UNIVERSITY OF SOUTH CAROLINA

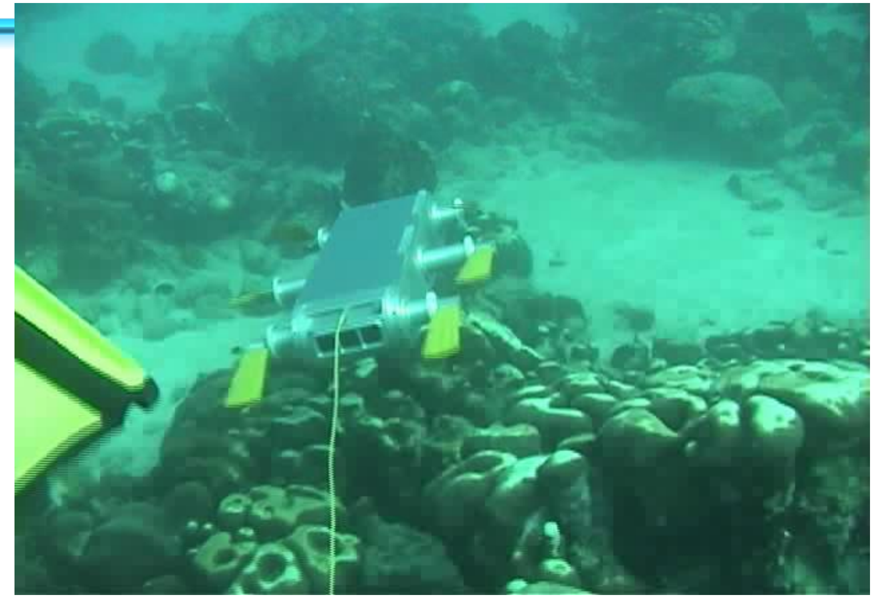
CSCE 774 ROBOTICS SYSTEMS

Introduction

Ioannis Rekleitis

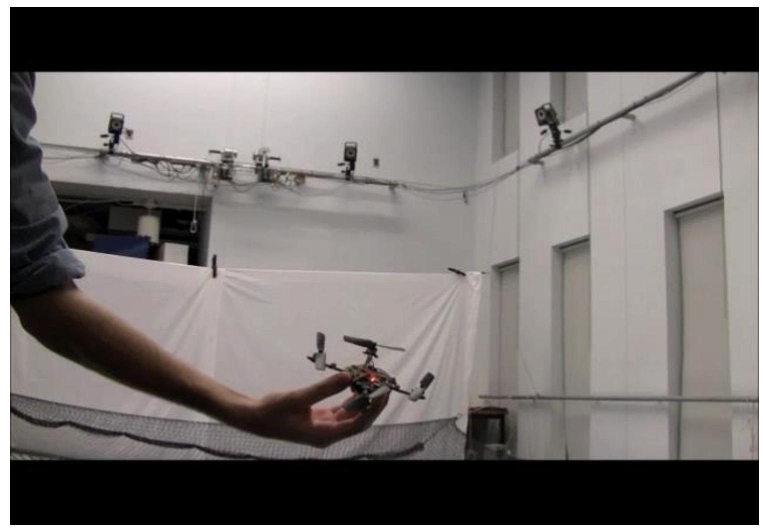
Why Robotics

Mars **E**xploration **R**over animation



Underwater exploration, Barbados

Roomba vacuuming robot in action.
More than 5M sold!



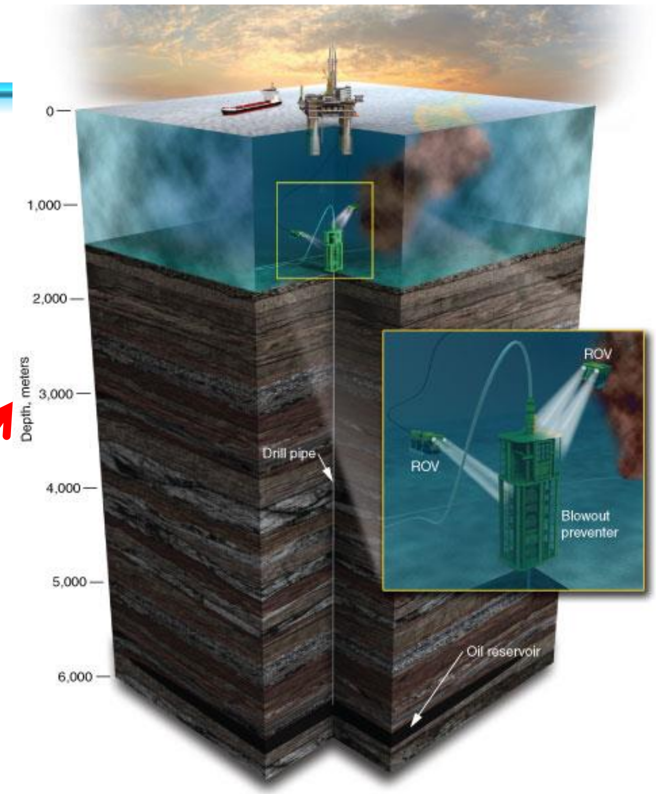
GRASP lab UPEN

Why Robotics?

- Manufacturing
- Labor shortage (agriculture, mining)
- Point where computers fast/cheap
- Automation of cars→more cars on highways
- To reach areas where no human can go

Present Everywhere

- At home
- On the road
- In the sky (drones)
- In the fields (agricultural robotics)
- In resource utilization (**ROV in the oil industry**)
- Along power lines
- In Hospitals
- Education



Robotic technology becomes affordable

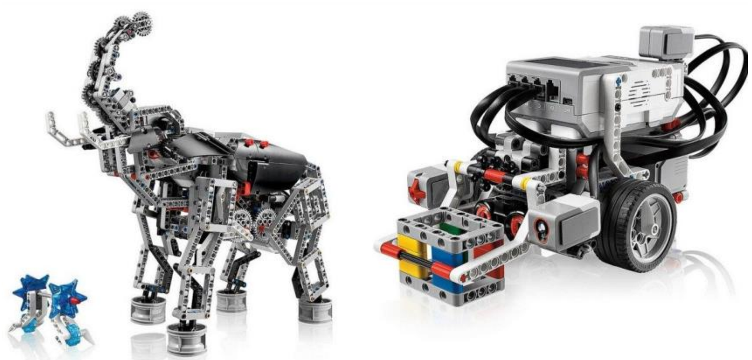
TurtleBot 2

AR.DRONE

Kinect

IMU

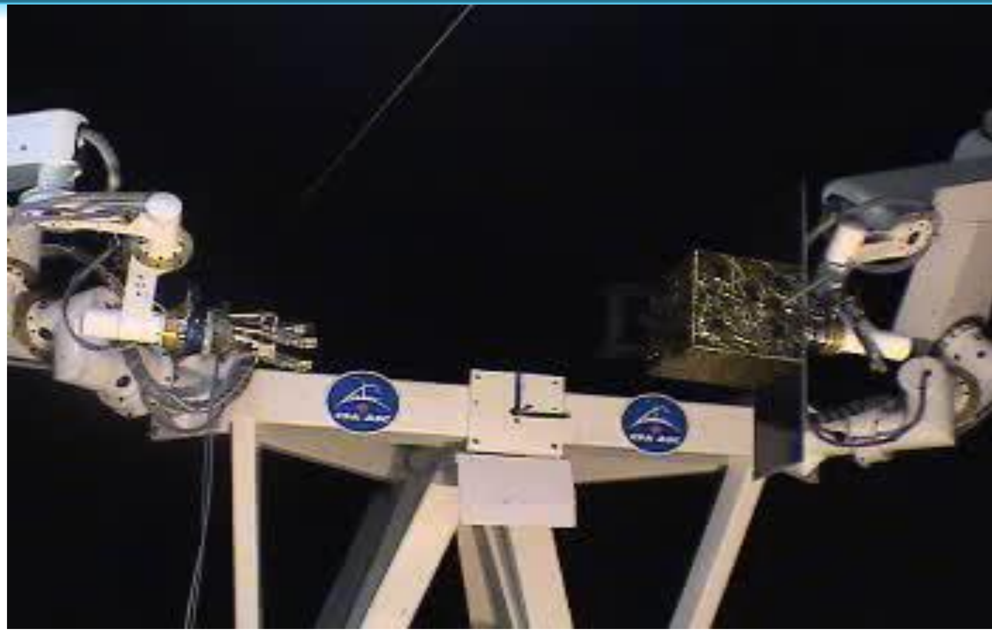
Raspberry Pi

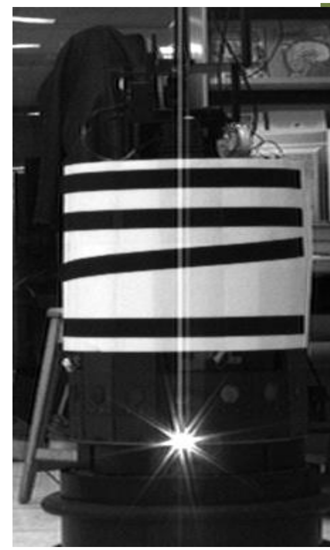


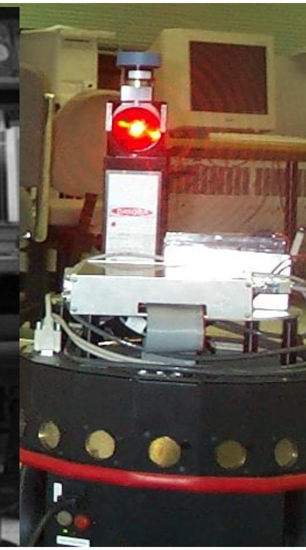
Lego Mindstorm

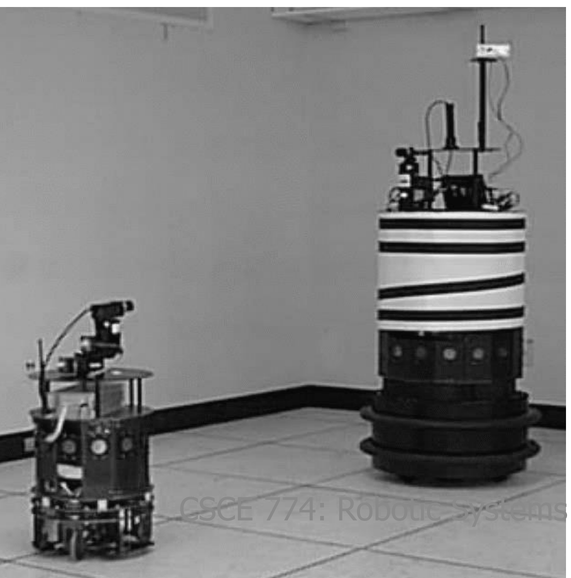
GPS

Past Projects

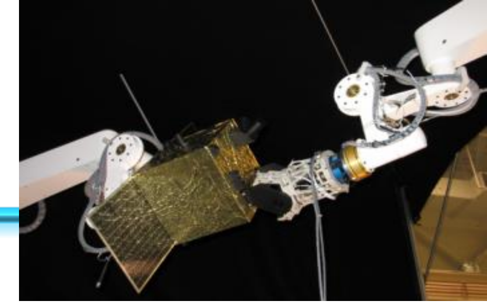


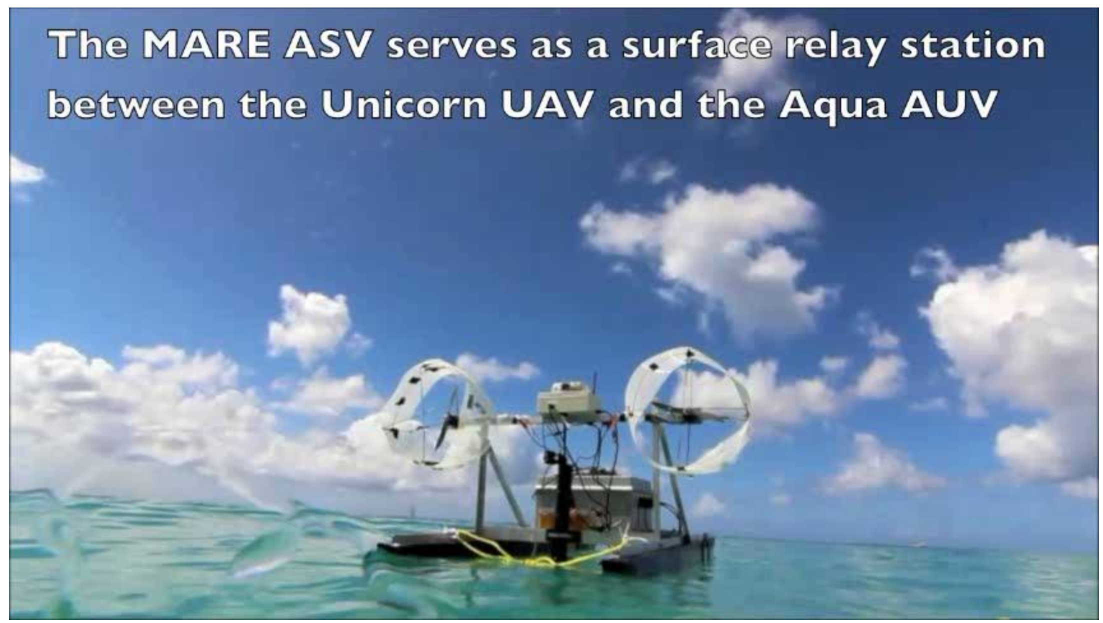






Past/Current Projects





Current work in U/W Robotics

Current work in indoor Robotics

Syllabus

Week 01: (21 Aug.) Syllabus presentation, Round Table, Introduction, History of Robotics. ROS
Week 02: (26 Aug.) Actuators. Locomotion. Sensor (Tactile, Range Finders, GPS, IMU, Position Encoders).
Week 03: (02 Sep.) Reactive Path Planning. Potential Fields. State Estimation, Bayesian Filtering
Week 04: (09Sep.) Particle and Kalman Filters
Week 05: (16 Sep.) Exploration, HRI
Week 06: (23 Sep.) Mapping: Metric Maps, Topological Maps, hybrids
Week 07: (30 Sep.) Visibility Graphs, Bug Algorithm, Generalized Voronoi Graphs, Atlas.
Week 08: (07 Oct.)
Week 09: (14 Oct.) Semantic hierarchy of spatial representations. Configuration Space, PRMs
Week 08: (21 Oct.) Architectures.
Week 09: (28 Oct.) Coverage, Multi-Robot Coverage
Week 10: (04 Nov.) Presentations
Week 11: (11 Nov.) Presentations
Week 12: (18 Nov.) Sensor (Vision).
Week 13: (25 Nov.) Presentations
Week 14: (02 Dec.) Review of Material
Week 15: **Oral Final**

Evaluation

• 3 Homeworks, 15% each:	45%
• Final Examination:	25%
• Project:	20%
• Presentation:	10%

Homeworks/Projects

- Using ROS
- Using Simulations
- Using sensor data from real robots
- Using real robots (TurtleBot, Parrot AirDrone2)

Contact

- http://www.cse.sc.edu/~yiannisr/
- http://www.cse.sc.edu/~yiannisr/774/2014

- **Email**: yiannisr@cse.sc.edu

- **Office hours**: 3A54 -- Tue/Th 14:30-15:30

  and by appointment

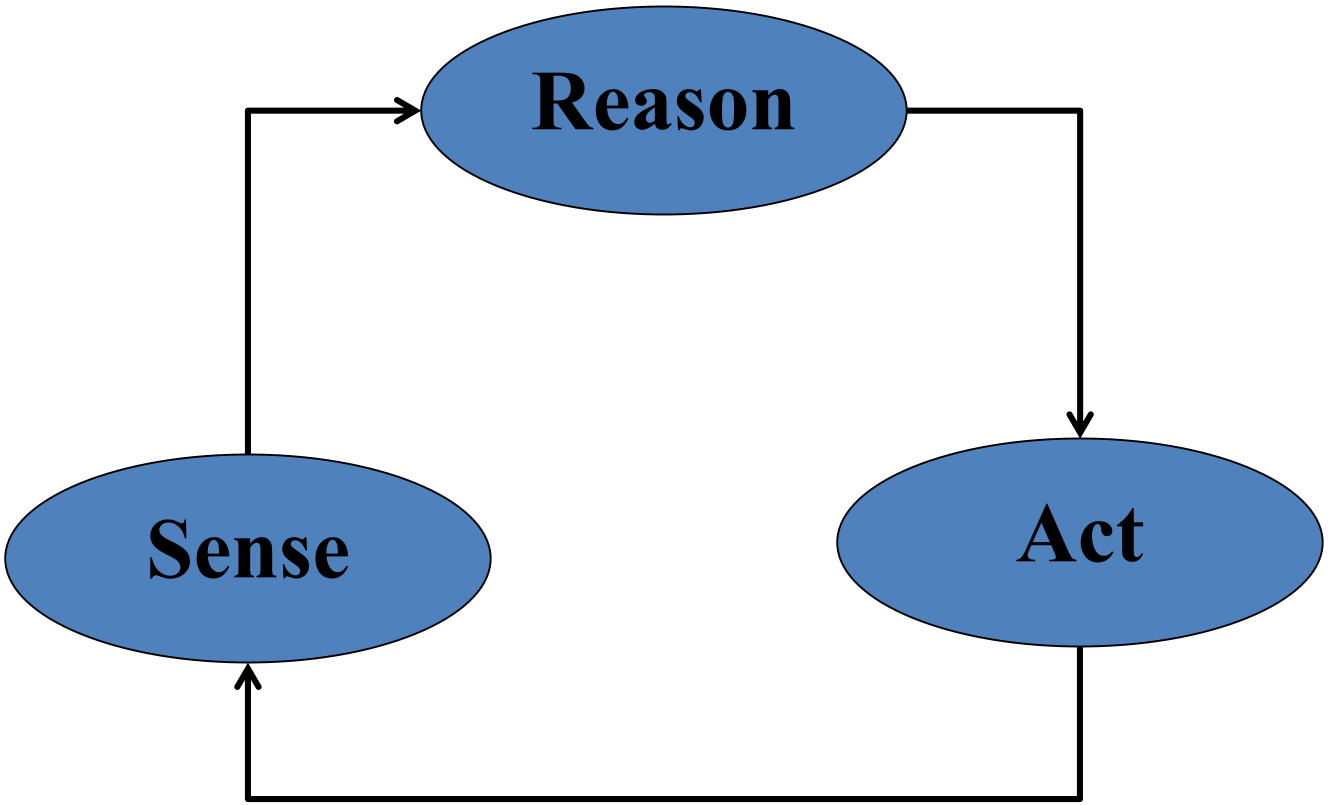
Class Interests

- Introductions
- Background
- Interests
- Projects
- Reasons
- Expectations

Three Main Challenges in Robotics

1. Where am I? (Localization)
2. What the world looks like? (Mapping)
   – Together 1 and 2 form the problem of *Simultaneous Localization and Mapping* (SLAM)
3. How do I go from **A** to **B**? (Path Planning)
   – More general: Which action should I pick next? (Planning)

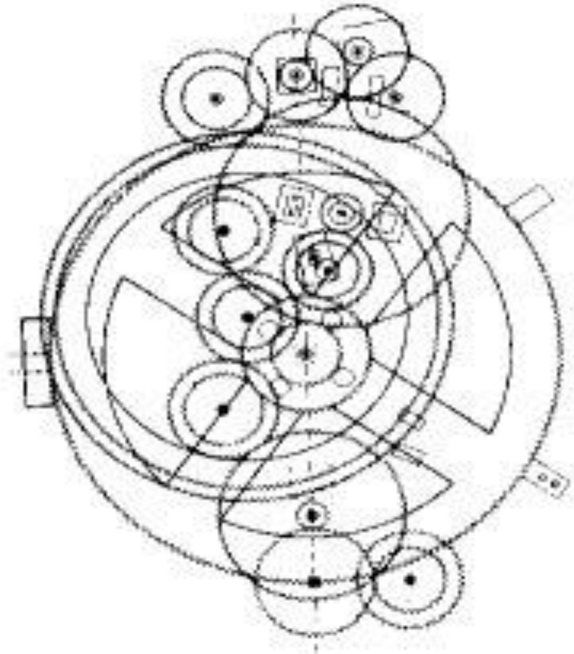
Robot



Talos (Τάλως/Τάλων) 400 BC

- A giant man of bronze who protected Europa in Crete, circling the island's shores three times daily while guarding it.
- Shore-length of Crete is 1.046 km.
- Average speed 130 Km/h

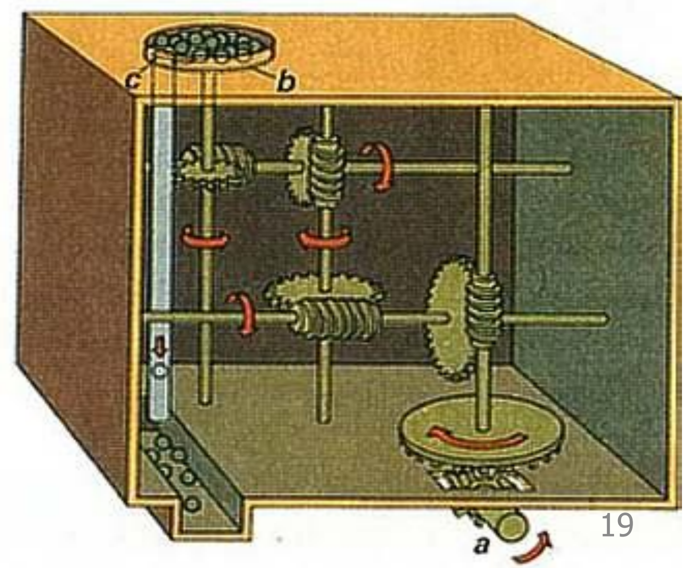
Automatons



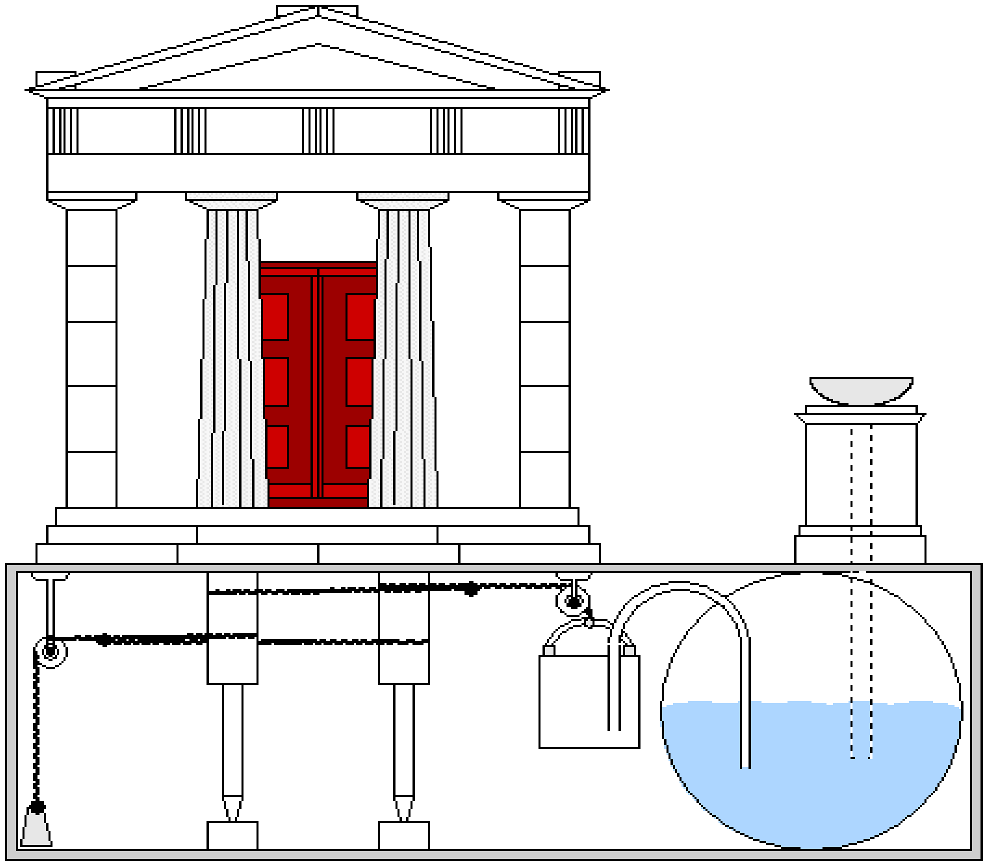
Antikythera, 150–100 BC

Heron of Alexandria (Ηρων ὁ Ἀλεξανδρεύς) 10-70AD

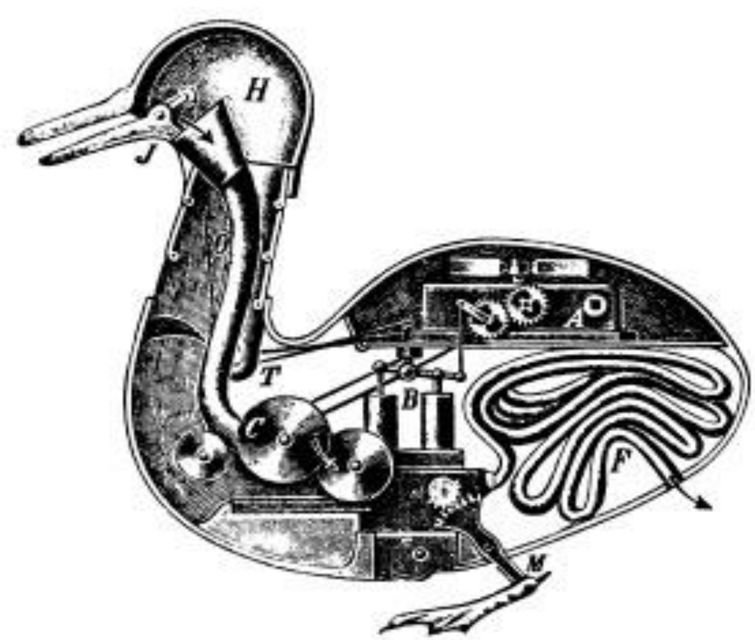
One of the first sensors: Odometer.



Heron of Alexandria

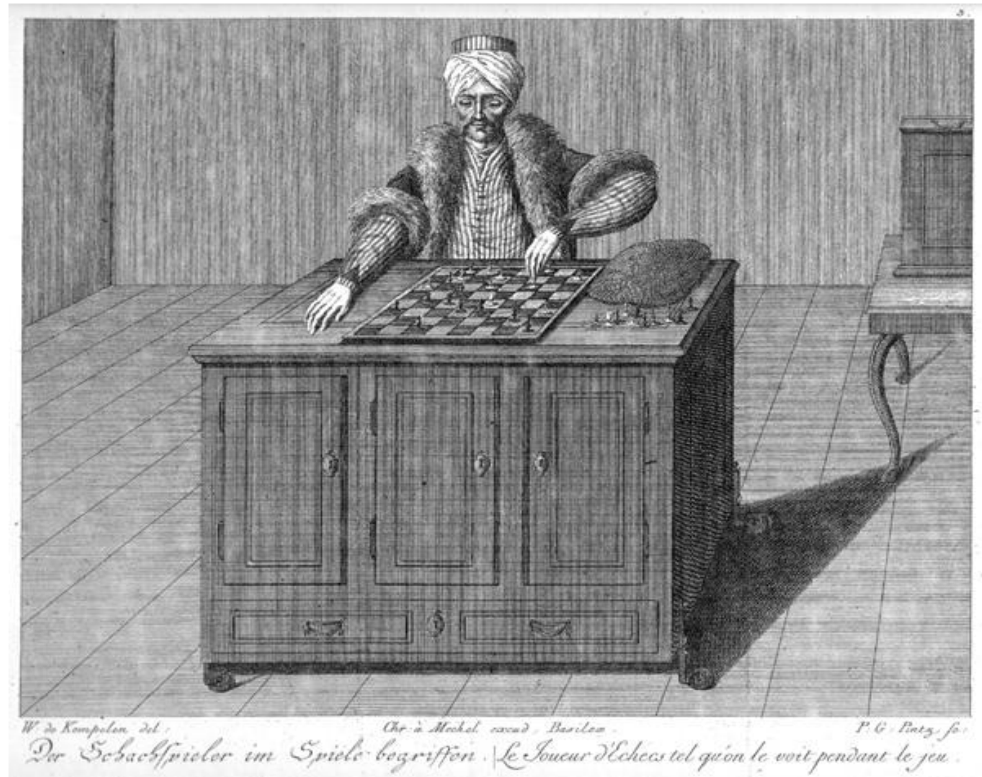


Automatons



“Canard Digérateur“,

1793



“The Turk“

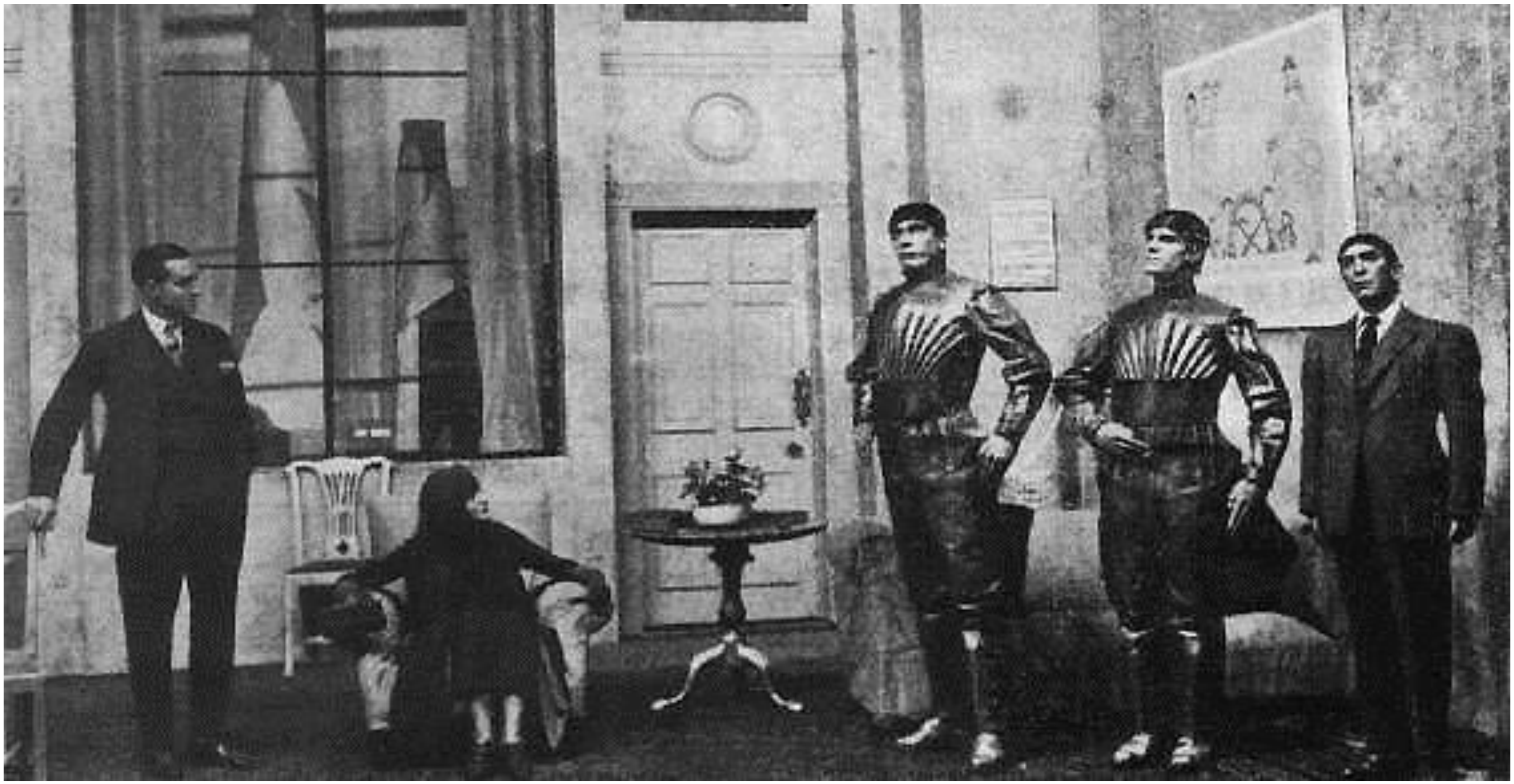
1770

Tea serving automaton

19th Century, Japan

Word "*Robot*"

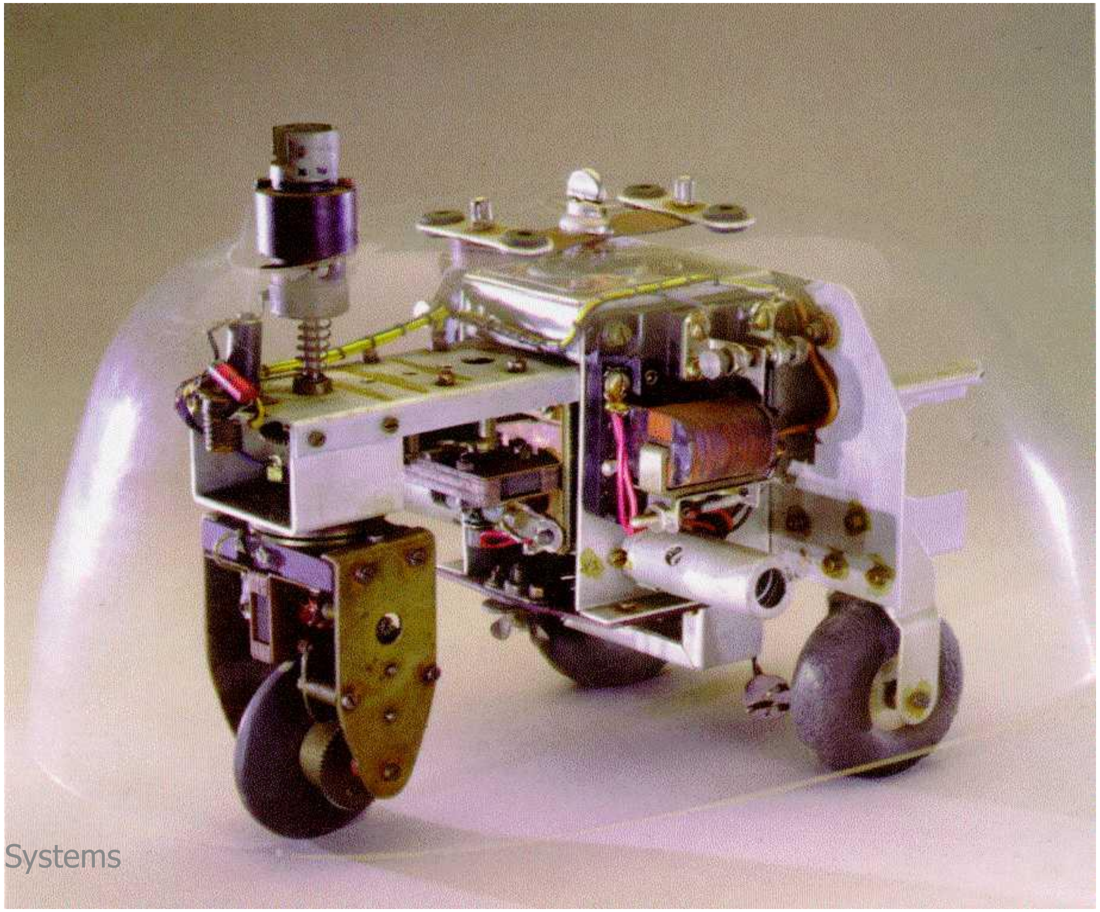
- *"Rossum's Universal Robots" a novel by* Karel Čapek, 1920.



Mobile Robots: 1950

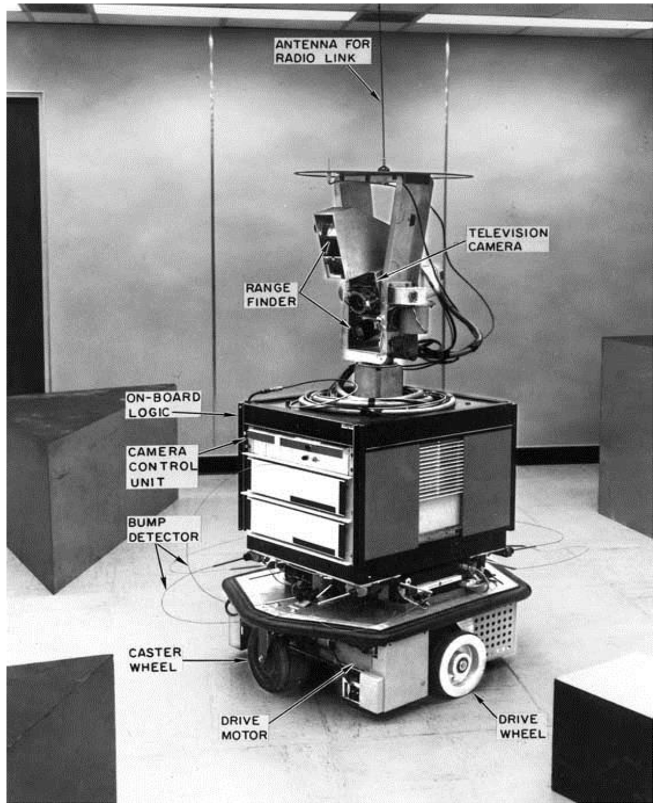
- Walter's *Tortoise*

  http://www.youtube.com/watch?v=lLULRlmXkKo



Shakey (1966 -1972)

- **Shakey** (Stanford Research Institute/SRI)
  - the first "autonomous" mobile robot to be operated using AI techniques
- **S**imple tasks to solve:
  - To recognize an object using vision, given a very restricted world
  - Find its way to the object
  - Perform some action on the object (for example, to push it over)
  - Perform compound actions and basic planning.



Stanford Cart

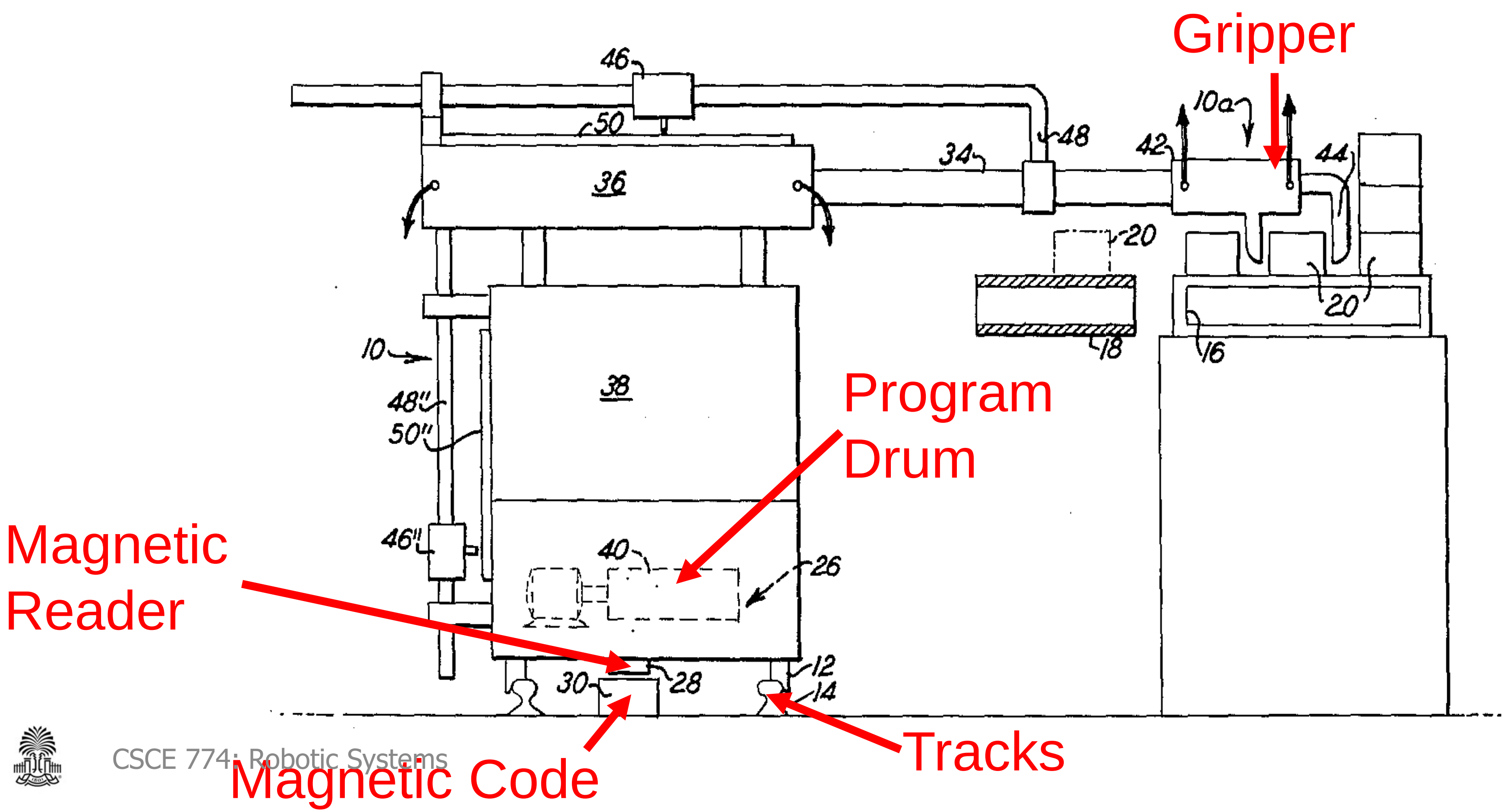
- 1973-1979
  - Stanford Cart developed by Hans Moravec
  - Use of stereo vision.
  - Took pictures from several different angles
  - The computer gauged the distance between the cart and obstacles in its path to do basic collision avoidance
  - About **15 min** to think about each image, then drives 1 foot or so.

Industrial history: 1961

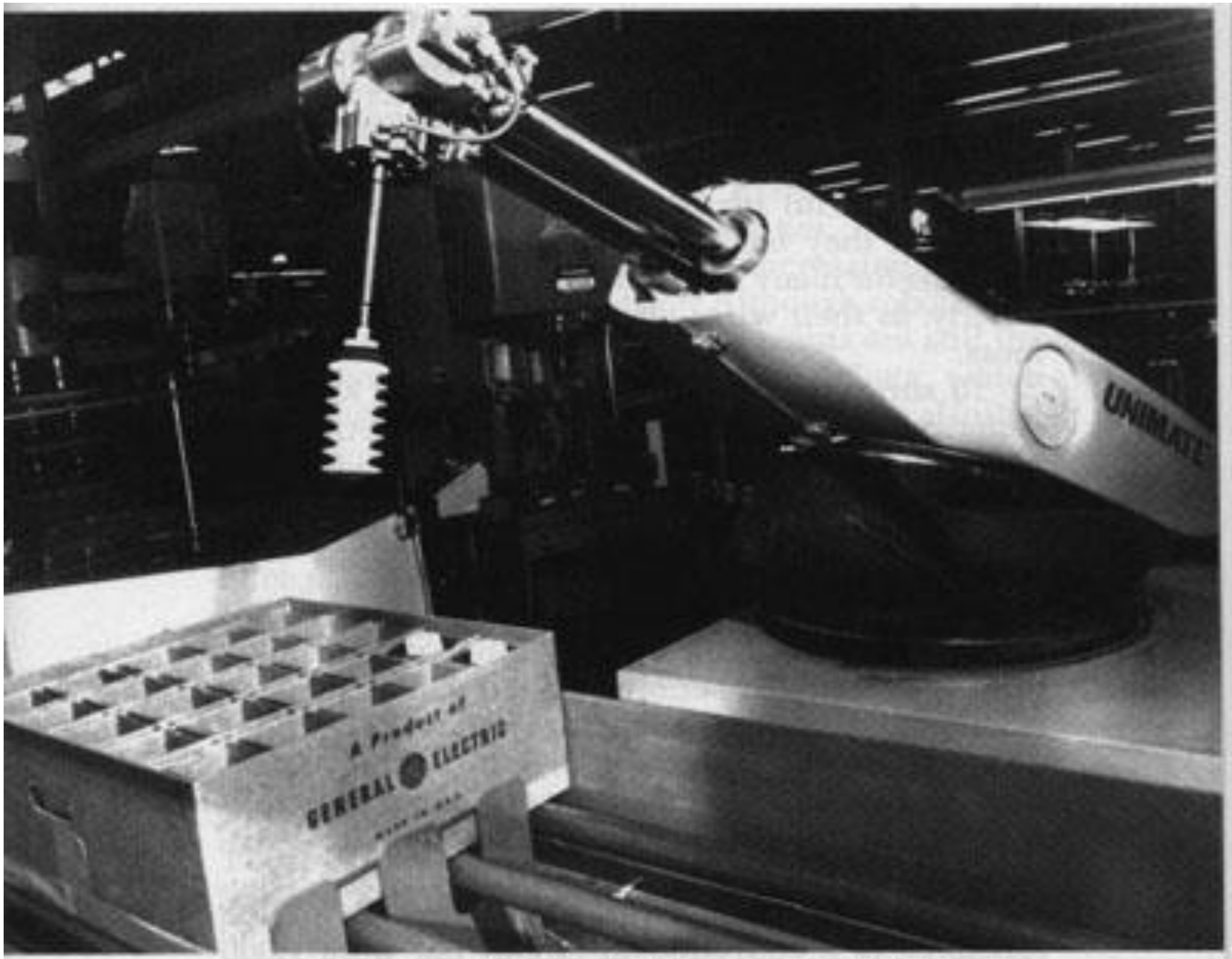
June 13, 1961 G. C. DEVOL, JR 2,988,237

PROGRAMMED ARTICLE TRANSFER

Filed Dec. 10, 1954 3 Sheets-Sheet 1

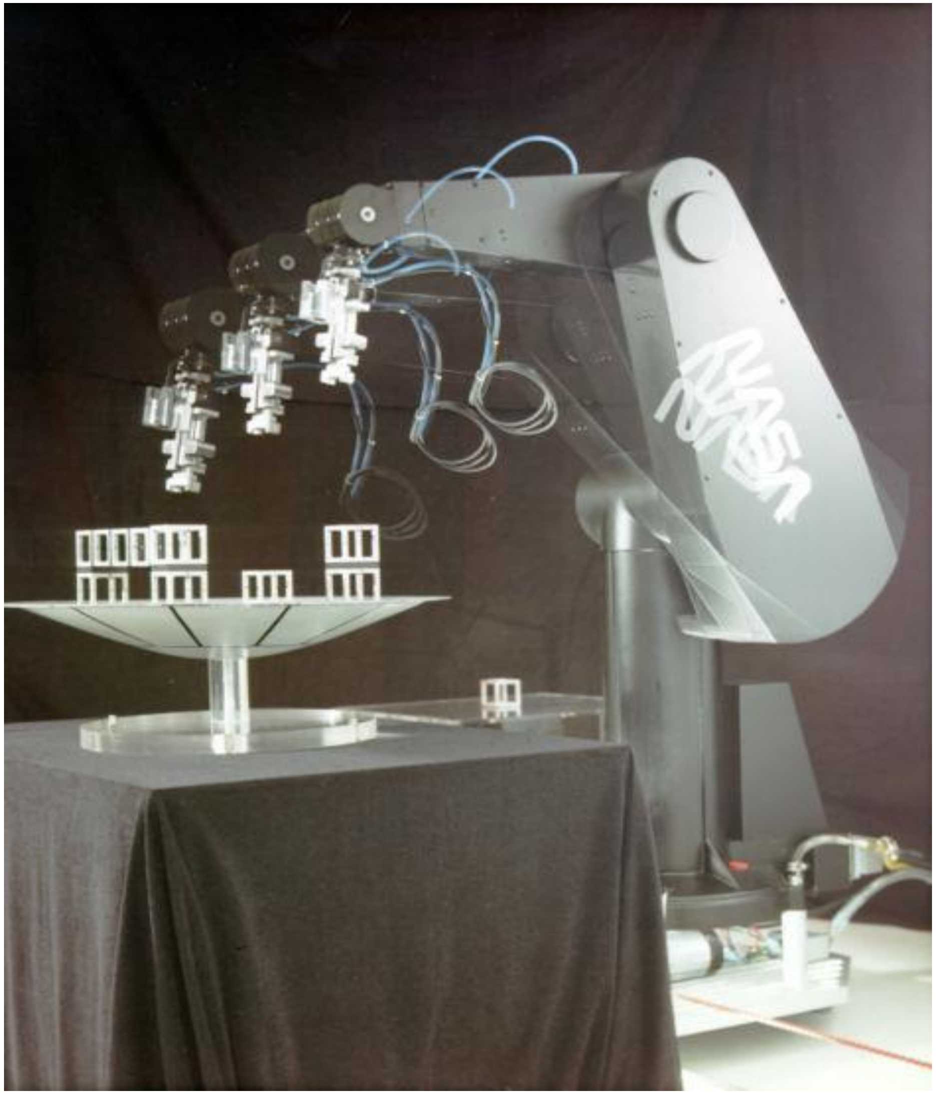


Industrial history: Unimate



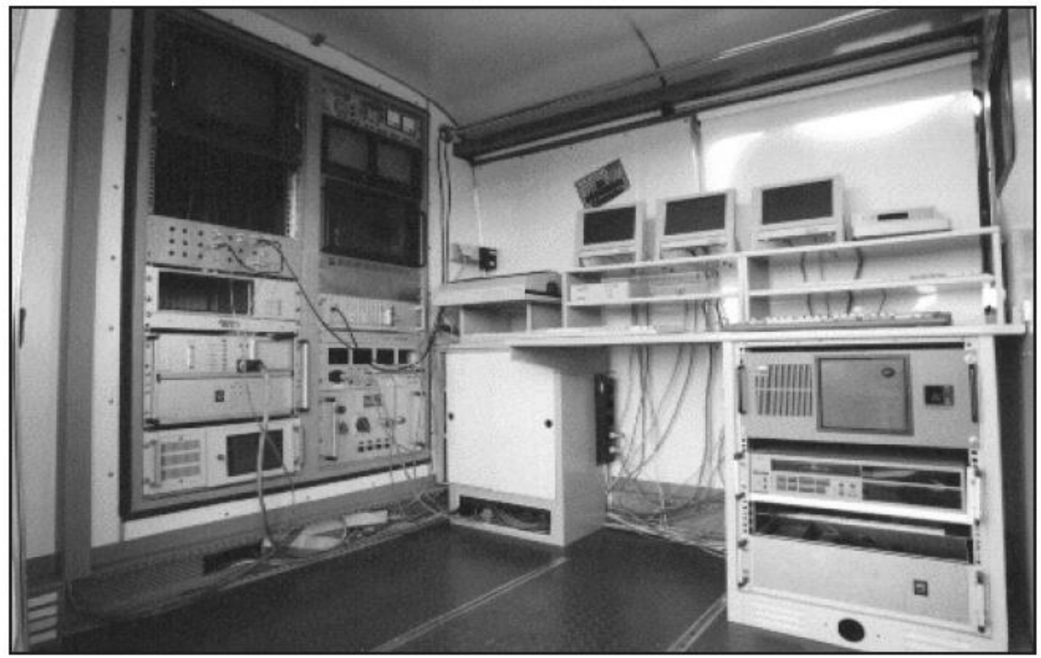
Armed for duty. A Unimate robot—really, just an arm—picks up and puts down parts in a General Electric factory.

Industrial history: Puma 1978



Robot Vehicle (Late 80's)

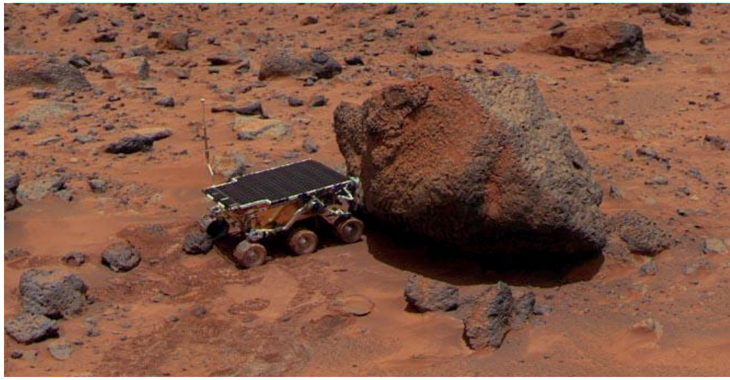
- *VaMoRs*: Highway driving
- Tracking white lines with Kalman filtering (Dickmanns)



Mid 90's: CMU's Navlab 5

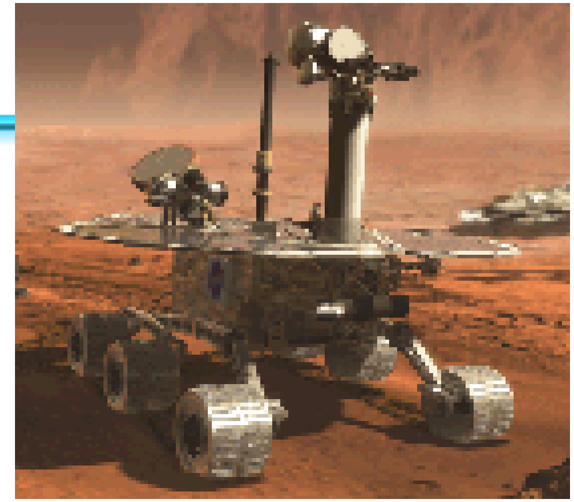
- Drove 2797/2849 miles (98.2%) on highways
- Throttle/Brake manually handled.

Exploring Mars

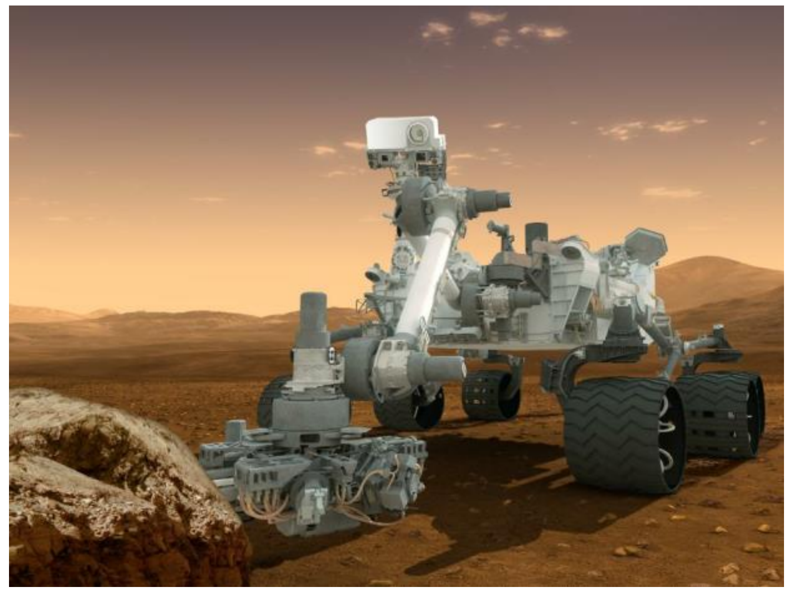


Sojourner
1997

Spirit and Opportunity
2003



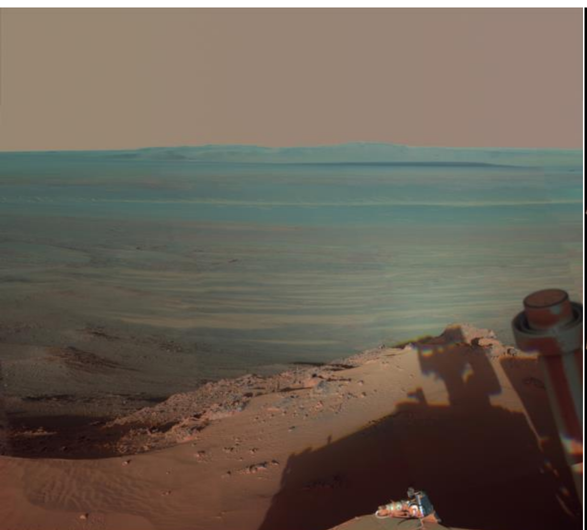
Phoenix-2008

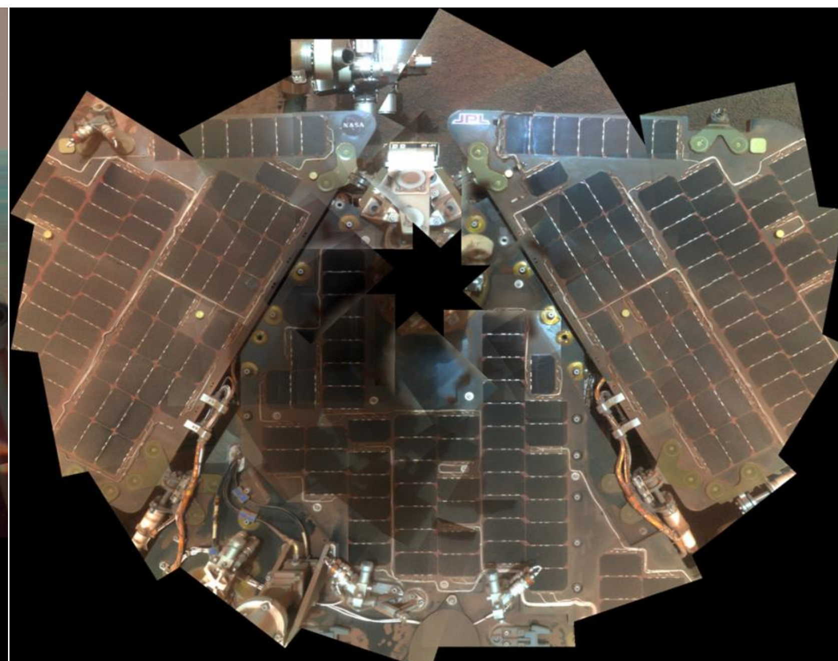


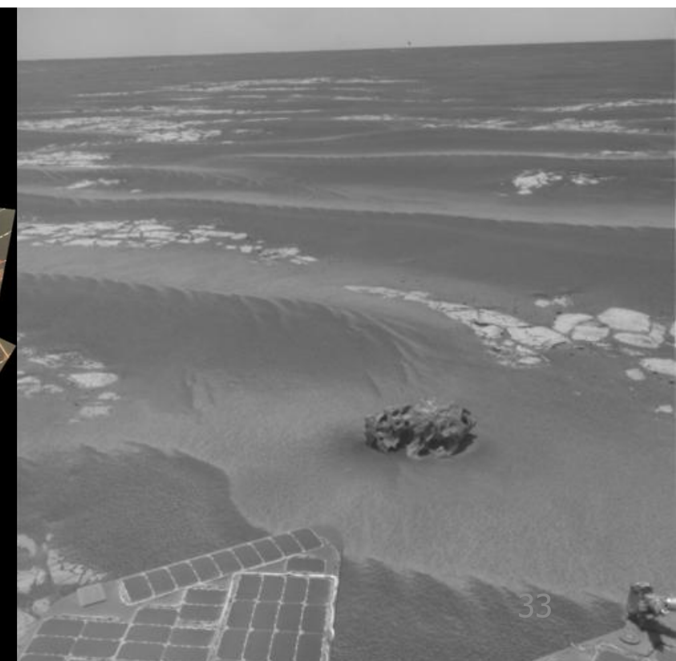
Mars Science Laboratory
Curiosity (2012)

More Current Data

- **Opportunity**, Sol **3751** (Aug. 12, 2014), 40+ Km
- **Spirit**, Sol 2210 (March 22, 2010), 7.7 km

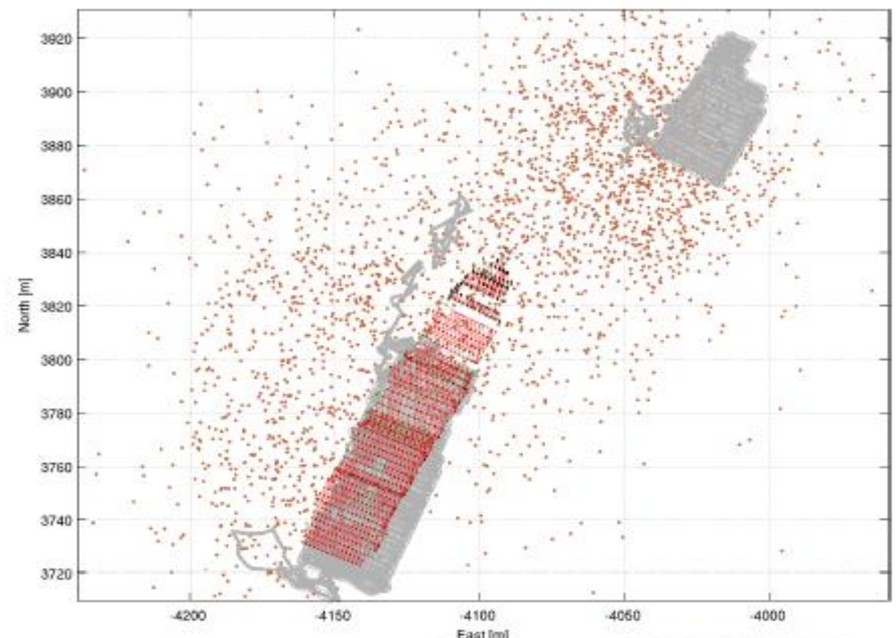






Highlights: Mapping the Titanic

Ryan Eustice, Hanumant Singh, John Leonard, Matthew Walter and Robert Ballard, *Visually navigating the RMS Titanic with SLAM information filters*. In Proceedings of the Robotics: Science & Systems Conference, pages 57-64, June 2005.



Highlights: DARPA Grand Challenge

- 2004: Mojave Desert USA, 240 km
  - CMU Sandstorm traveled the farthest distance, completing 11.78 km

- 2005: Mojave Desert USA, 240 km
  - **Stanford's Stanley, first place 6h54m**
  - CMU's Sandstorm, second place 7h05m

Highlights: DARPA Urban Challenge 2007

- George Air Force Base, California. 96 km urban area course

CMU's BOS,
first place 4h10m

Stanford's Junior,
second place
4h29m

Highlights: DARPA Robotics Challenge

1. Drive a utility vehicle at the site
2. Travel dismounted across rubble
3. Remove debris blocking an entryway
4. Open a door and enter a building
5. Climb an industrial ladder and traverse an industrial walkway
6. Use a tool to break through a concrete panel
7. Locate and close a valve near a leaking pipe
8. Replace a component such as a cooling pump

Highlights: DARPA Robotics Challenge

http://www.youtube.com/watch?v=hpeZGCzUmNY&feature=youtu.be

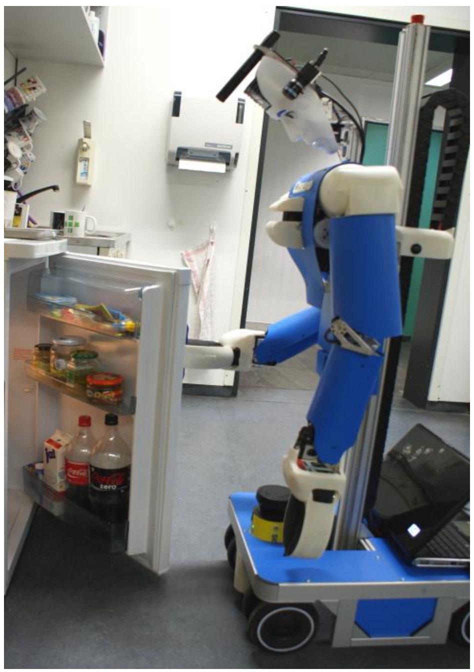
Driverless Car

- Safer
- More efficient
- Enable people

- The Nevada law went into effect on **March 1, 2012**, and the Nevada Department of Motor Vehicles issued the first license for a self-driven car in **May 2012**. The license was issued to a Toyota Prius modified with Google's experimental driverless technology.
- Google driverless car, with a test fleet of autonomous vehicles that as of May 2012 has driven **282,000** km.

Another trend
Mobile Manipulation

The robots have only interpreted the world, in various ways; the point is to change it.



http://pr.cs.cornell.edu/videos.php