Welcome to

CSE 571
AI-based Mobile Robotics

Instructor: Dieter Fox

Teaching Assistant: Cody Kwok

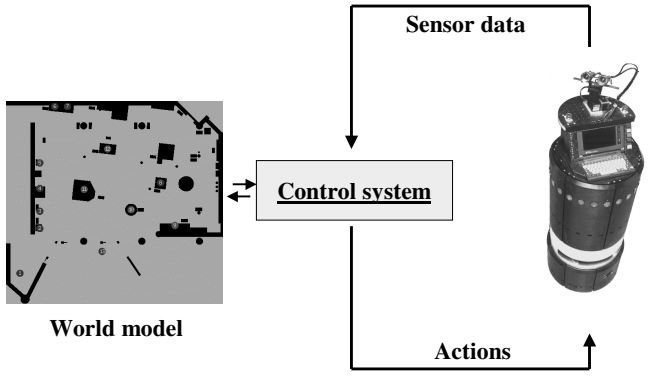
Organization

- W/F 2:00 – 3:20
  - Mostly lectures, discussions (EE1 031)
  - Some lab meetings (Sieg 423)
- Web page:
  - www.cs.washington.edu/571

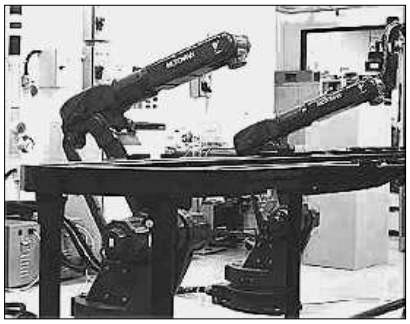
Goal of this course

- Provide an overview of problems / approaches in mobile robotics
- Hands-on experience

AI View on Mobile Robotics



Robotics Yesterday

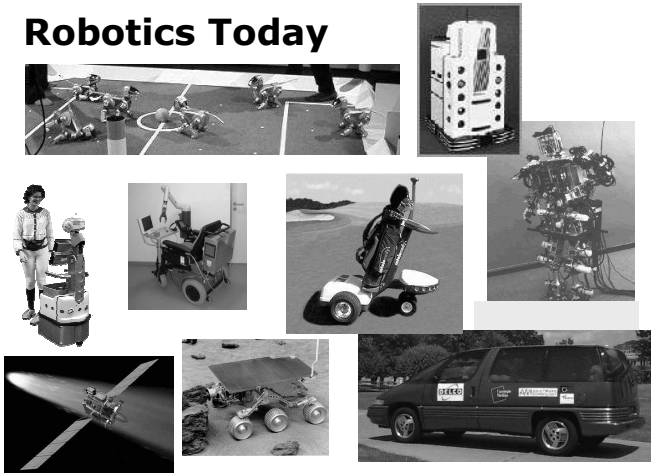


Current Trends in Robotics

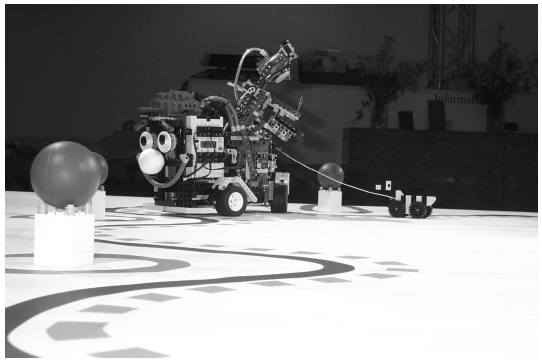
Robots are moving away from factory floors to

- Entertainment, toys
- Personal services
- Medical, surgery
- Industrial automation (mining, harvesting, …)
- Hazardous environments (space, underwater)

Robotics Today



Entertainment Robots



RoboCup 2002, Fukuoka, Japan

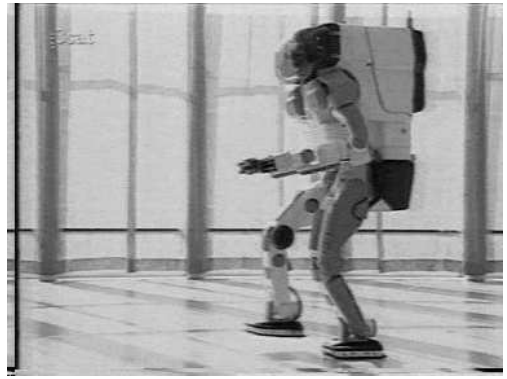
RoboCup 2002, Fukuoka, Japan

Finals: UNSW vs. CMU

Mobile Manipulation

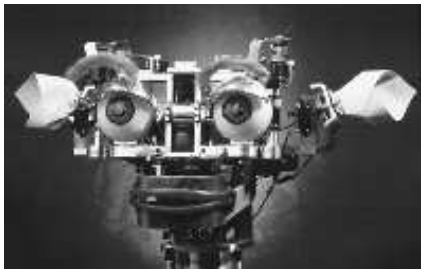
[Brock et al., Robotics Lab, Stanford University, 2002]

Humanoids: P2



Honda P2

Emotional Robots: Cog & Kismet



[Brooks et al., MIT AI Lab, 1993-today]

Brief History of Mobile Robotics

- Autonomous, automaton
  - self-willed (Greek, auto+matos)
- Robot
  - Karel Capek in 1923 play R.U.R. (Rossum's Universal Robots)
    - labor (Czech or Polish, robota)
    - workman (Czech or Polish, robotnik)

Asimov's Three Laws of Robotics

1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given it by human beings except when such orders would conflict with the first law.
3. A robot must protect its own existence as long as such protection does not conflict with the first or second law.

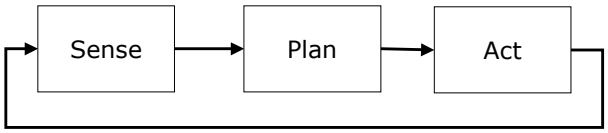
[Runaround, 1942]

Wiener, Cybernetics

- Studied regulatory systems and their application to control (antiaircraft gun)
- "it has long been clear to me that the modern ultra-rapid computing machine was in principle an ideal central nervous system to an apparatus for automatic control; and its input and output need not be in the form of numbers or diagrams, but might very well be, respectively, the readings of artificial sensors such as photoelectric cells or thermometers, and the performance of motors or solenoids".

[Electronics, 1949]

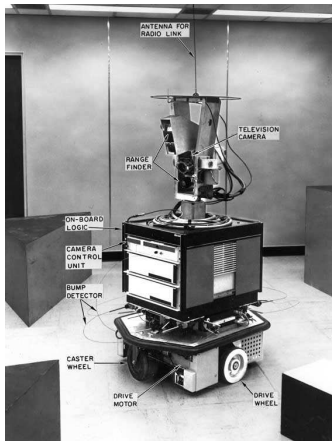
Classical / Hierarchical Paradigm



- 70s
- Focus on automated reasoning and knowledge representation
- STRIPS (Stanford Research Institute Problem Solver): Perfect world model, closed world assumption
- Find boxes and move them to designated position

Shakey '69

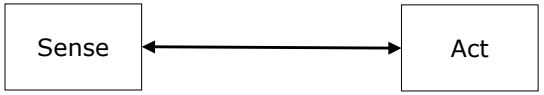
Stanford Research Institute



Stanford CART '73

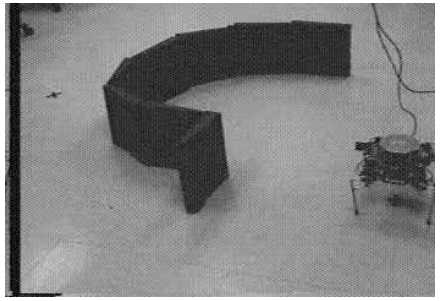
Stanford Artificial Intelligence Laboratory / CMU (Moravec)

Reactive / Behavior-based Paradigm



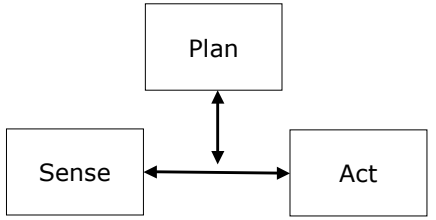
- No models: The world is its own, best model
- Easy successes, but also limitations
- Investigate biological systems

Thing



[Zelinsky et al., Australian National University]

Hybrid Deliberative/reactive Paradigm



- Combines advantages of previous paradigms
  - World model used for planning
  - Closed loop, reactive control

Trends in Robotics Research

Classical Robotics (mid-70's)
- exact models
- no sensing necessary

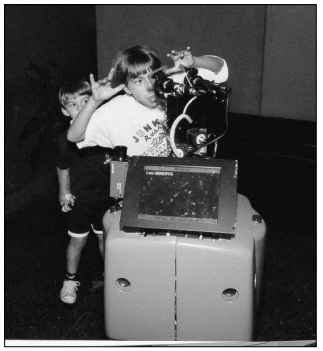
Reactive Paradigm (mid-80's)
- no models
- relies heavily on good sensing

Hybrids (since 90's)
- model-based at higher levels
- reactive at lower levels

Probabilistic Robotics (since mid-90's)
- seamless integration of models and sensing
- inaccurate models, inaccurate sensors

Brief Case Study: Museum Tour-Guide Robots

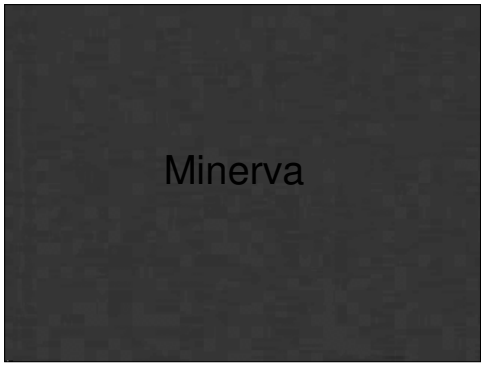
Rhino, 1997



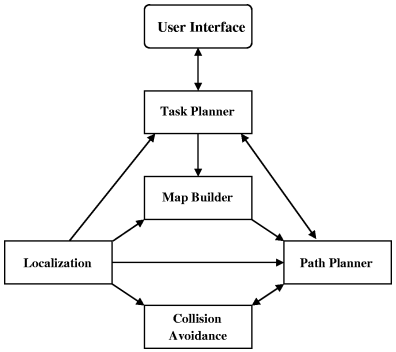
Minerva, 1998

Rhino (Univ. Bonn + CMU, 1997)

Minerva (CMU + Univ. Bonn, 1998)



Architecture of the Control System



Seen this?

$$P(a|b) = P(b|a)\,P(a) / P(b)$$

Course Outline

Week	Content	Project
Mobile Robot Motion / Behavior Based Paradigm		
#1	Introduction, lab session	Reactive control
#2	Behavior based control, robot programming	
Probabilistic Models / State Estimation		
#3	Review of probability theory, lab session	Wall following, models of motion / sonar
#4	Motion and sensor model	
Localization / Path Planning		
#5	Bayesian state estimation, localization, lab session	Particle filters for localization
#6	Map building	
#7	Path planning	
Reasoning		
#8	Decision making, lab session	Suggested: Global localization, navigation
#9	High-level planning	
#10	Review, lab session	