Introduction to Vision & Robotics

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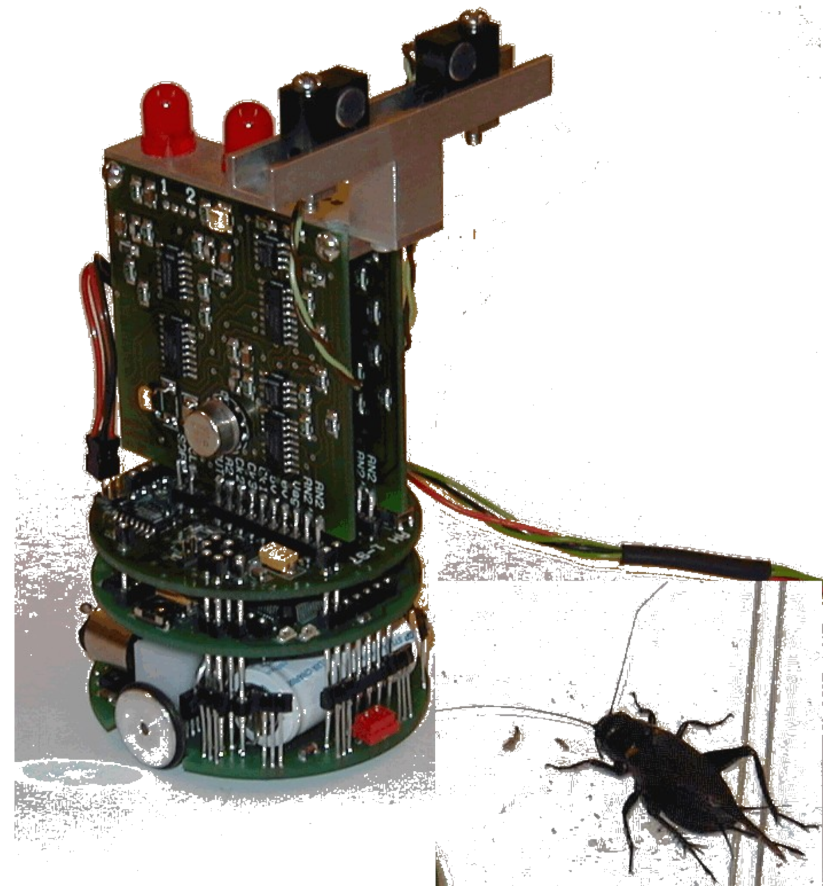


Lectures:

Handouts will be on the web (but are not a substitute for lecture attendance)

Practicals: please sign up for a time-slot (AT 3.01)

14:10 to 16:00 on Monday or 14:10 to 16:00 on Thursday from week 2

Problems: please let me know or see class reps.

Vision and Robotics: some definitions

- Connecting the computer to the “raw unwashed world” (Russell & Norvig)
- “create [from 2-d image] an accurate representation of the three-dimensional world and its properties, then using this information we can perform any visual task” (Aloimonos & Rosenfeld)
- Vision is the direct extraction of affordances from the optic array (Gibson)
- A robot is:“A programmable multi-function manipulator designed to move material, parts, or specialised devices through variable programmed motions for the performance of a variety of tasks” (Robot Institute of America)
- “Robotics is the intelligent connection of perception to action’’ (Brady)

Applications: dull, dirty or dangerous

Visual inspection of parts

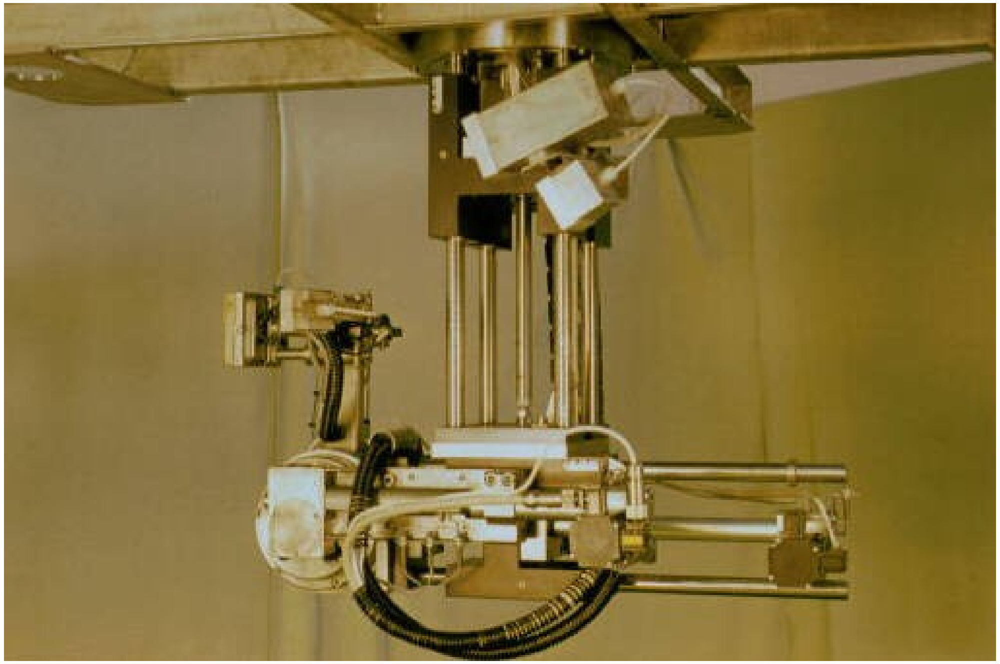
Detecting crime on CCTV

Welding on cars

N.B. Overlap with automation

Applications: dull, dirty or dangerous

Robot vacuum cleaners



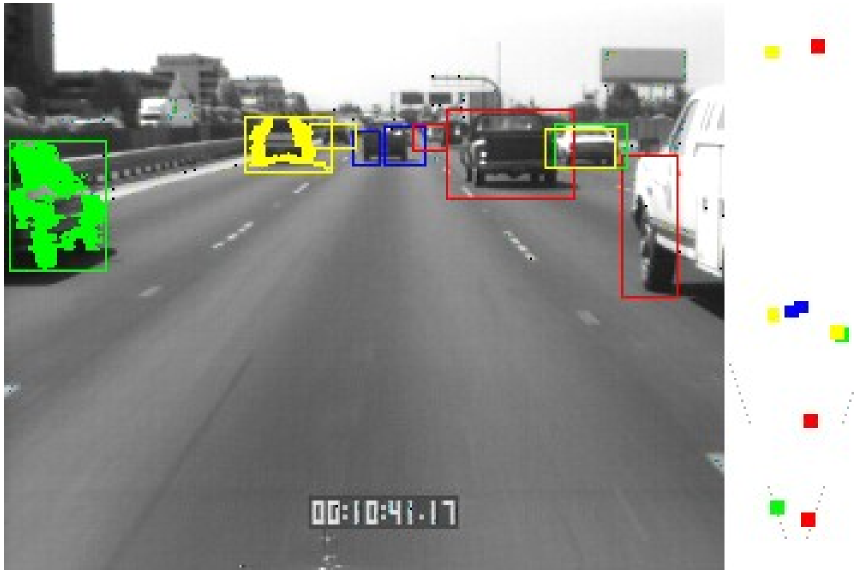
Cleaning nuclear plants

Robot sewer inspection

N.B. Overlaps with teleoperation

Applications: dull, dirty or dangerous

Visual aids for driving



Demining

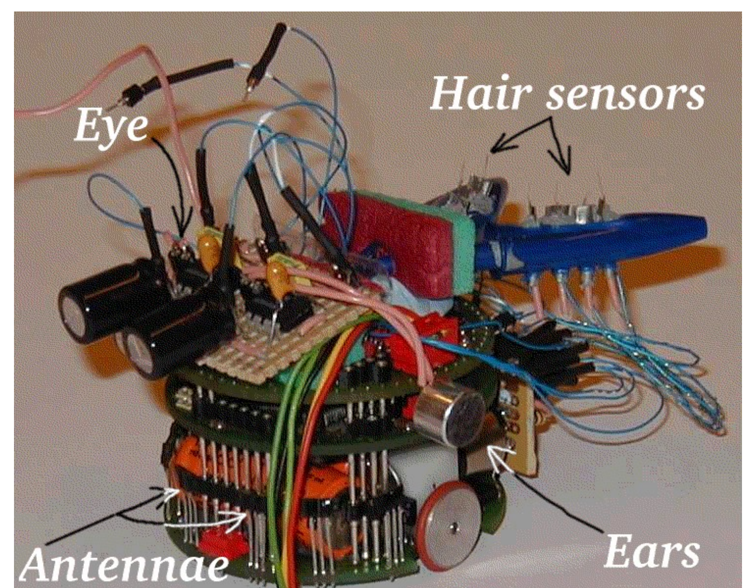
Space exploration

Applications: also...?

Entertainment industry

Service industry

Science



A challenging problem

- We don't have much introspective insight into how we see or how we control action
- Building vision and robot systems involves a variety of interacting *technology domains:*
  - *Mechanical, electrical, digital, computational...*
- This has proved to be a hard problem for AI
  - Can beat the human grandmaster at chess
  - Can't replace a house cleaner

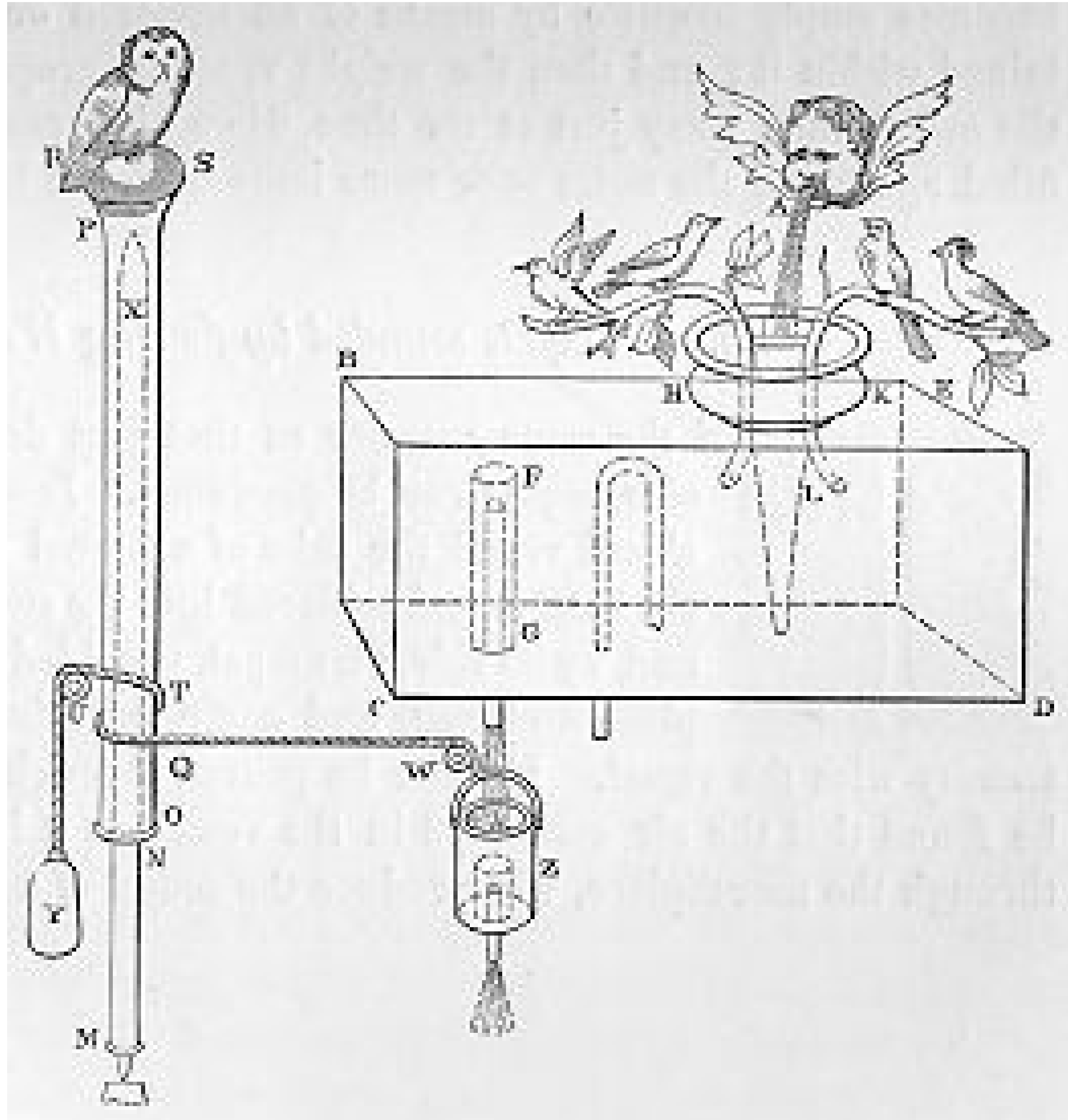
Vision and robotics uses all areas of AI:

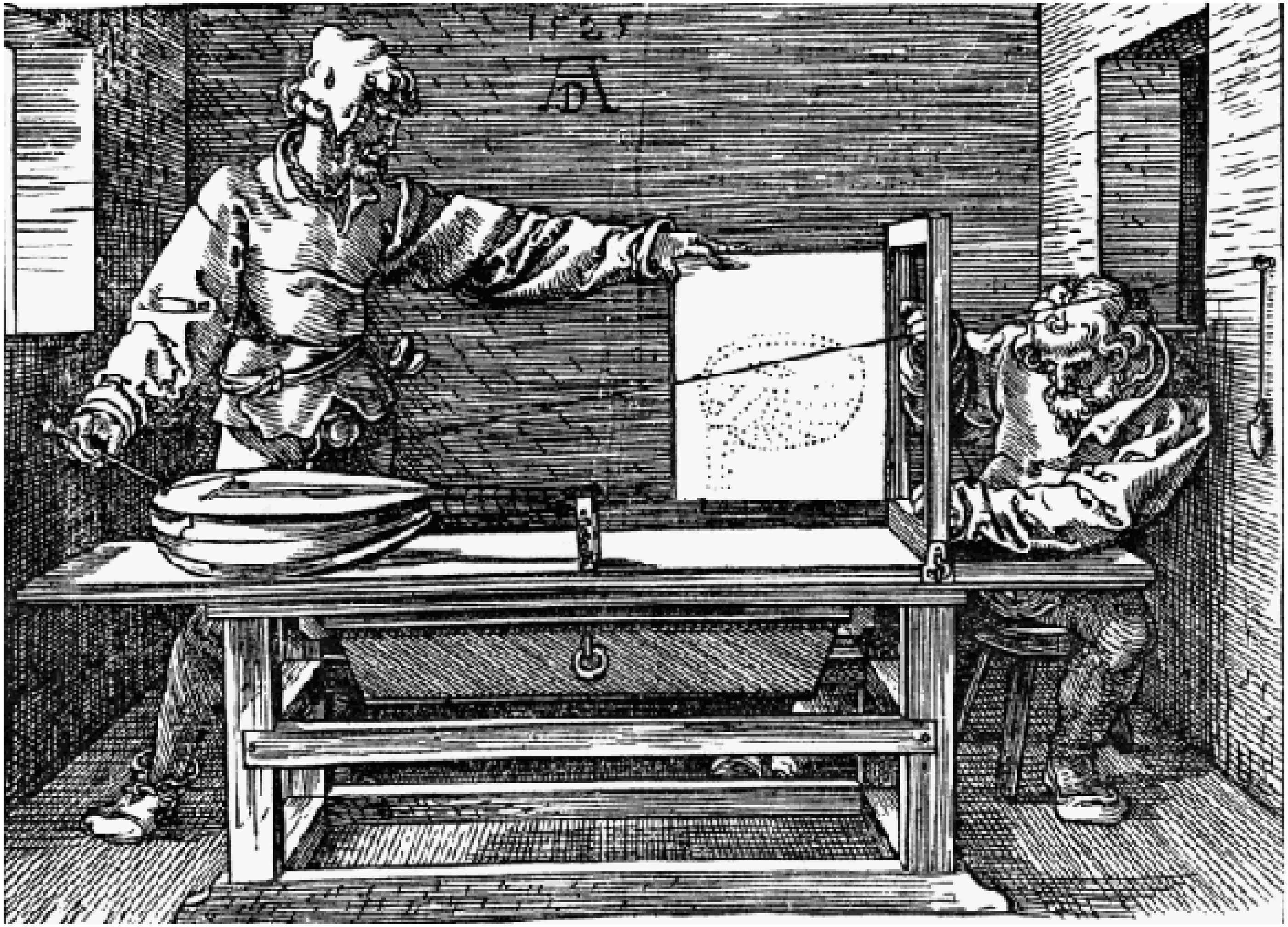
- Problem solving, planning, search, inference, knowledge representation, learning etc...
- But we can't just plug sensors and effectors onto an AI simulation and expect it to work
- Have constraints such as:
  - Limited, noisy, raw information
  - Continuous dynamic problem space
  - Time, power, cost and hardware limitations
- Often solutions grounded in these constraints do not resemble conventional AI approaches

Ancient Greek hydraulic and mechanical automata

Hero of Alexandria

AD 100





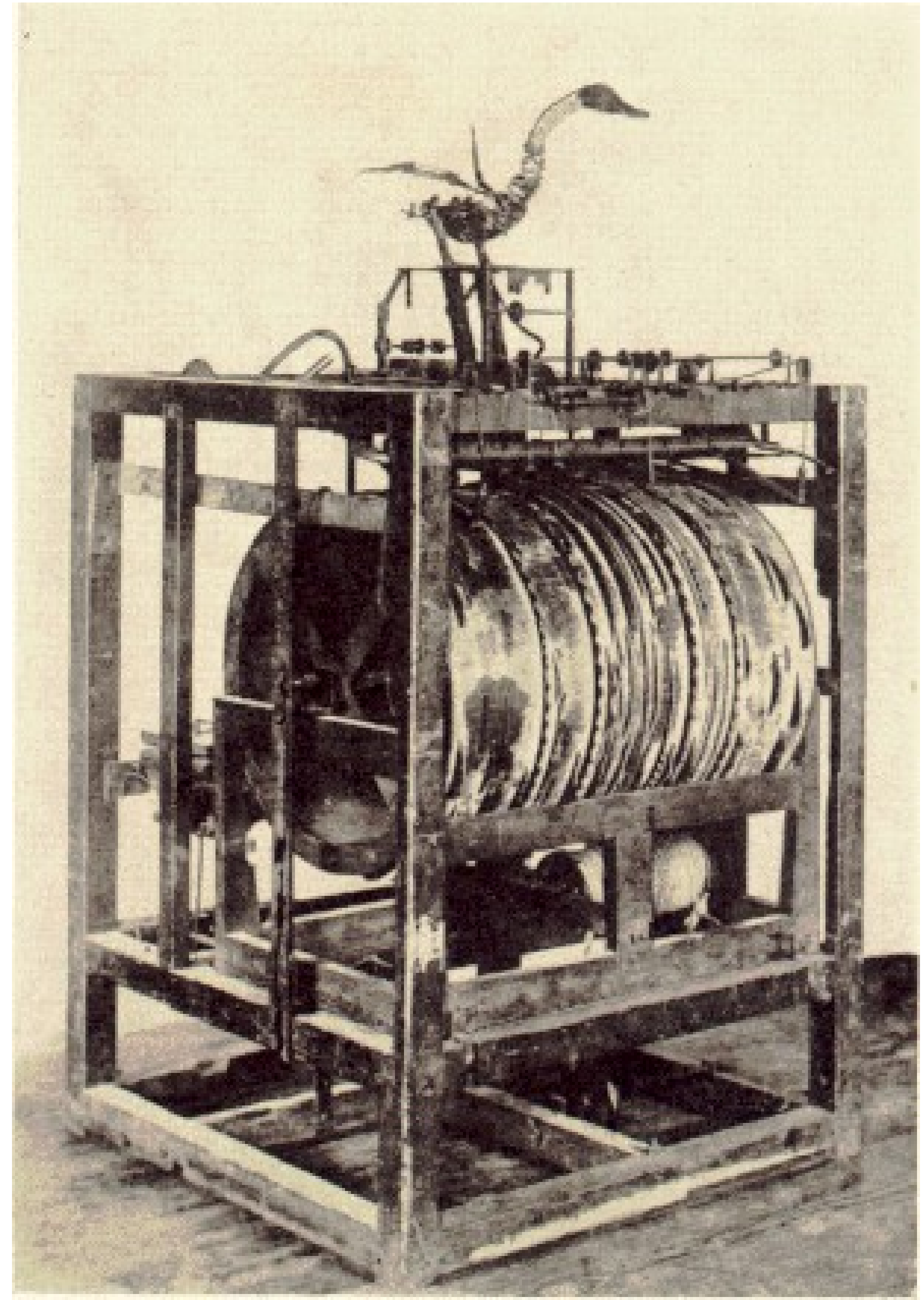
Renaissance optics:

The algorithmic connection between the world and the image - Dürer c.1500

18th century clockwork animals

Vaucanson's duck

Karakuri ningyō

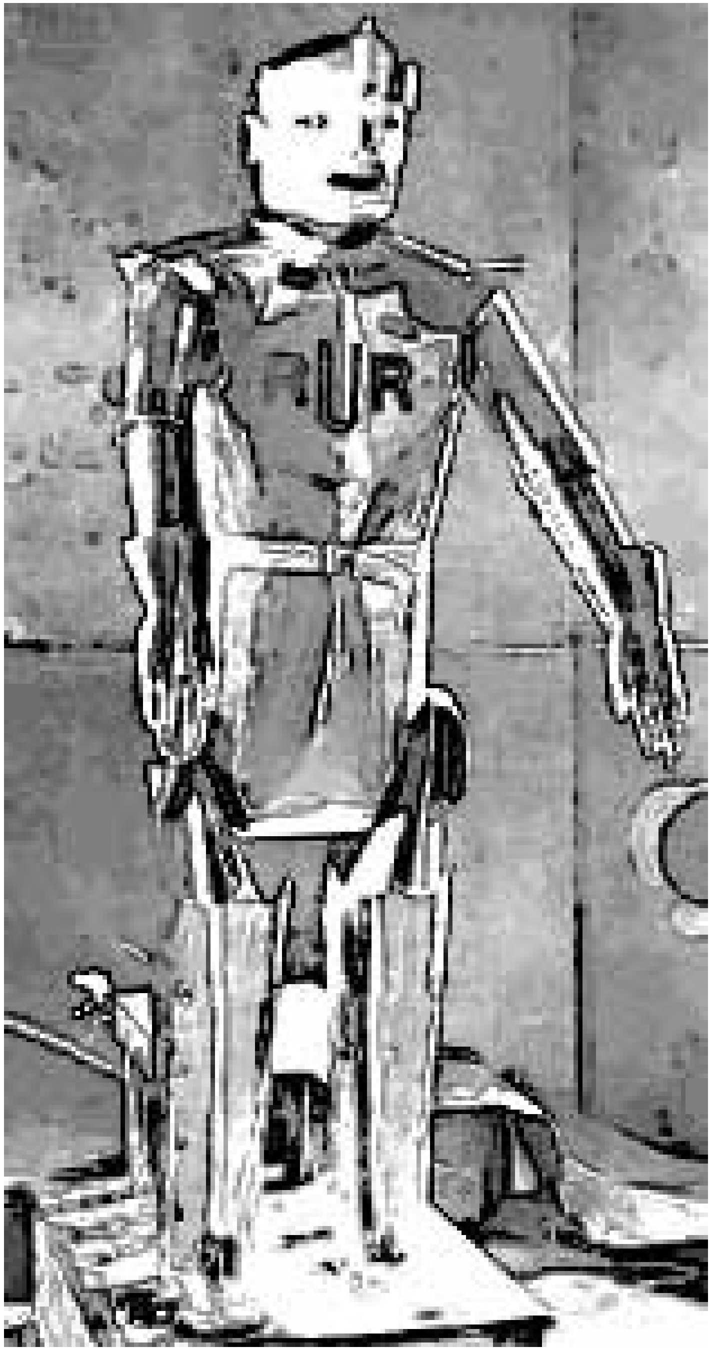


Early 20th century

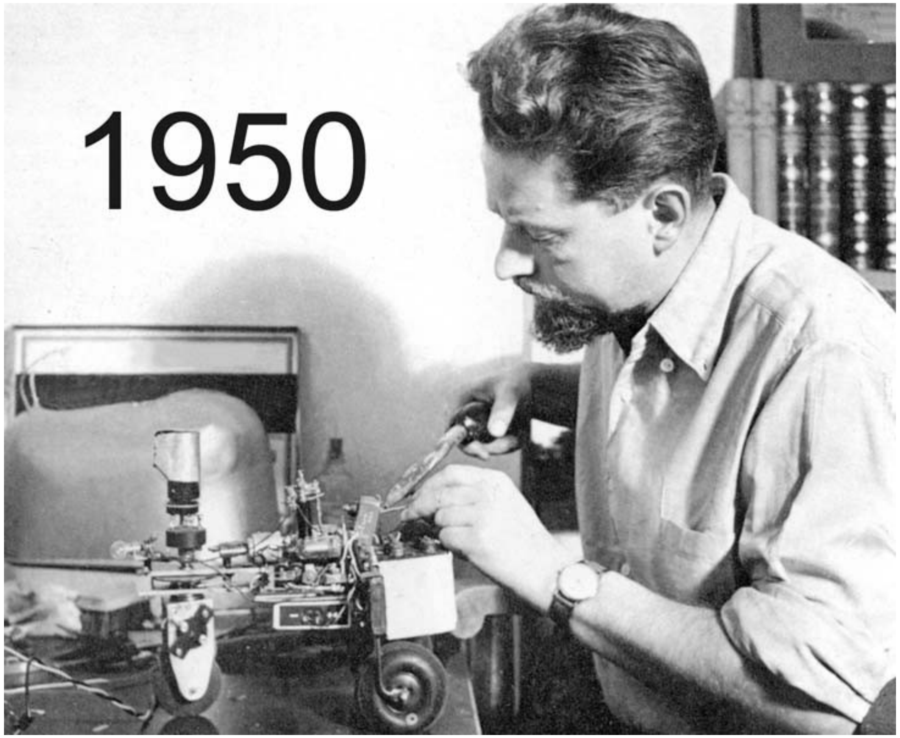
Electronic devices for remote control – Tesla

Methods for transducing images into electrical signals

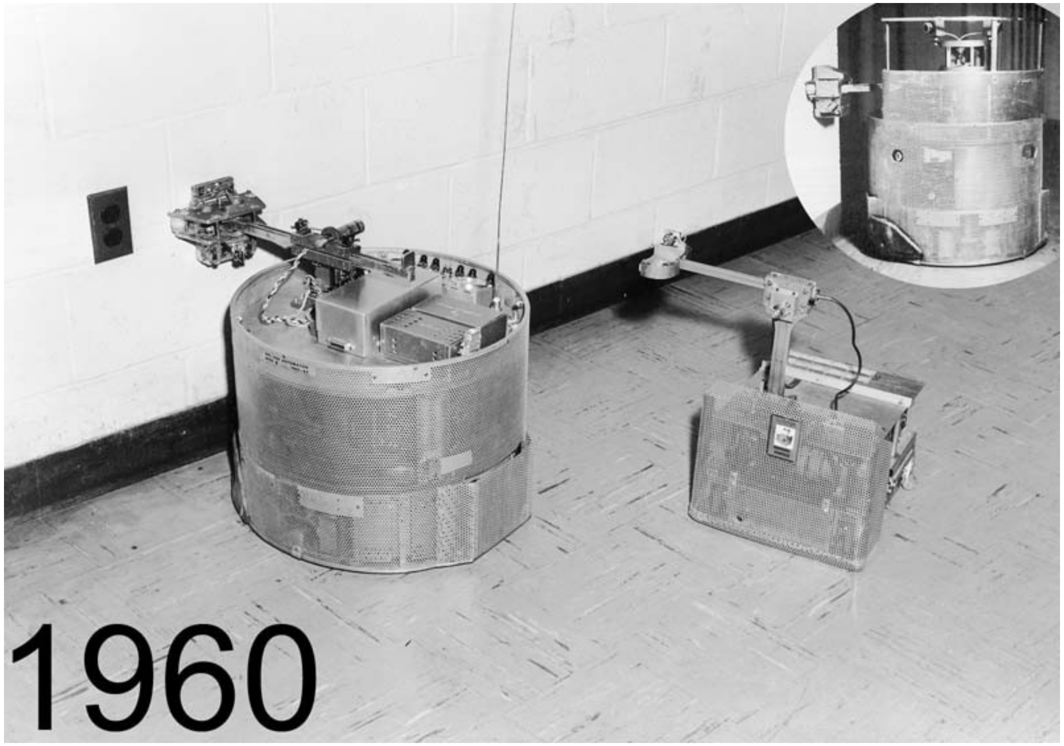
‘Robot’ used to describe artificial humanoid slaves in Capek’s play “Rossum’s Universal Robots” 1920



1940s –1950s



Development of electronic computer and control theory



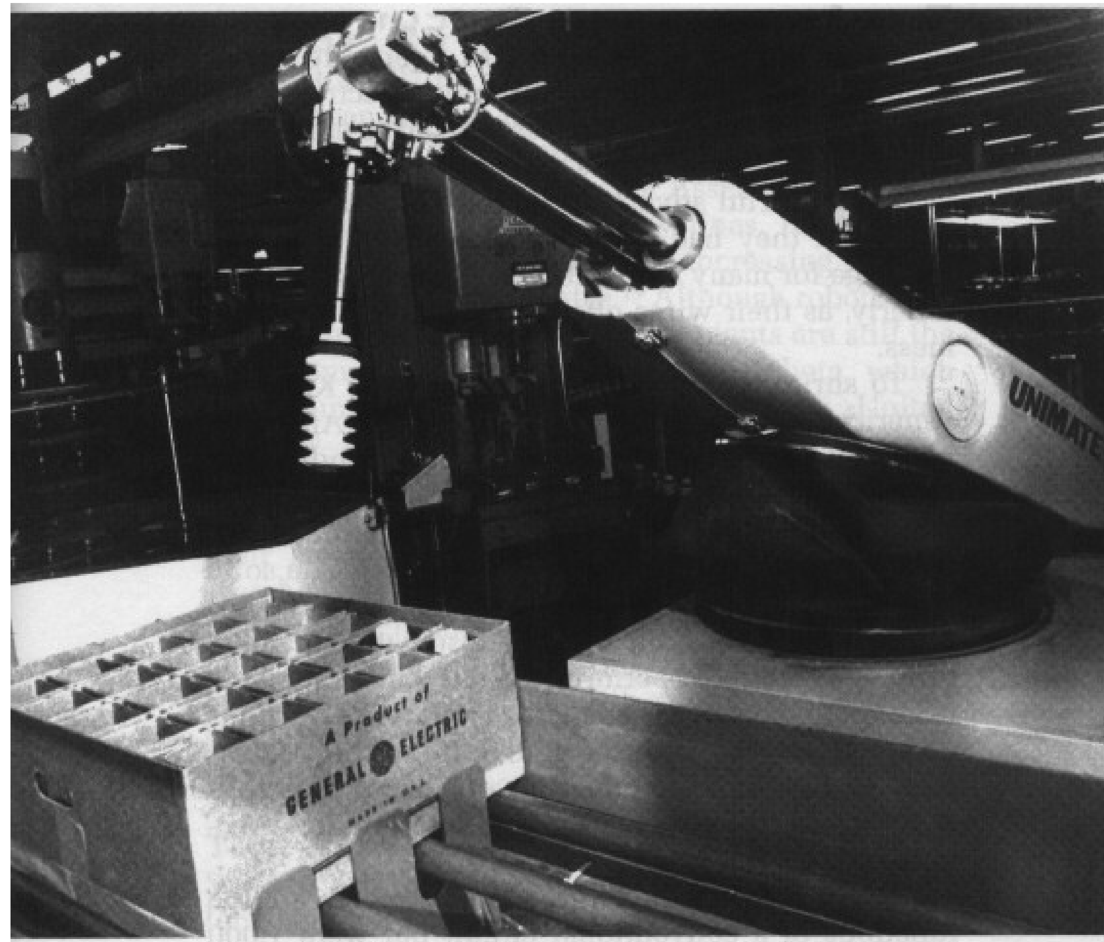
Used for artificial creatures e.g. Walter’s ‘tortoise’ and John Hopkins’ ‘beast’

1960s

Industrial robot arms:

Unimation

Methods for image enhancement and pattern recognition



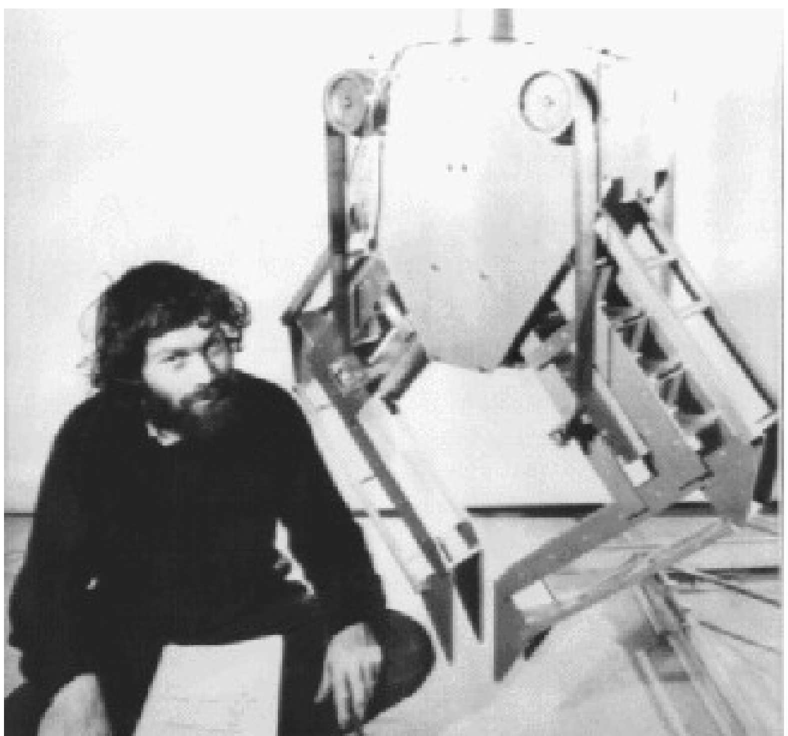
Armed for duty. A Unimate robot—really, just an arm—picks up and puts down parts in a General Electric factory.

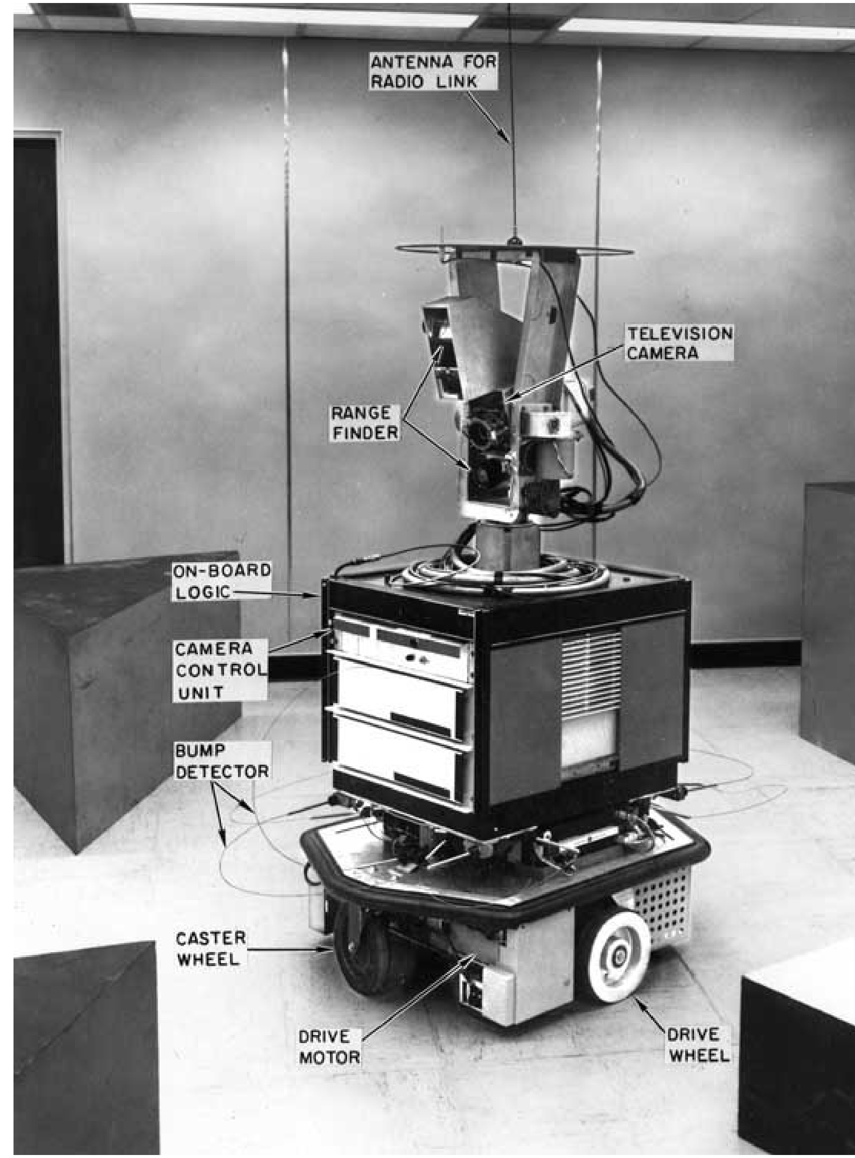
1970s

Work on systems in restricted domains

e.g. Shakey in blocks world

Freddy assembly task





1980s

Tackling more realistic problems:

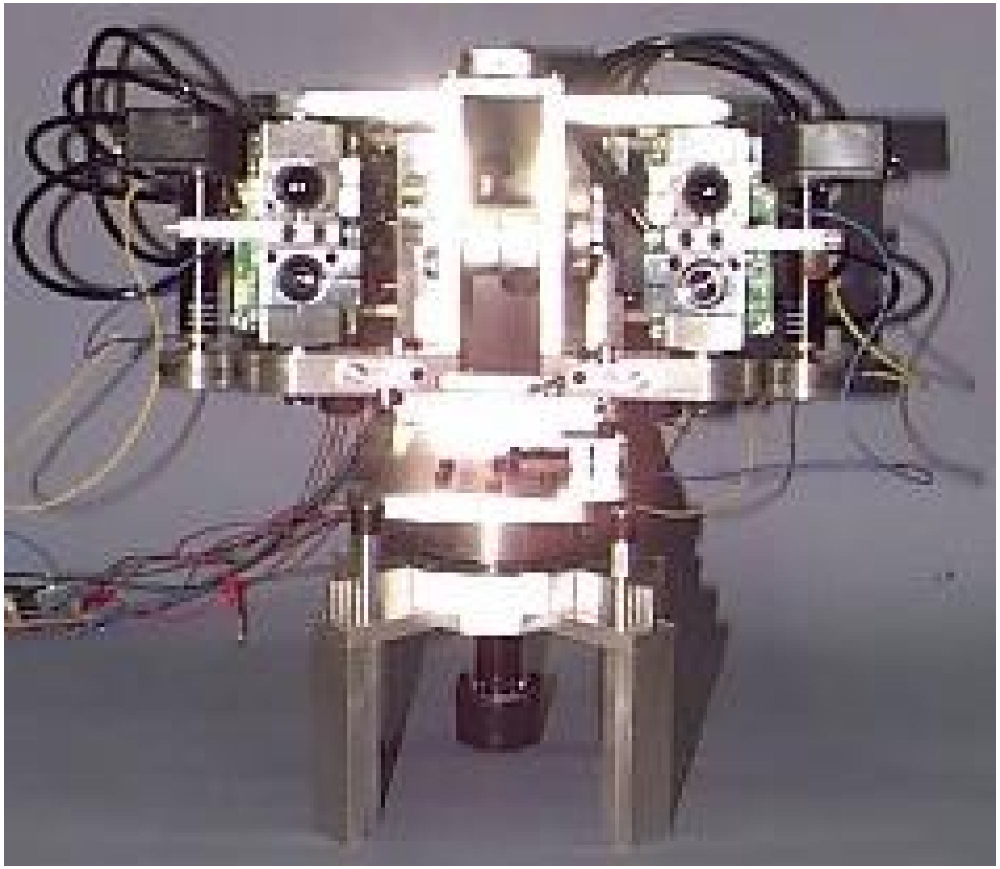
Natural scene analysis

Face recognition

Dynamic locomotion

Significant impact in manufacturing

Active vision

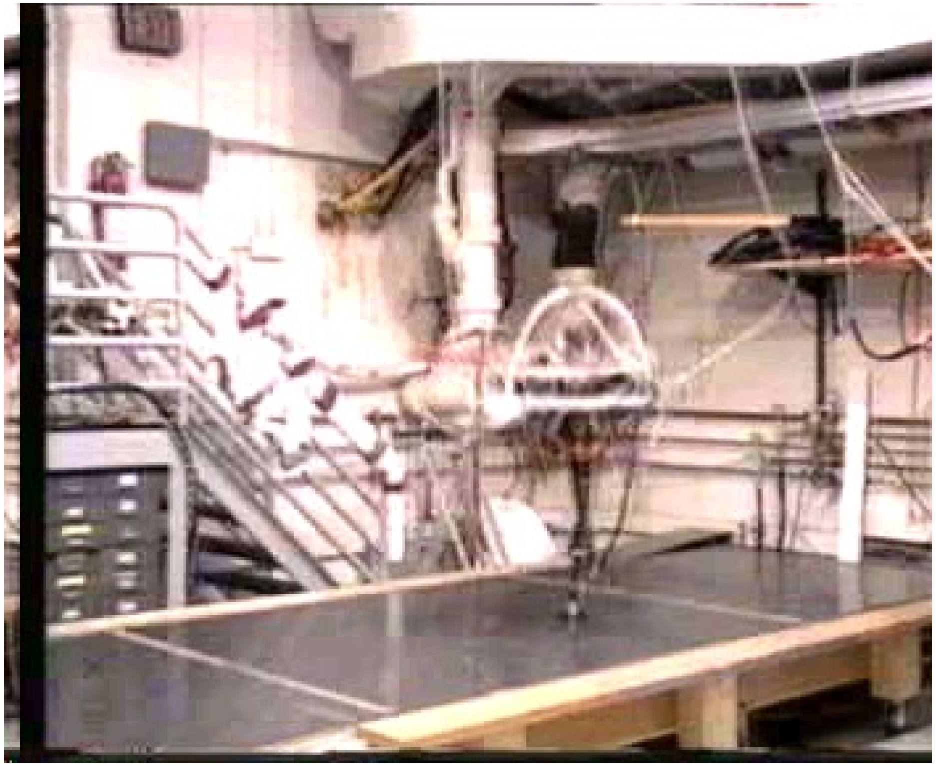


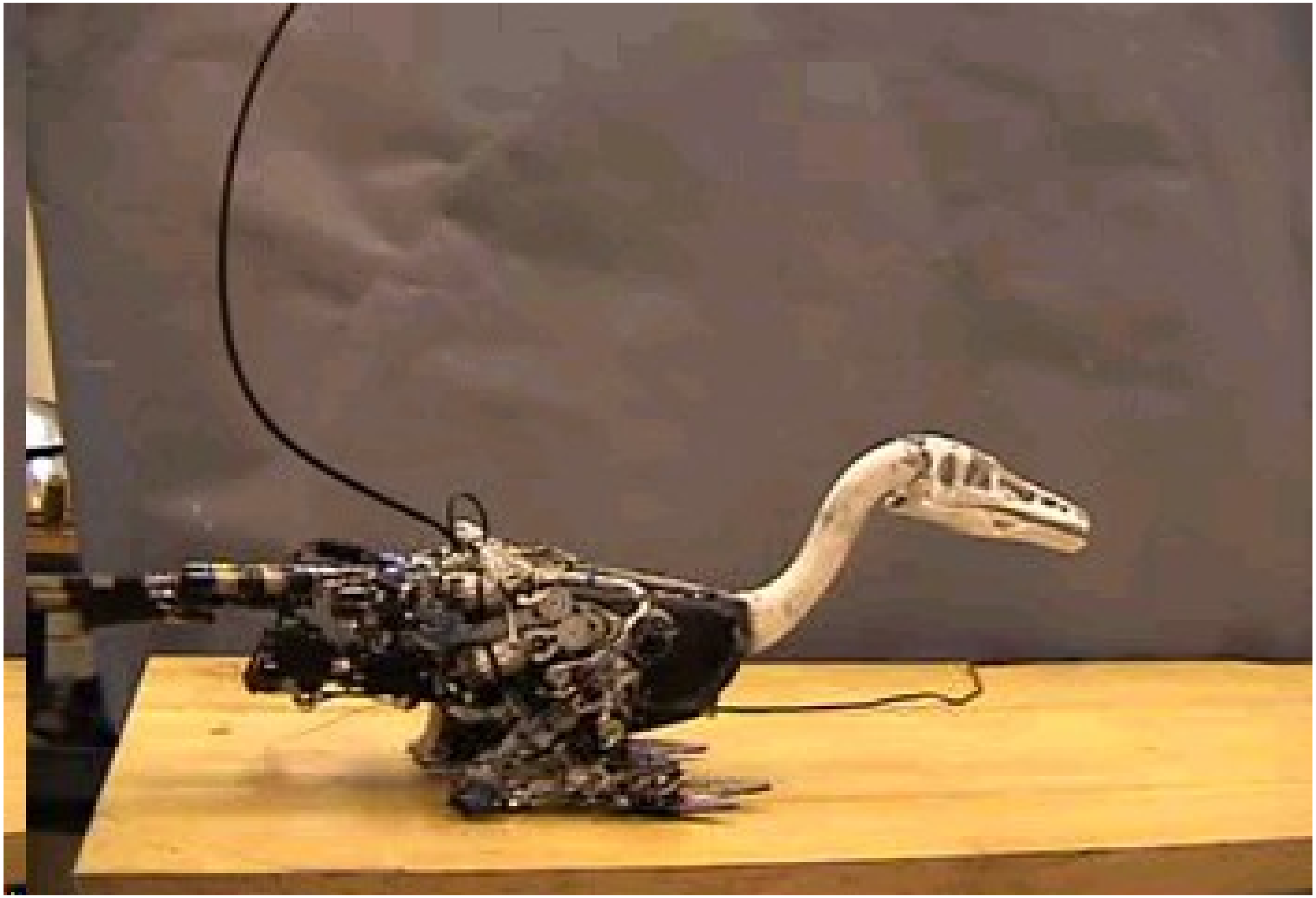
Recent highlights:

Leg Lab - MIT

1980 onward

1995 – biped acrobatics





(Leg lab continued) 2000 – complex biped

Recent highlights:

NavLab

CMU 1987 onwards

1995 ‘No hands across America’ drive from Pittsburgh to SanDiego

98.2% autonomous

3 U.S. states have passed laws permitting driverless cars: NV, FL, CA

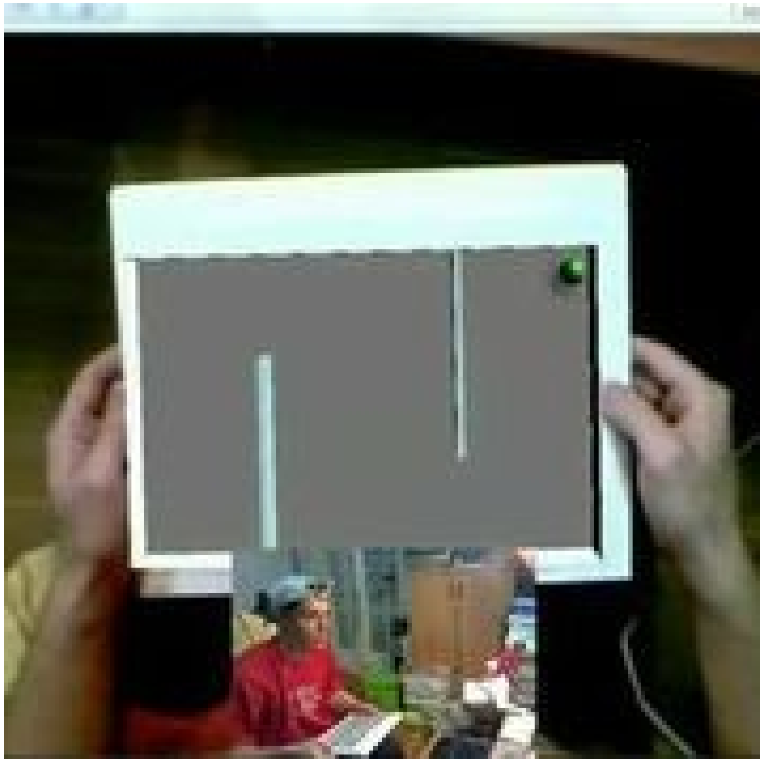
Military – Predator UAV

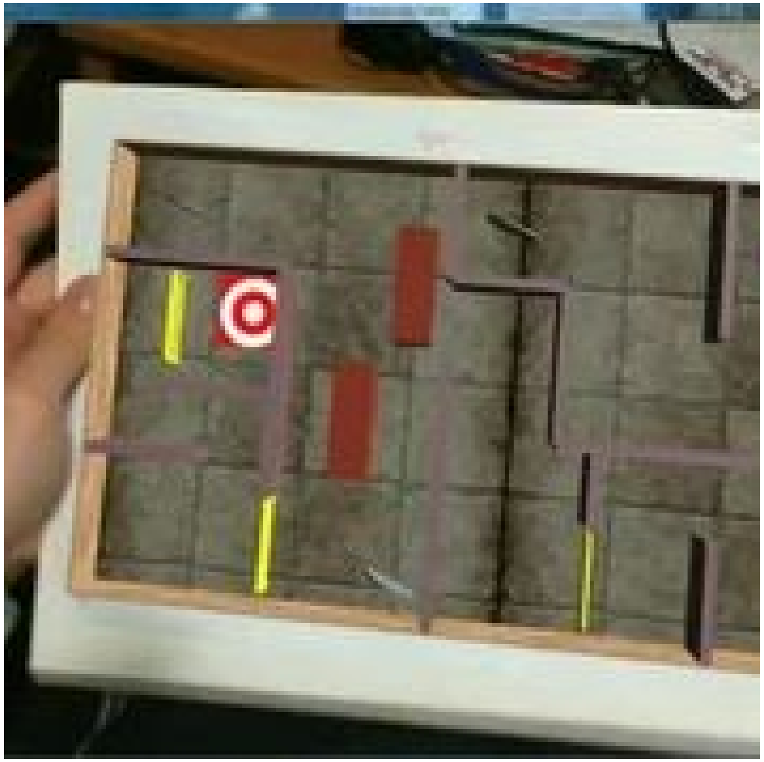
Walking Reactive "Insects"

Atilla & Ghengis – MIT Brooks Lab c. 1990

Barrett Gripper

Augmented Reality





Computer Vision Applications

Kinect: Motion Tracking

DARPA Urban Challenge

Introduction to Vision and Robotics

- Image and capture, segmentation
- Shape description and shape matching
- Object recognition, interest points
- Active vision

- Sensing: Exteroception and proprioception
- Acting: Moving, reaching, grasping
- Connecting sensors and effectors: Robot control

Overview of the course:

Assessment

- Lectures:
  - Sensing and Vision
  - Effectors and Control
  - Architectures and wider issues
- Supervised practicals:
  - Using real and simulated robots
  - Image capture, processing and classification

(Lectures and supervised practicals: Exam 75%)

- Pract 1: Assessed vision practical — 12.5%
- Pract 2: Assessed robotics practical — 12.5%

Further reading:

Russell & Norvig Chapters 24 & 25 in Artificial Intelligence: A Modern Approach, Prentice Hall, 1995.

Solomon & Breckon, "Fundamentals of Digital Image Processing - A Practical Approach with Examples in Matlab", Wiley-Blackwell, 2010.

Ulrich **Nehmzow**, Mobile Robotics: A Practical Introduction, Springer; 2. ed. (2003).

Robin R. **Murphy**, Introduction to AI Robotics, MIT Press, 2000.

W. **Burger**, M. **Burge**; Principles of Digital Image Processing, Springer, 2009.

R.C. **Gonzalez**, R.E. **Woods**, S.L. **Eddins**; Digital Image Processing Using MATLAB, 2nd edition, Prentice Hall, 2009, ISBN 9780982085400.

Ethem **Alpaydin**: Introduction to Machine Learning. The MIT Press, October 2004,

Phillip J. **McKerrow**, Introduction to Robotics, Addison Wesley, 1998.

Ulrich **Nehmzow**, Mobile Robotics: A Practical Introduction, Springer; 2. ed. (2003).

Some historical highlights:

W.G. Walter (1950) An imitation of life. Scientific American, May, 42-45.

N. J. Nilsson (1984) Shakey the robot. Tech report 223, SRI International.

V. Braitenberg (1984) Vehicles. Cambridge, MA: MIT Press.

Freddy: www.ipab.inf.ed.ac.uk/IAS.html

MIT Leg Lab: www.ai.mit.edu/projects/leglab

CMU NavLab: www.cs.cmu.edu/afs/cs/project/alv/www/