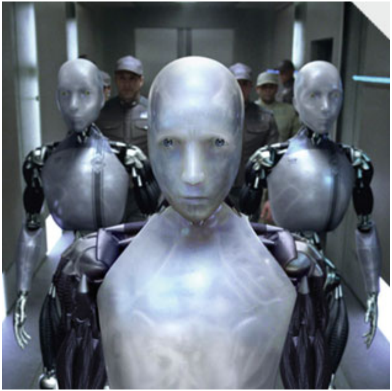
Robot Motion Planning

CS 689 - Spring 2018

Amarda Shehu

Department of Computer Science
George Mason University

What is a Robot?



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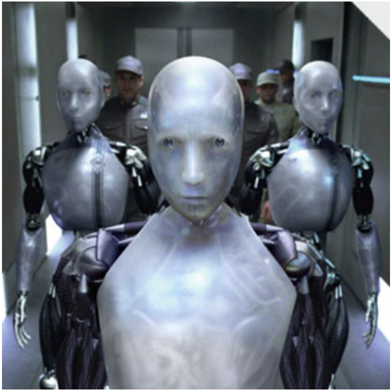

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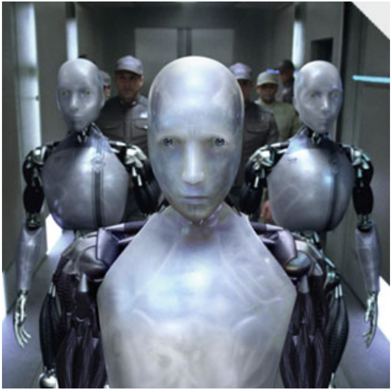

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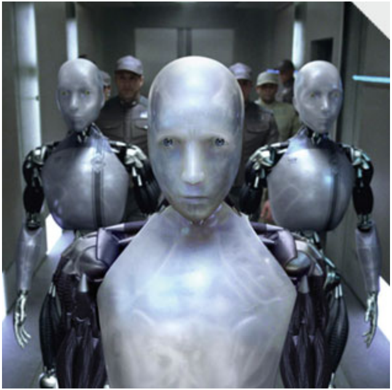

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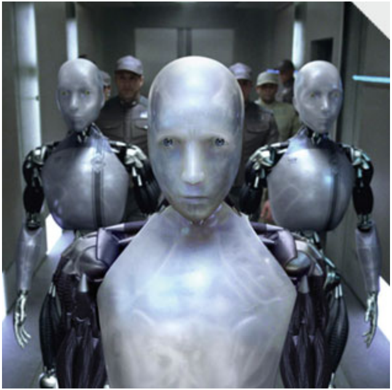

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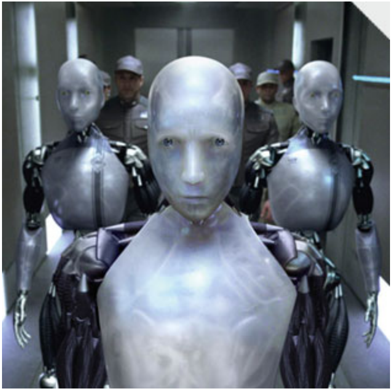

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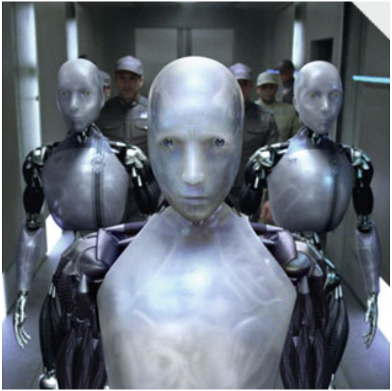
  3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.



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Robotics Institute of America: "device that automatically performs complicated often repetitive tasks," or a "mechanism guided by automatic controls"

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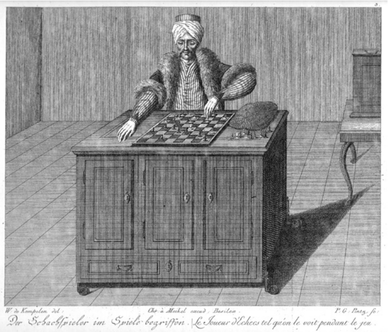
First Robot – The Turk / Automaton Chess Player (1770)



http://en.wikipedia.org/wiki/The_Turk

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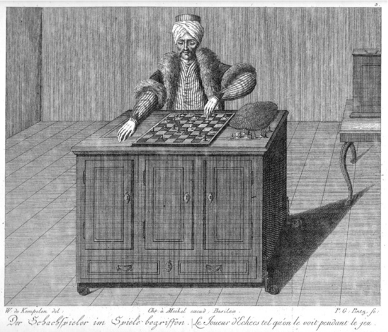

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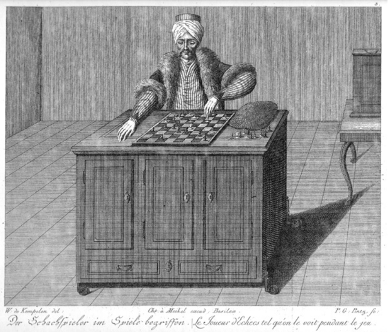
- Constructed by Wolfgang von Kempelen in 1770
- Played many exhibition chess games
- Solved the knight-tour problem
- Even played against Benjamin Franklin in France

First Fake Robot – The Turk / Automaton Chess Player (1770)



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. . . it was a fake, however, human player hid inside machine

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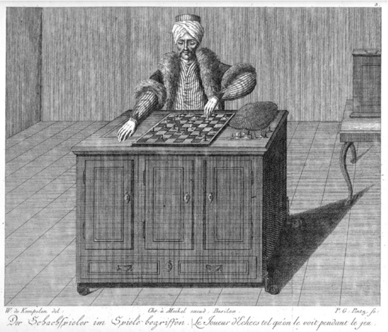

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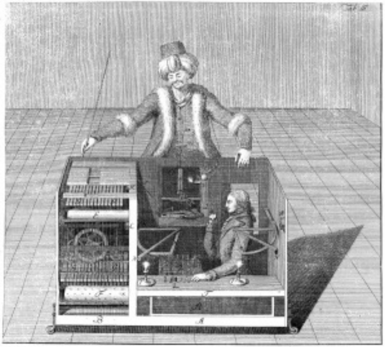
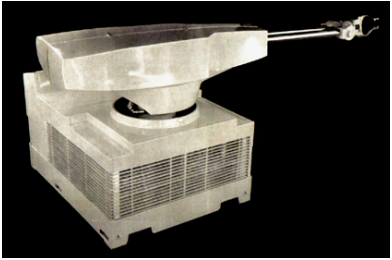
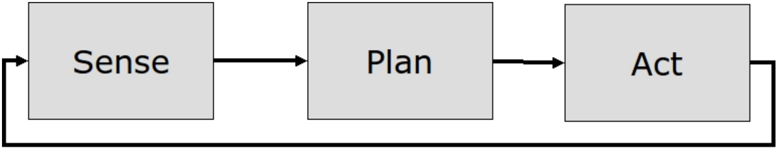


First Real Robot – Unimate (1961)



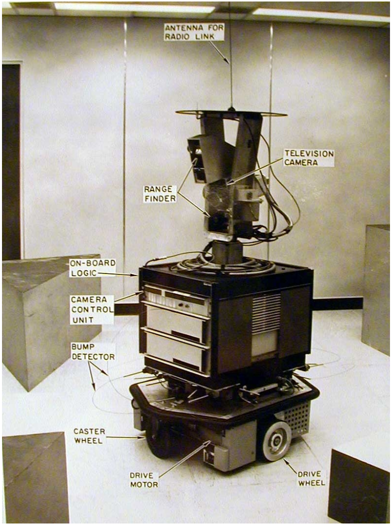
http://en.wikipedia.org/wiki/Unimate

- Created by George Devol
- Worked on a General Motors assembly line in New Jersey in 1961
- Job consisted of transporting die castings from an assembly line and welding these parts on auto bodies
- Conducted in Robot Hall of Fame in 2003



- Focus on automated reasoning and knowledge representation
- Perfect world model
- Closed world assumption: “what is not currently known to be true, is false”
- STRIPS (Stanford Research Institute Problem Solver)

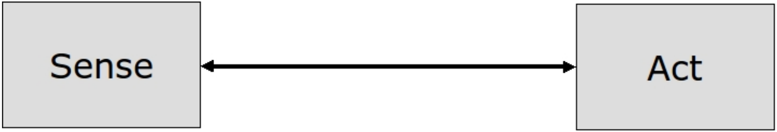
Shakey (Stanford Research Institute, 1966)



http://en.wikipedia.org/wiki/Shakey_the_robot

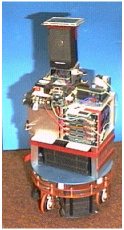
- First mobile robot to reason about its own actions
- Programs for "seeing," "reasoning," and "acting"
- Triangulating range-finder for sensing obstacles
- Wireless radio and video camera
- Used STRIPS to perform "block-worlds" tasks
- Conducted in Robot Hall of Fame in 2004

Trends in Robotics Research: Reactive Paradigm

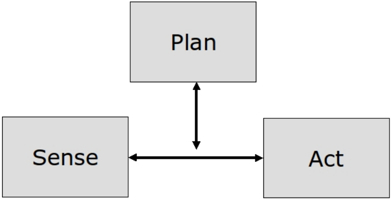


- No models: The world is its own, best model
- Many successes, but also limitations
- Inspired by biological systems

Genghis by Rodney A. Brooks



Polly by Ian Horswill



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

Classical Paradigm (mid 1970s)

- exact models
- no sensing necessary

Reactive Paradigm (mid 1980s)

- no models
- relies heavily on good sensing

Hybrid Paradigm (since 1990s)

- model-based at higher levels
- reactive at lower levels

Probabilistic Paradigm (since mid 1990s)

- seamless integration of models and sensing
- inaccurate models, inaccurate sensors

Robots Today

[auto] [bdog] [rhex] [heli1] [heli2] [heli3] [snake] [hand] [asimo]

Google: "Kuka robot playing ping ping"

The Duel: Timo Boll vs. KUKA Robot - YouTube

This Course

Focus on two themes:

- Motion Planning: How can the robot automatically plan and execute a sequence of motions that avoids collision with obstacles and accomplishes the assigned task?

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Emphasis on algorithms, analysis, and implementations

Illustrated with practical applications arising in diverse areas such as mobile systems, navigation and exploration, robot manipulation, computer animation, video games, computational biology, and medicine

Syllabus

Basic Motion-Planning Algorithms and Foundations (3 WKS)

- Bug Algorithms
- Configuration Spaces
- Forward and Inverse Kinematics for Manipulators
- Potential Fields
- Roadmaps/Cell Decompositions

Sampling-based and Probabilistic Motion Planning (3WKS)

- Roadmap Approaches
- Tree Approaches

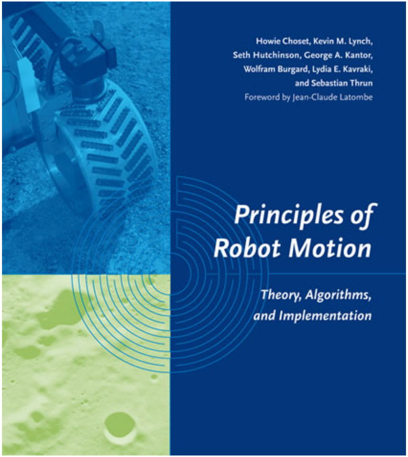
Advanced Motion Planning (4 WKS)

- Multiple Robots
- Manipulation Planning
- Dynamics/Physics Game Engines
- Dynamic Environments/Uncertainty

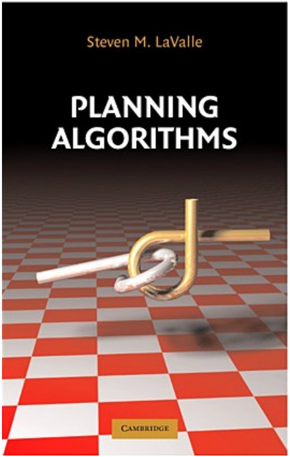
Localization and Mapping (2 WKS)

- Kalman Filtering/Bayesian Methods
- Mapping and SLAM

Required



Recommended (available online, free)



Grading

- Homeworks (45%)
- Paper Presentation (5%)
- Exam (30%)
- Final Project (20%)

Contact Information

- Class: Innovation Hall 136 4:30-7:10 pm
- Office: Engineering Building 4452
- Email: amarda@gmu.edu
- Office Hours: Mondays 2:30-4:30pm