission-oriented agencies (e.g., DoD, NASA, DHS, VA) in U.S.
  - Air Force Vision 2020
  - DARPA Robotic Vision 2020
  - NASA Robotic and Human Exploration of Mars
  - DARPA Challenges: Grand/Urban (2002-07); Robotic (2012-15)
  - Homeland Security (e.g. port monitoring, ship inspection)
- Economic, social, demographic factors in Europe and Japan

Honda ASIMO project (1986 -)

ZMP: Nuvo humanoid robots (domestic companions)

Market for Service Robots



* Report investigating technical strategies for creating a robot society in the 21st century
Japan Robot Association (JARA)

Why is Robotics Difficult?

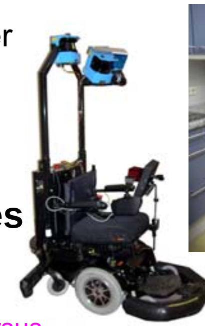
- Actions in the world must be coordinated with perception of, and models of, the world
- Physical world is continuous, dynamic, and accessible only through sensing
- Sensors and actuators are uncertain; they exhibit noise, and are subject to error
- Communication of intent often requires rich existing knowledge of the world
- To be useful in human-occupied environments, robots must be tolerated by the people there

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**



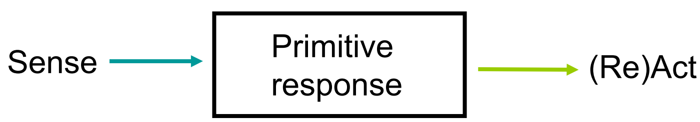



PERSONAL and PERVASIVE

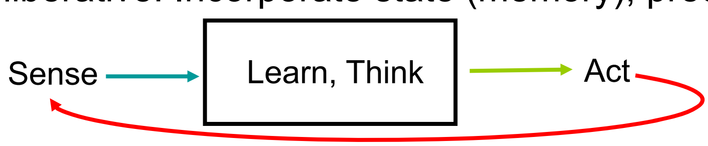
Structured / prepared (known) versus unstructured / unprepared (unknown) environments

Reactive vs. Deliberative Architectures

- Reactive: Connect sensing directly to 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 a region, given an uncertain prior map
  - Gather prefabricated materials dropped from orbit
  - Transport materials to a selected building site
  - Assemble them purposefully into a wall or structure
- Eight teams, 4-5 students per team
- Challenge described in more detail on RSS web page, and will be discussed both in class and lab

What's Next

- Lab today **(starting at 330pm)** in 38-630
  - Introduction to μORC board (used in MASlab, RSS)
  - Multimeters, oscilloscopes, battery safety
  - Admission/waitlist decisions via email this evening
- Communication Forum on Friday at 1pm
  - Expectations for technical briefings, collaboration
- Individually written Challenge Design Exercise
  - Due this **Sunday evening at 1159pm**, turnin TBD
- Lecture Monday at 1pm
  - Electric Motors
- Lab Monday at 3pm
  - Motor characterization and control