Introduction to Vision & Robotics

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Lectures (Mon and Thr 9:00 – 9:50) are available in LEARN course page www.inf.ed.ac.uk/teaching/courses/ivr

Practicals: From week 2 - week 6
Mondays starting at 11:00 – 13:00 (AT 3.01)
Tuedays starting at 9:00 – 11:00 (AT 3.01)

Problems: Please contact Tim or Michael or see class reps.

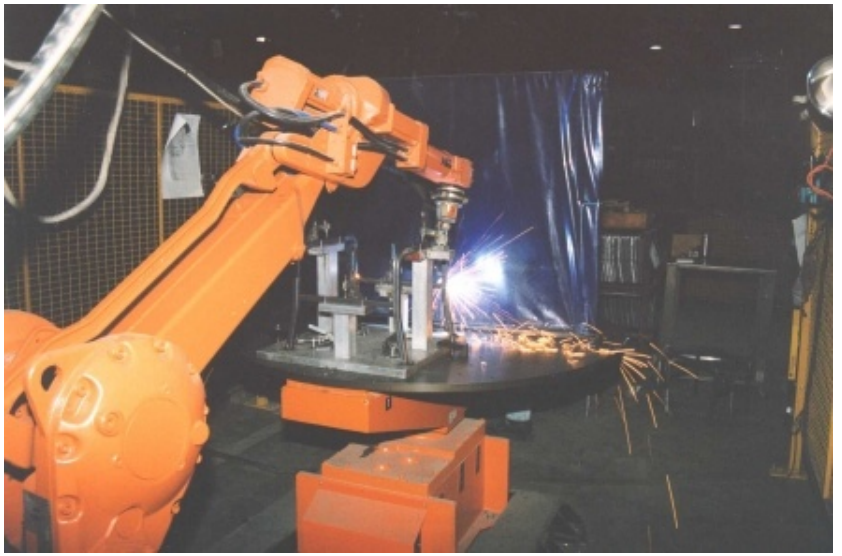
Vision and Robotics: some definitions

- 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

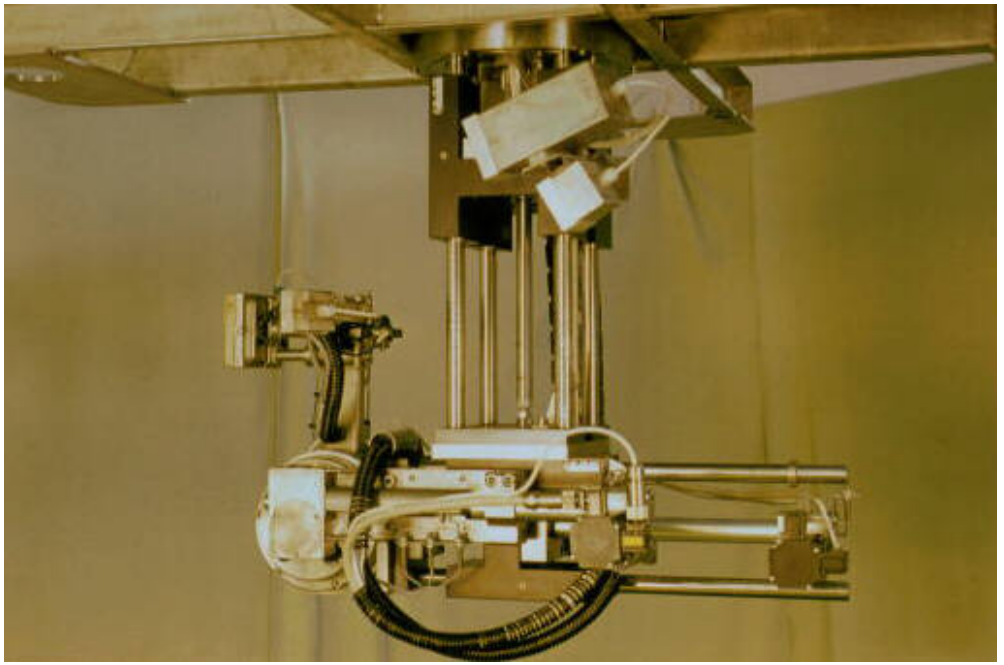


Welding on cars

N.B. Overlap with automation

Applications: dull, dirty or dangerous

Robot vacuum cleaners



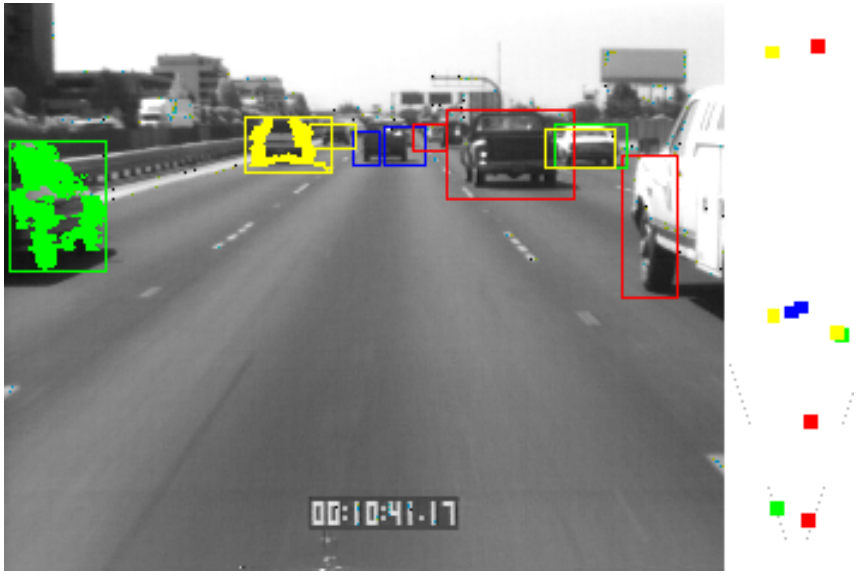
Cleaning nuclear plants

Robot sewer inspection

N.B. Overlaps with teleoperation

Applications: dull, dirty or dangerous

Visual aids for driving



Demining

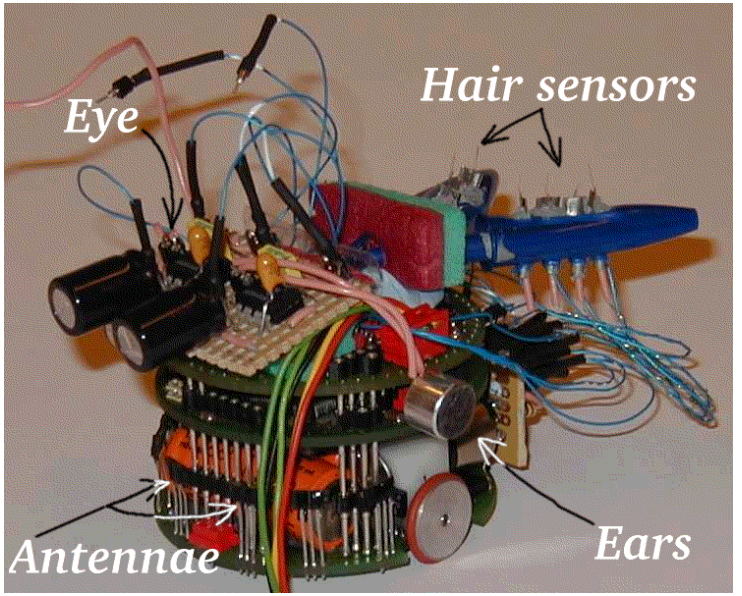
Space exploration

Applications

Entertainment robotics

Service robotics

Science



A challenging problem

- We do not 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
  - Cannot replace a house cleaner

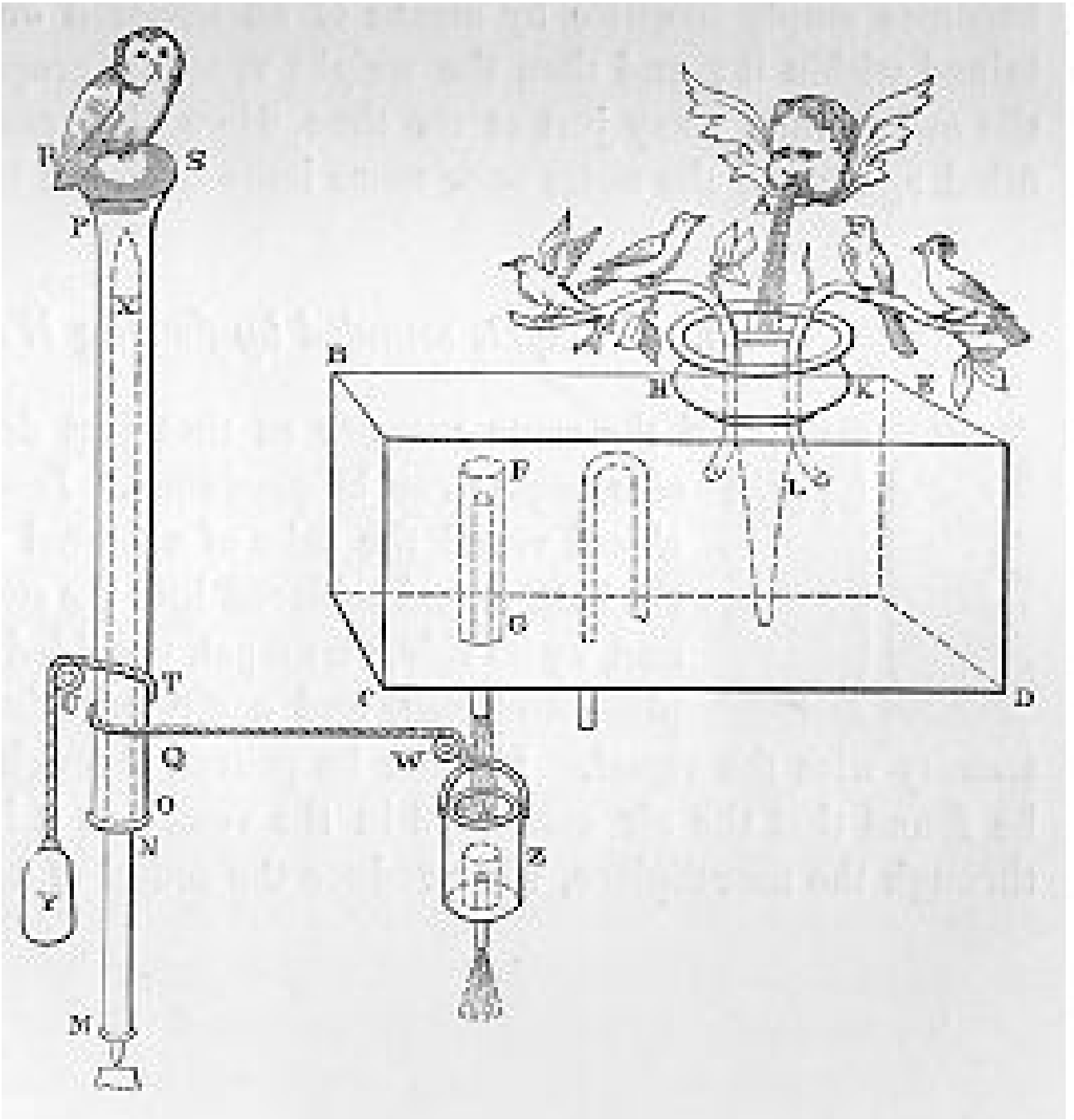
Vision and robotics uses all areas of AI:

- Problem solving, planning, search, inference, knowledge representation, learning etc...
- But we cannot 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

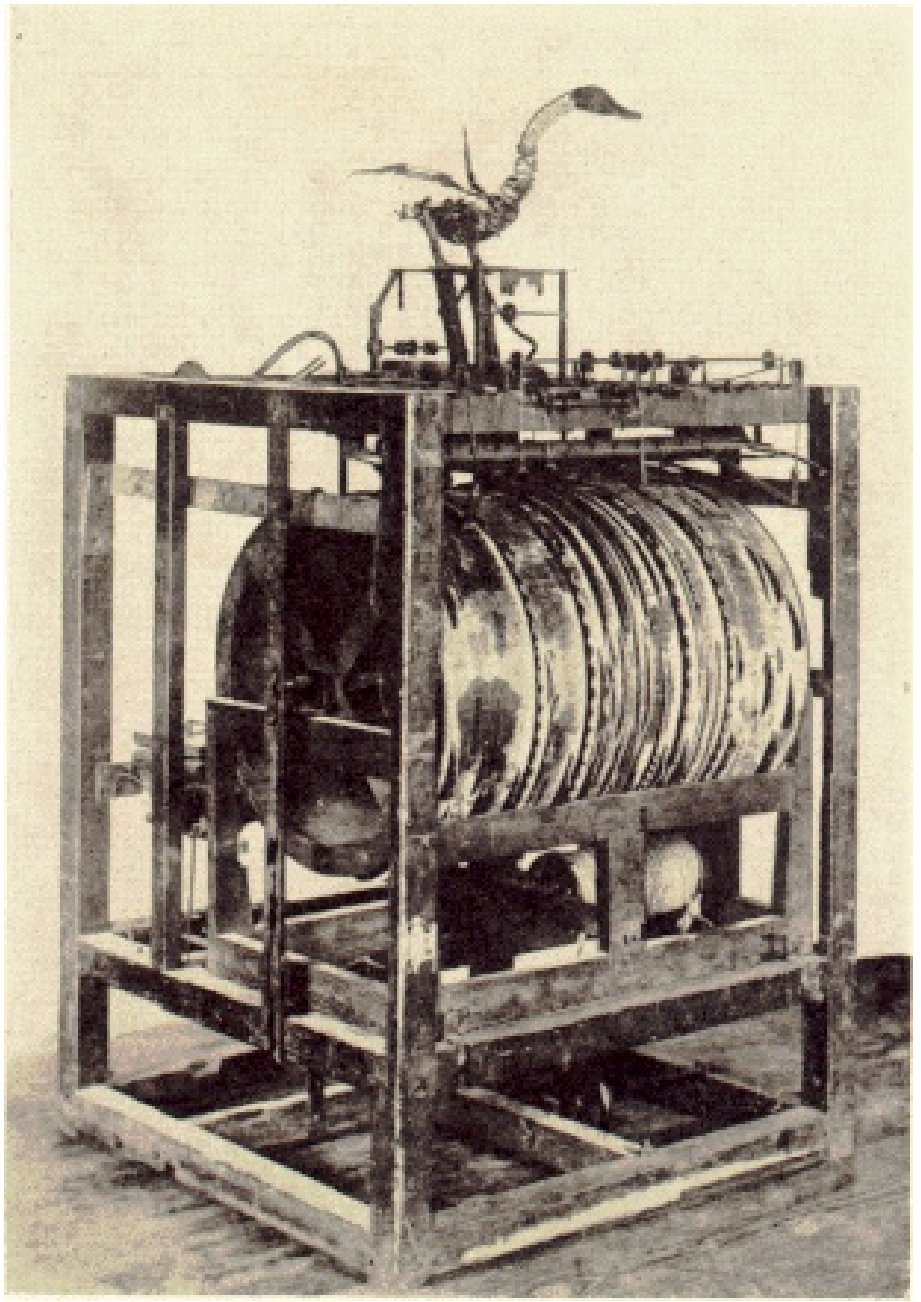
AD 100



18th century clockwork automata

Vaucanson’s duck

Karakuri ningyō

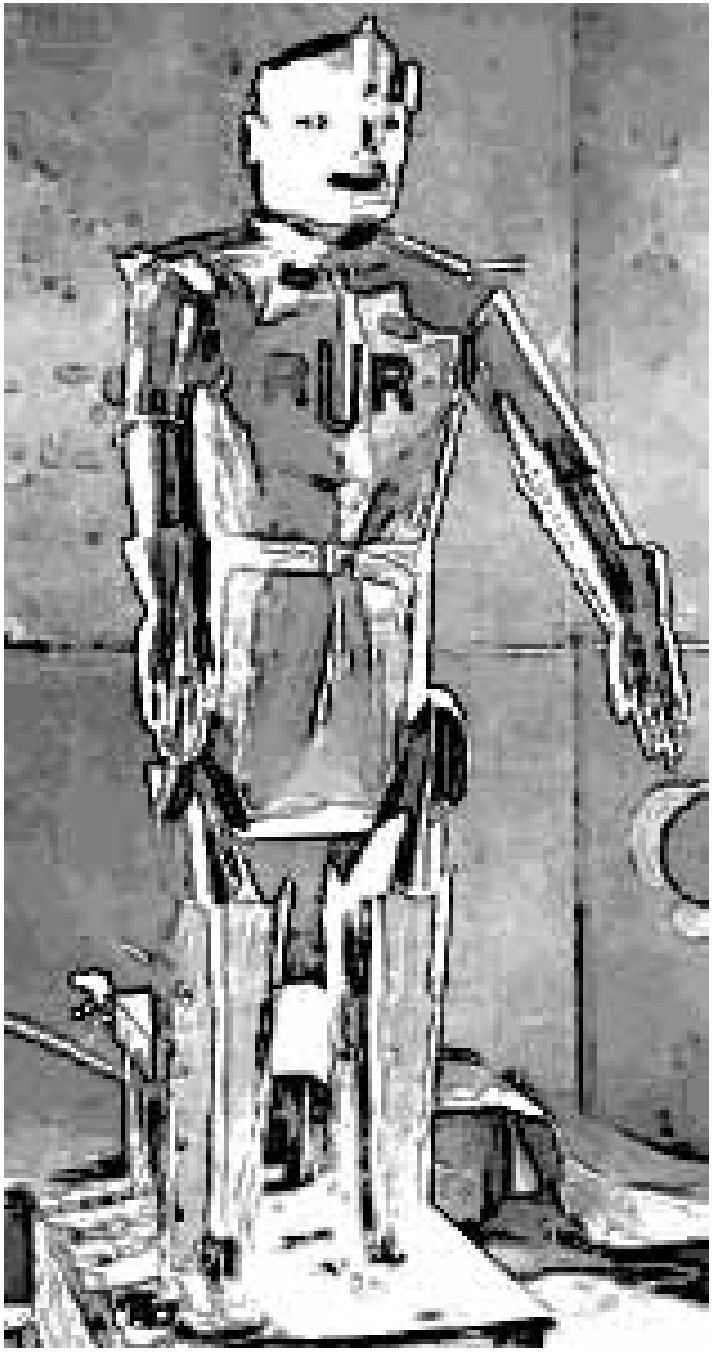


Early 20th century

Electronic devices for remote control (Nicola Tesla, 1898)

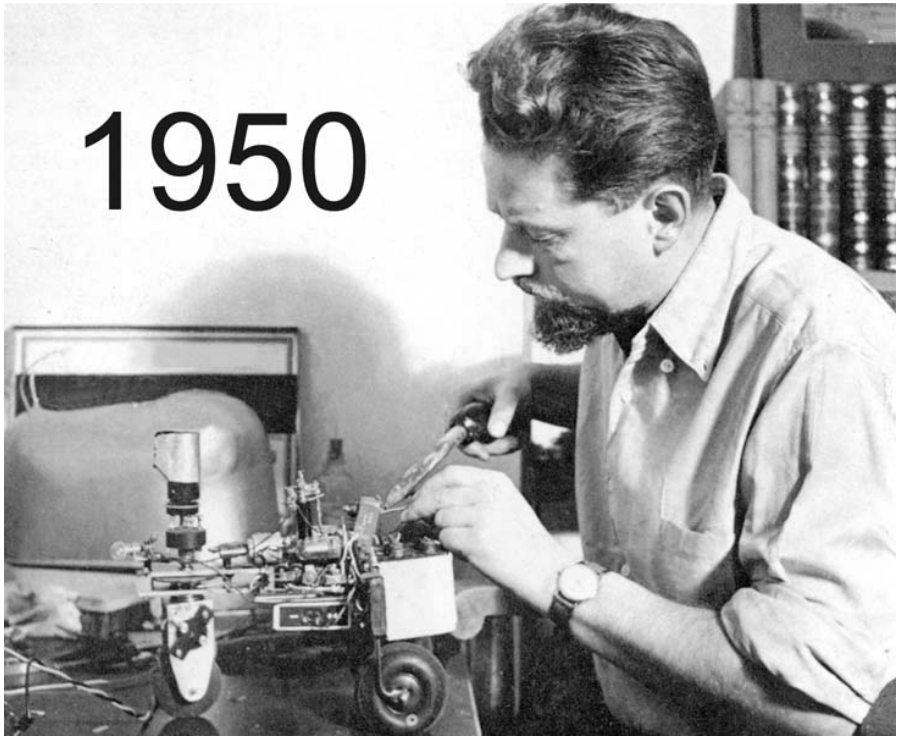
Methods for transducing images into electrical signals (Vladimir Zworykin's Iconoscope, 1923)

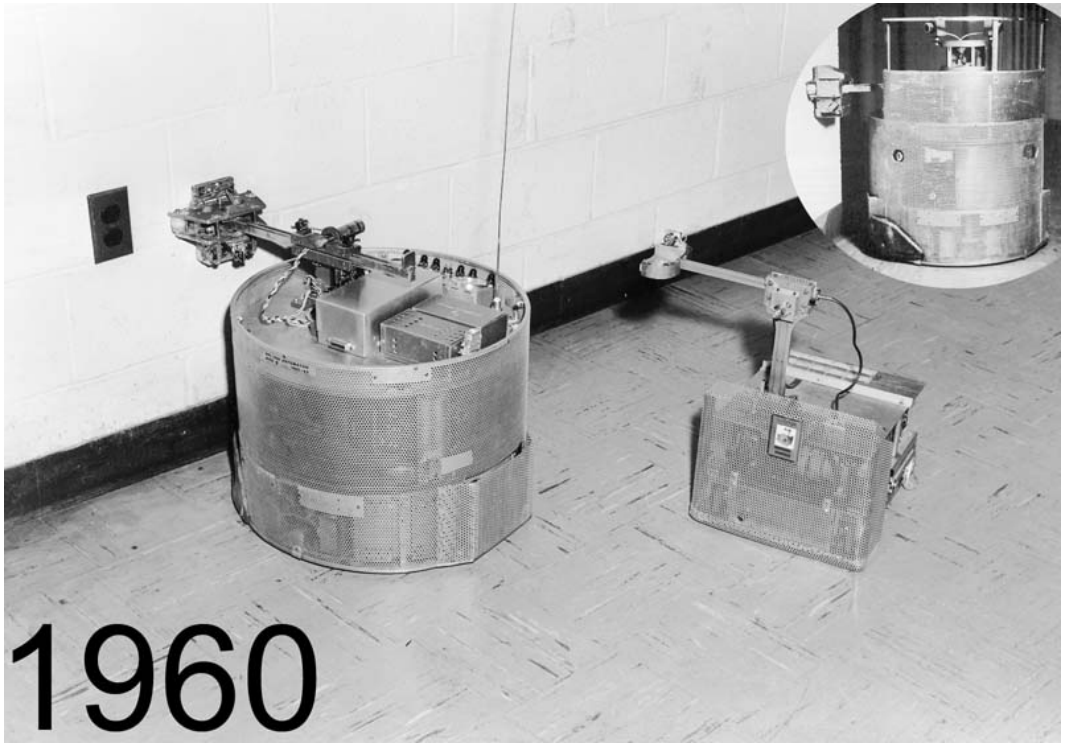
'Robot' used to describe artificial humanoid slaves in Karel Capek's play "Rossum's Universal Robots" (1920)



1940s –1950s

Development of electronic computer and control theory





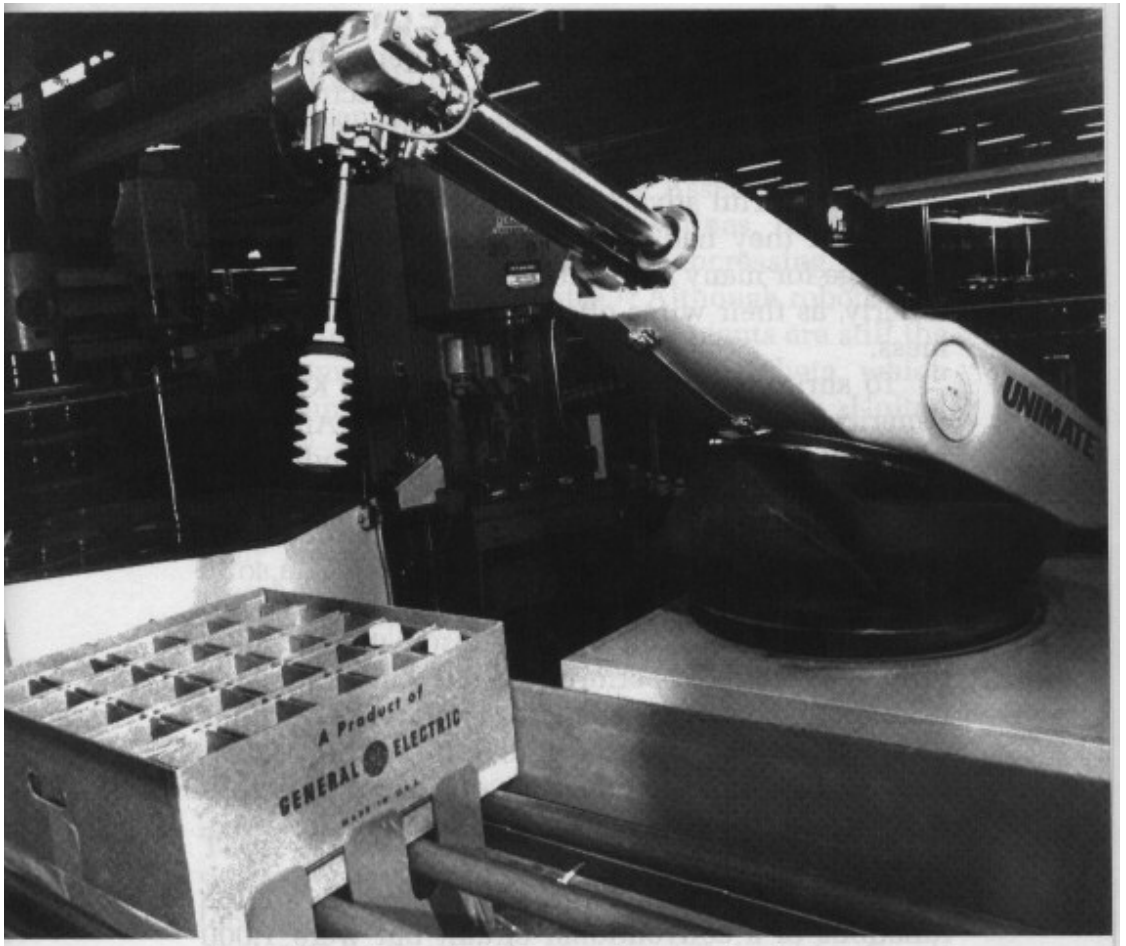
Used for artificial creatures e.g. Grey Walter's 'tortoise' and John Hopkins' 'beast'

1960s

Industrial robot arms:

Unimation

Methods for image enhancement and pattern recognition



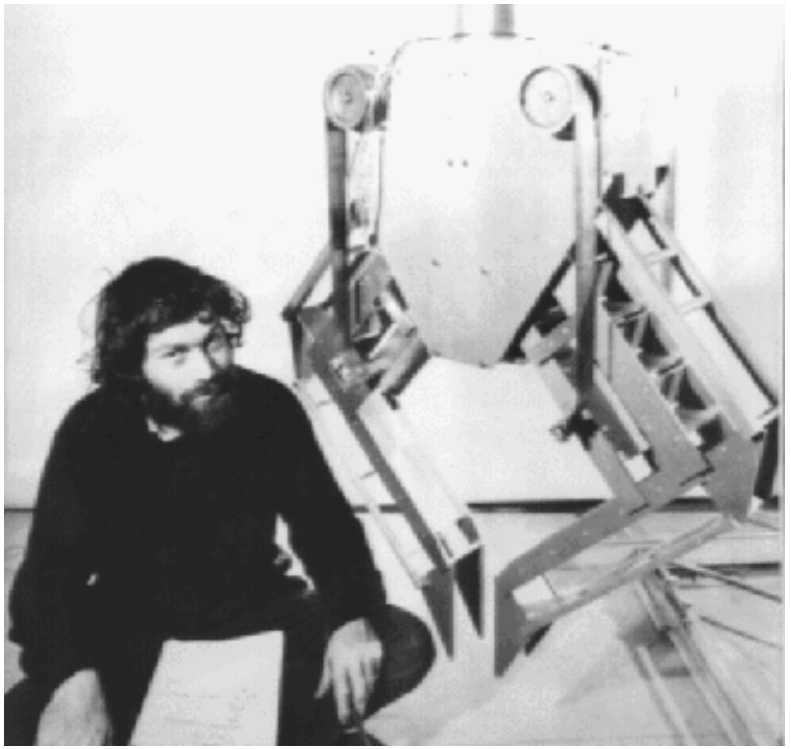
Armed for duty. A Unimate robot—really, just an arm—picks up and puts down parts in a General Electric factory.

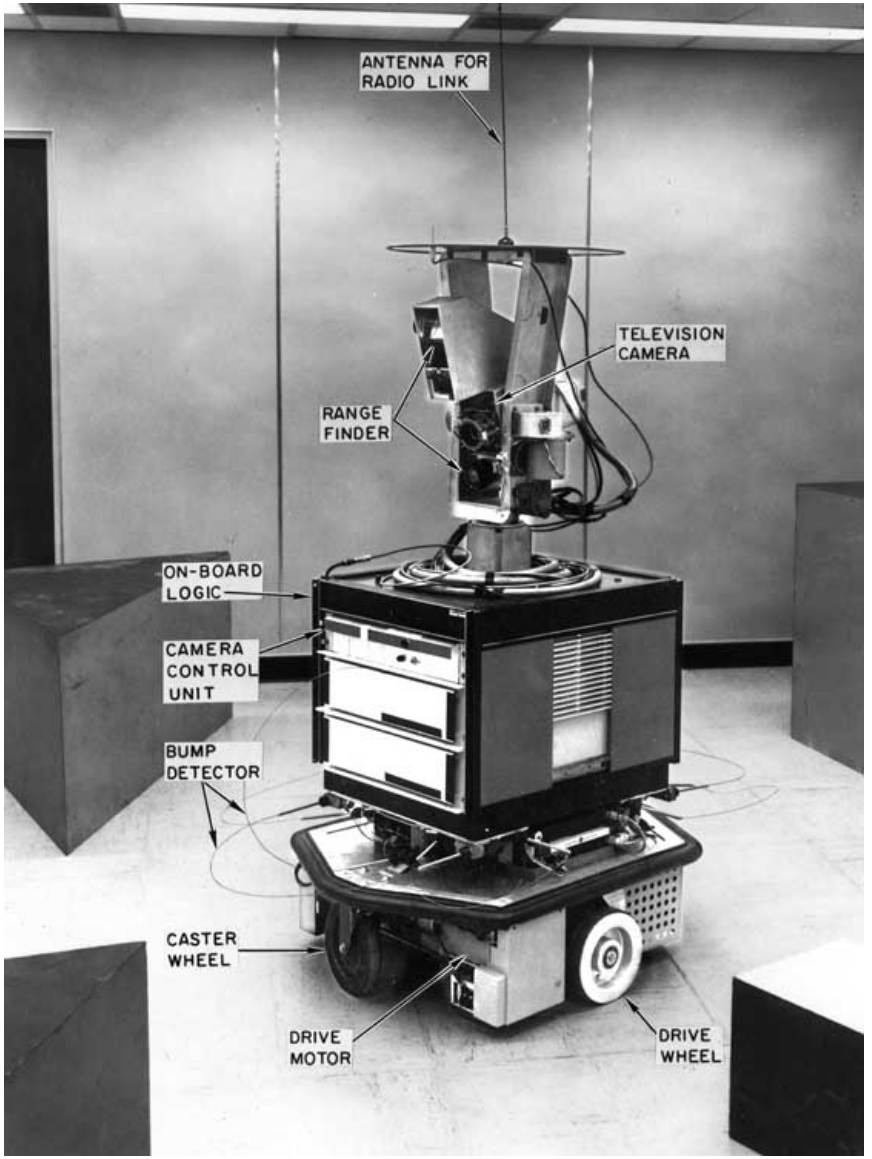
1970s

Work on systems in restricted domains

e.g. Shakey in blocks world

Freddy assembly task





1980s

Tackling more realistic problems:

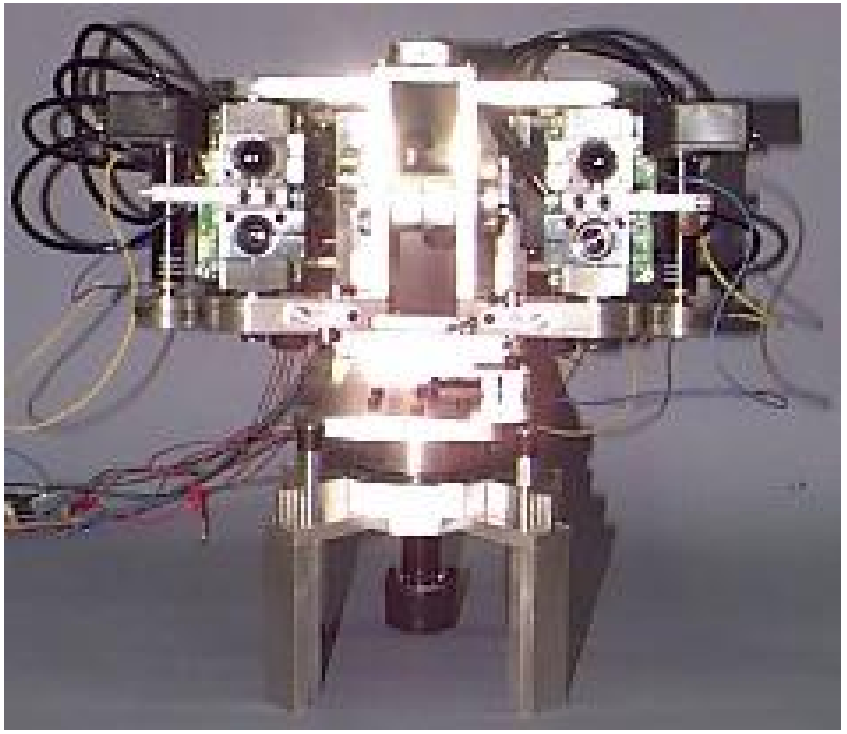
Natural scene analysis

Face recognition

Dynamic locomotion

Significant impact in manufacturing

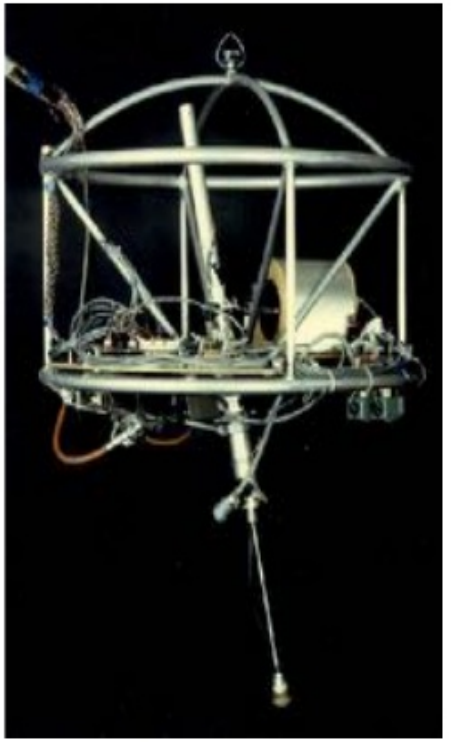
Active vision

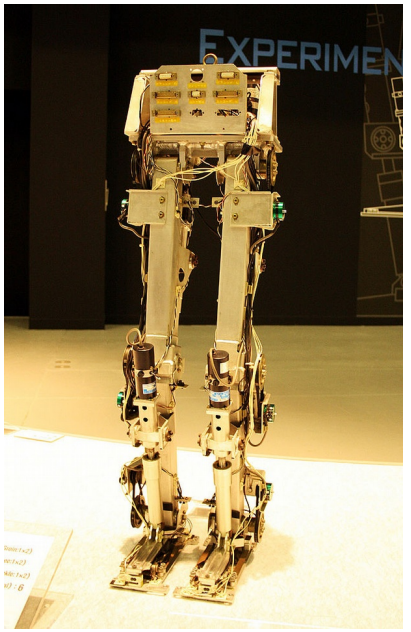


Leg Lab (CMU 1980, MIT 1986 onwards)

1995 biped acrobatics

2000s: Asimo, Qrio, HOAP, Nao, iCub, Valkyrie, PR2, ...

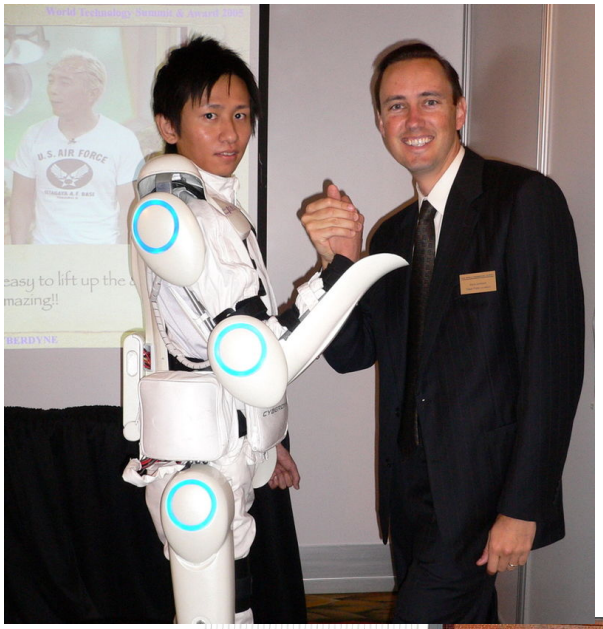


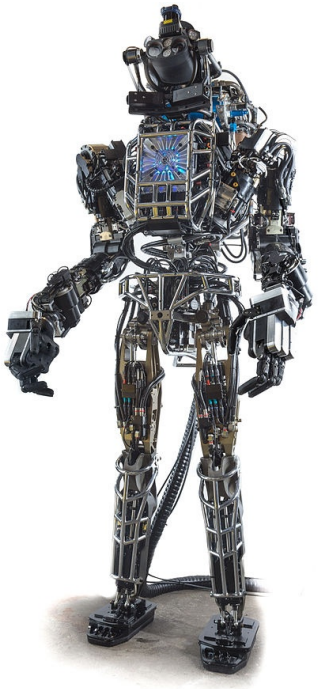


Honda E1 (1987) Asimo (2011)

Legged locomotion

Atilla & Ghengis
MIT Brooks Lab c. 1990

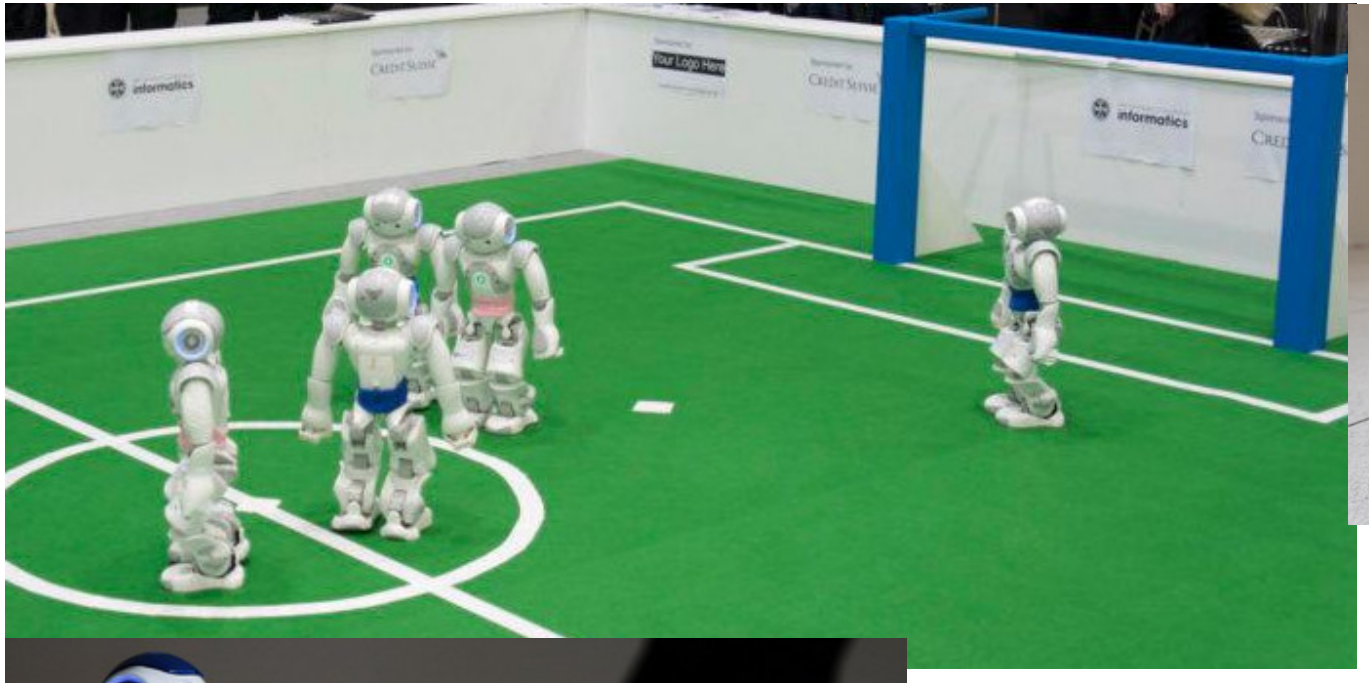




HAL
Cyber-
Dyne

BigDog & Atlas
Boston Dynamics 2005

RoboCup: Robot Soccer (since 1997)



Edinferno (2010)

Edinferno

THE UNIVERSITY of EDINBURGH
informatics

ipab | Institute of Perception, Action and Behaviour

Autonomous driving

NavLab: CMU from 1987

1995 ‘No hands across America’ 98.2% autonomous

2005 DARPA Grand Challenge (S. Thrun)

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

2014 Google Self-Driving Car: "fully functional" prototype

Drones: Unpiloted aerial vehicles

Usually remotely piloted

Can be airborne for several days

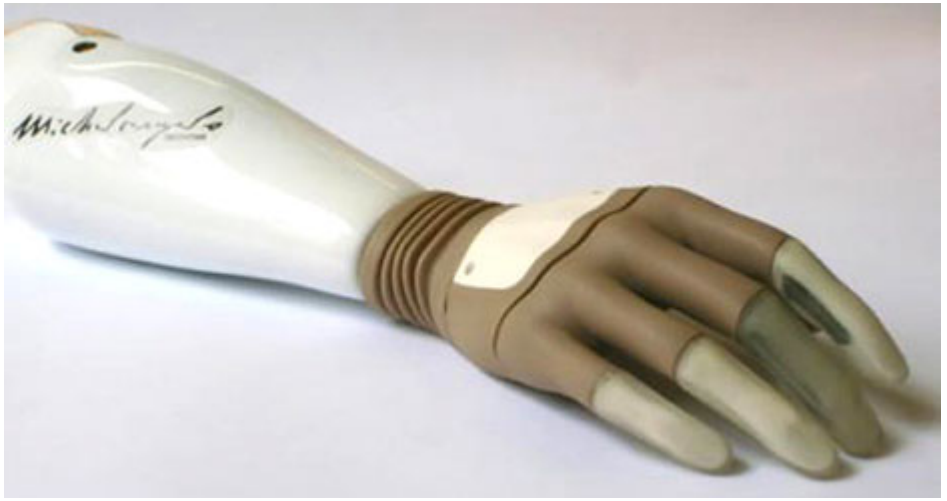
Applications:

- Military
- Exploration
- Transport
- Archaeology
- ….

Manipulation

KUKA robot (6 DoF)

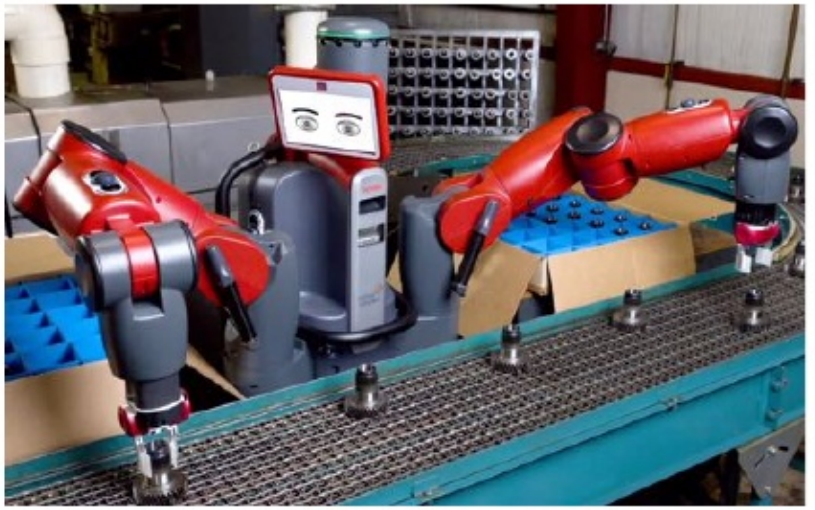
Barrett Gripper (7 DoF)



“Michelangelo” hand (4 DoF)

Shadow hand (20 DoF)

Edinburgh Centre for Robotics



Introduction to Vision and Robotics

Vision Topics

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

Robotics Topics

- 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

Exam 70%

- Assessed practical

30%

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/