CS148 - Building Intelligent Robots

Lecture 2: Robotics Introduction and Philosophy

Instructor: Chad Jenkins (cjenkins)

Brown Computer Science

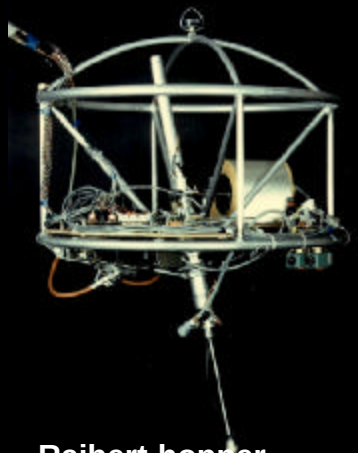
What is robotics?

- Robot: a machine with a physical embodiment that produces actuation based on its sensory information
  - sensing, actuation, control

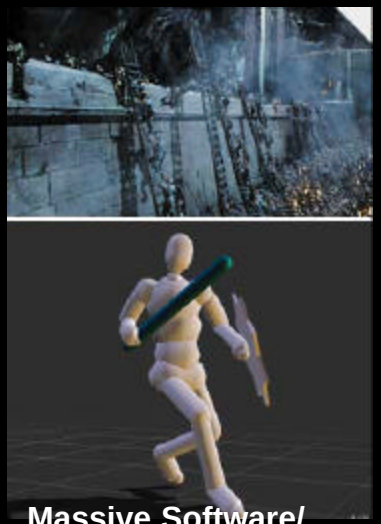
- A simple robot: a thermostat, 1DOF robot

- Robot examples:


NASA Robonaut


Raibert hopper


ActivMedia Pioneer


Massive Software/
LOTR: Return of the King

Robots, machines, and agents

- Another definition: a robot is a situated agent with embodiment
- Agent: one that acts or has the power or authority to act

Robots, machines, and agents

- Embodiment
  - a robot's embodiment is its medium to interact (sensing and actuation) with its environment
  - embodiement constrains a robot (michael jordan)
- Situatedness
  - robots are strongly affected by the environment and deal with its immediate demands directly
- Situated intelligence
  - observed behavior resulting from interaction between a robot and its environment
  - cannot be attributed to a single source, model, or rationale

Robots, machines, and agents

- Autonomy
  - a robot is a machine with autonomy
    - the robot acts based on its own decision making
  - engineering robotics versus autonomous robotics
  - robots are motivated to achieve some goal... but what goal?
- Uncertainty
  - an inherent property of the real world
  - Physical sensors and actuators provide limited, noisy, and inaccurate information and force generation
  - The certainty of physical sensors and effectors cannot be well characterized, so robots have no available a priori models

What is not robotics?

- Battlebots
  - actuation only
  - teleoperated

www.ptc.com

www.robodojo.com

- "Robot" toys

- Segway?
  - sensing, actuation, and control
  - who is doing the driving?

segway.com

NASA Segwanaut

Teleoperation

- A machine externally controlled by an operator is "tele"-"operated"
  - segwaynaut + teleoperator
  - engineering robotics

- Autonomous robotics
  - segwaynaut - teleoperator
  - robot decides itself
  - can listen or not listen to human
  - program robot with "good" behavior

Miller, Jenkins, Kallmann, Mataric

Asimov's three laws of robotics

- One idea for robot's being on "good behavior"
  - A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
  - A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
  - A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.
- Science fiction and science fact

The larger view

- Robotics is a vast interdisciplinary field
  - thus, characterizing what is "not robotics" may not be fair

- Core technical areas of robotics
  - mech. engineering, electrical engineering, **computer science**
- Philosophical areas of robotics
  - cognitive science, ethics, psychology,
- Inspiration for robotics research
  - neuroscience, biology, biomechanics
- Foundation for robotics
  - physics, mathematics, materials science

Robotics and computation

- Engineering robotics ⟷ Computer hardware development

NASA Opportunity

- Control theory/ signal processing ⟷ Operating systems
- Autonomous control ⟷ Software/ application development
- Robot learning and adaptation ⟷ Self-healing systems

---

hardware platforms are less mature

lesser degree of uncertainty

Applications for robotic technology

- Robots are designed to automate services:
  - Industrial/assembly/inspection
  - Search and rescue
  - Hazardous operation (demining, defusing, chemical)
  - Medical (surgery...)
  - Entertainment
  - Space and underwater exploration and development
  - Assistive/rehabilitation
  - Education
  - Transportation
  - Ecology, geoscience

Basic roadmap of robotics

- Engineering robotics:
  - constructing physical embodiment and physical dynamics
  - mechanical engineering
- Control theory/ Signal processing
- Autonomous control
- Learning/Adaptation

Basic roadmap of robotics

- Engineering robotics (at bottom):
- Control theory/ Signal processing
  - producing appropriate control signals
  - interpreting/processing the world from sensory data
  - mechanical and electrical engineering
- Autonomous control
- Learning/Adaptation

Basic roadmap of robotics

- Engineering robotics (at bottom):
- Control theory/ Signal processing
- Autonomous control
  - programs for producing control signals from sensory data
  - computer science and electrical engineering
- Learning/Adaptation

Basic roadmap of robotics

- Engineering robotics (at bottom):
- Control theory/ Signal processing
- Autonomous control
- Learning/Adaptation
  - extending the robot's autonomy beyond what is explicitly programmed
  - computer science

A brief history of robotics

- The term "robot" was popularized by Czech playwright Karel Capek, combining
  - "rabota" meaning "obligatory work"
  - "robotnik" meaning "serf"

- Traditional notions of robots
  - clever mechanical devices or automatons
  - player pianos, animatronics

Disney's General Electric Carousel of Progress
www.parnasas.com

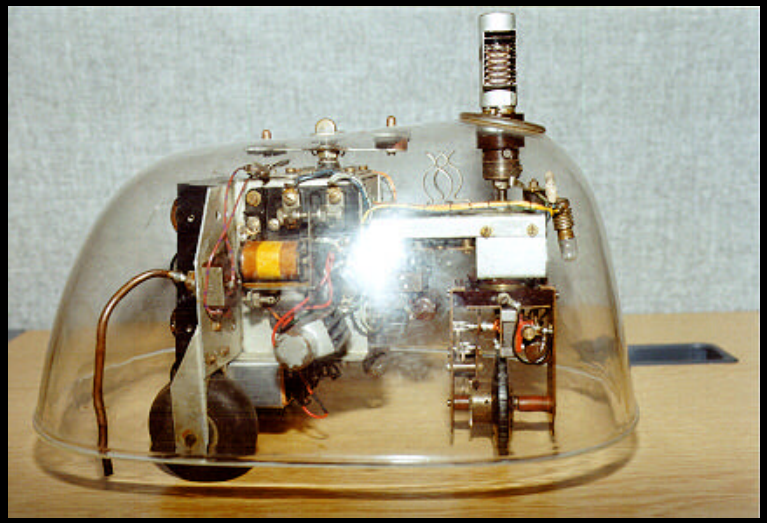
- Advancement in computation has redefined these notions

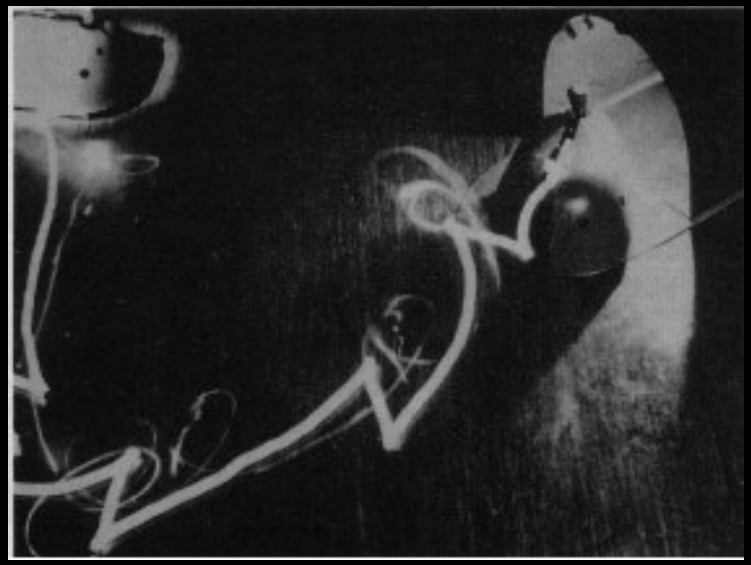
Fields leading to robotics

- Control theory
  - mathematical study of automated control systems
  - feedback control
- Cybernetics (Norbert Wiener, 1940s)
  - study of biological systems for robot control
  - focus on the interaction of an organism and its environment
  - Tortoise, Braitenberg Vehicles
- Artificial intelligence (Dartmouth Conference, 1956)
  - methods for endowing intelligence to machines
  - internal modeling, search for solutions, sequential execution
  - Shakey

Grey Walter's Tortoise

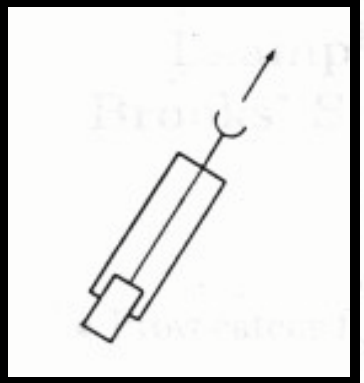
- Acknowledged as the first robot (1953)
- Inspired by cybernetics
- Exhibited emergent behavior from reactive control

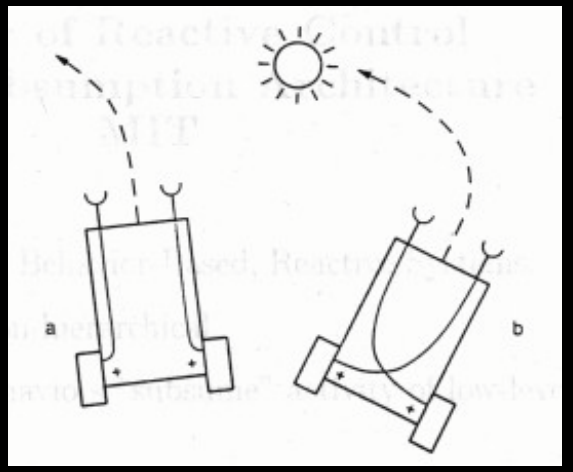


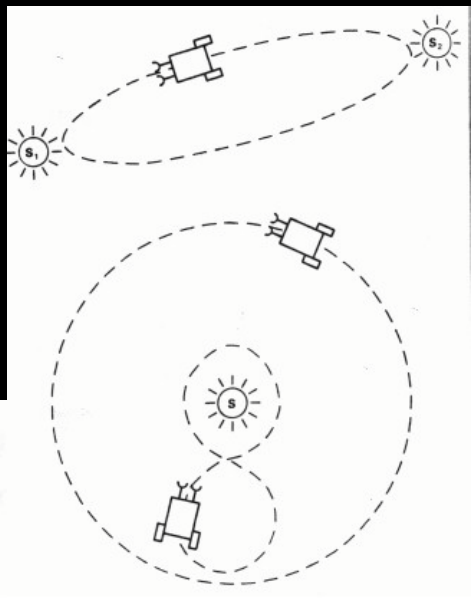


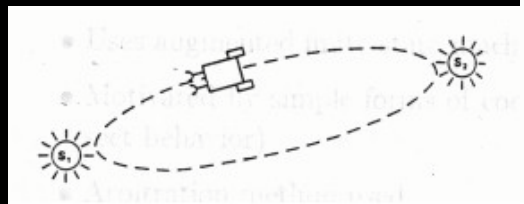
Braitenberg vehicles

- Valentino Braitenberg's thought experiments
- simple robots that exhibit animal- or life-like behavior
- Photophilic or photophobic behavior
- Results from exhibitory or inhibitory connections between light sensors and motors



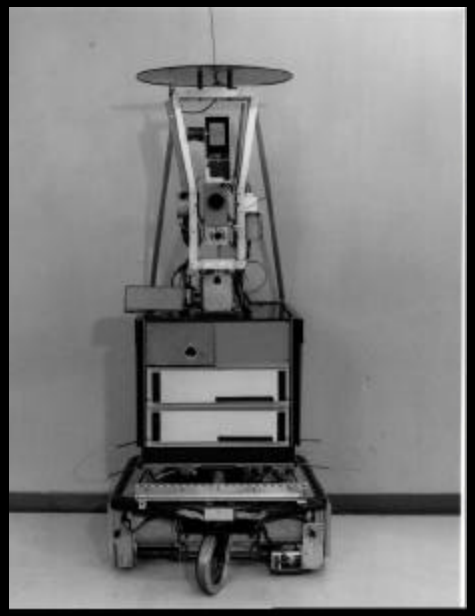






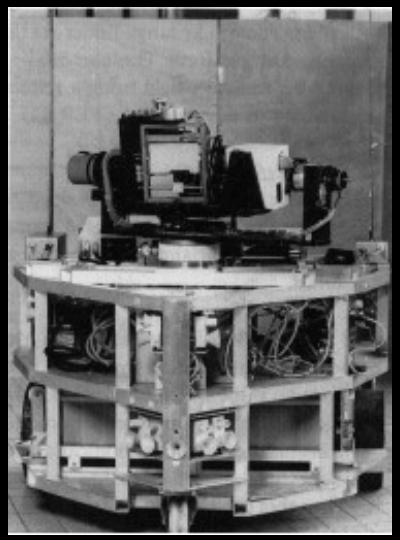
Shakey

- One of the first AI-inspired robots
- mobile robot with contact and camera sensors
- lived in a specially constructed world
- Shakey name derived from how it executed it plans

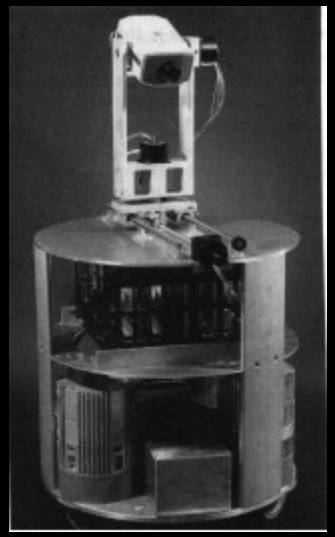


Other early AI-inspired robots

- HILARE

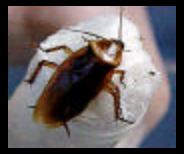


- Moravec's CART/Rover



Engineering and Philosophy (slide in progress)






Robot hardware

Robot arms (PUMA)

Sony Aibo

Biologically inspired robots (B. Full)

Battlebots

Automated machines

Industrial robotics

Asimov's 3 laws

Robot ethics

RoboTuna

Roomba

Segway

Localization and mapping
DARPA Grand Challenge

Autonomous robotics

Robot soccer, Assistive Robotics

Subsumption, Behavior-based

Engineering

Philosophy

Kitano's robocup challenge

- Team of robots will be able to defeat a team of humans by 2050

DARPA Grand Challenge