Introduction to Vision & Robotics

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Official page and lecture schedule:
www.inf.ed.ac.uk/teaching/courses/ivr
Lectures are available as videos online:
https://www.learn.ed.ac.uk

Practicals: Week 2 - 10

- Tuesday starting at 9:10 (AT 3.D02)
- Wednesdays starting at 14:10
- Thursdays starting at 13:10 (AT 3.D02)

Problems: please contact Dr. Fallon or Demonstrators.

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

Applications: dull, dirty or dangerous

Robot vacuum cleaners

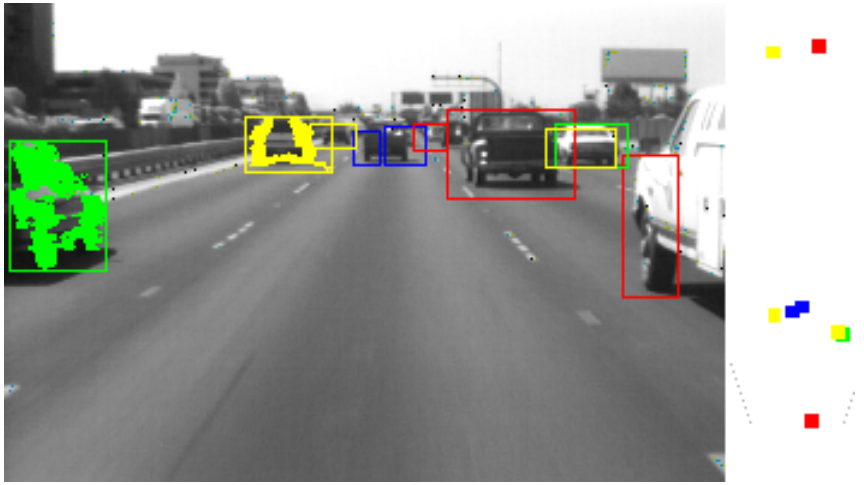
Robot sewer inspection

Cleaning nuclear plants

N.B. Overlaps with teleoperation

Applications: dull, dirty or dangerous

Visual aids for driving



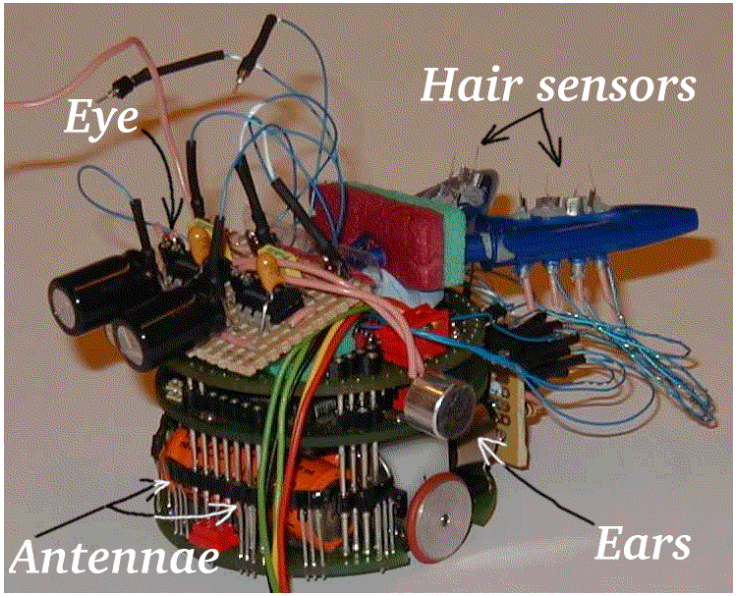
Demining

Space exploration

Applications

Entertainment robotics

Service robotics



Science

A challenging problem

- We 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

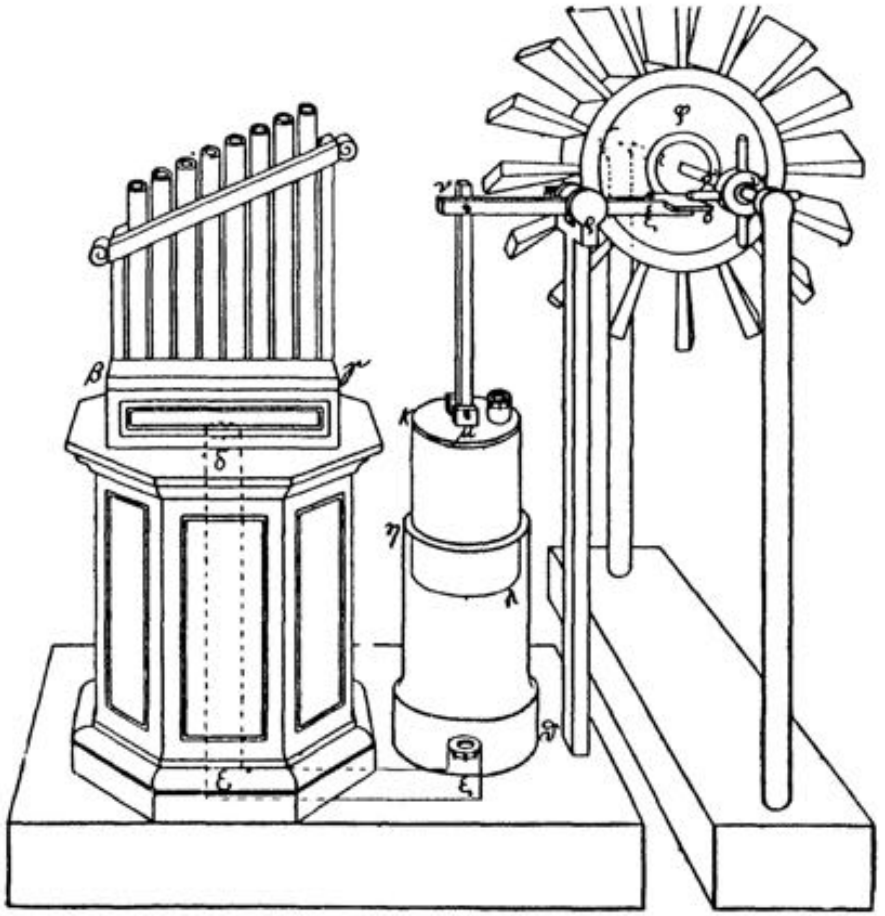
Vision and robotics uses all areas of AI:

- 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 Greece:

hydraulic and mechanical automata

Hero of Alexandria
AD 100

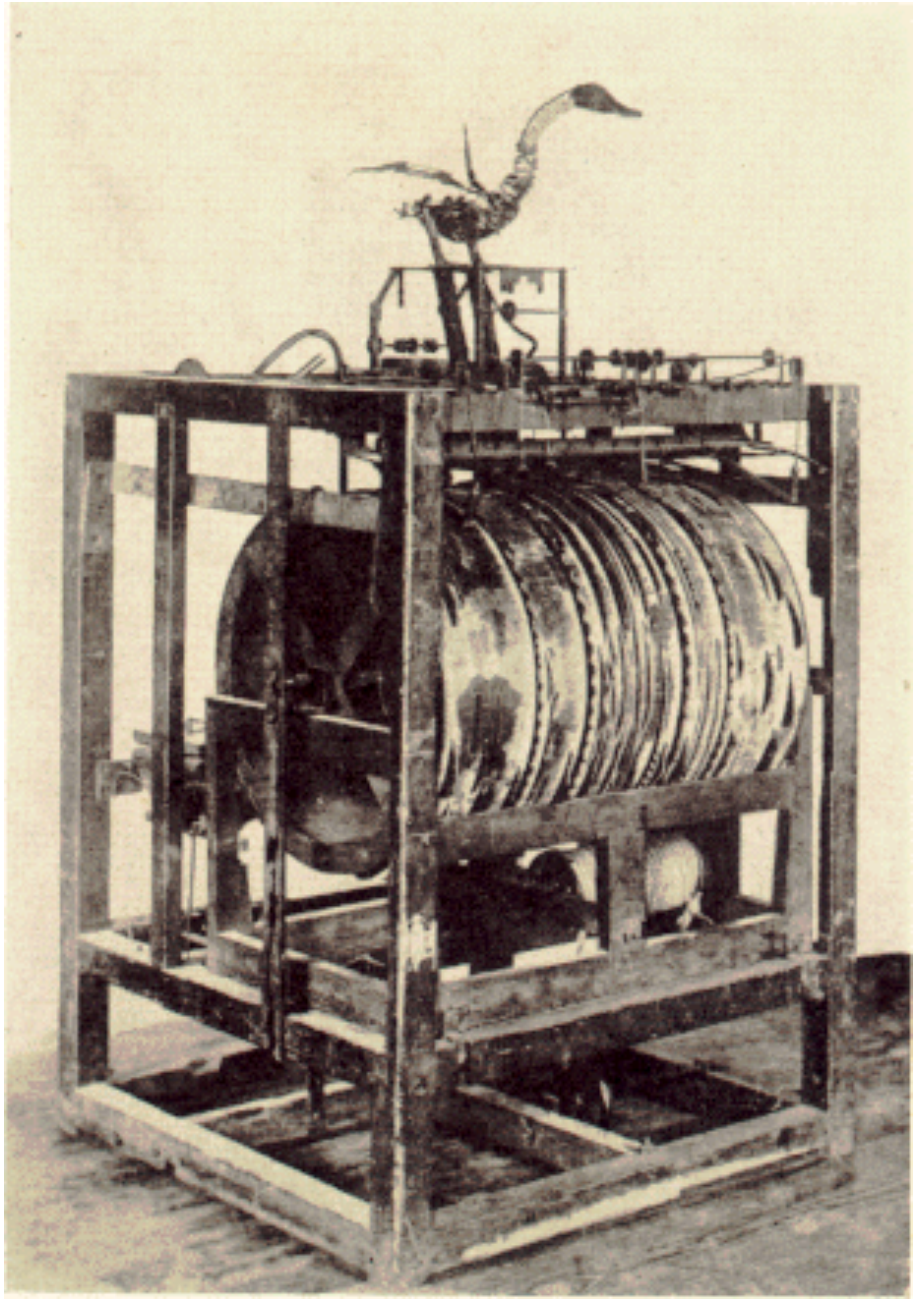


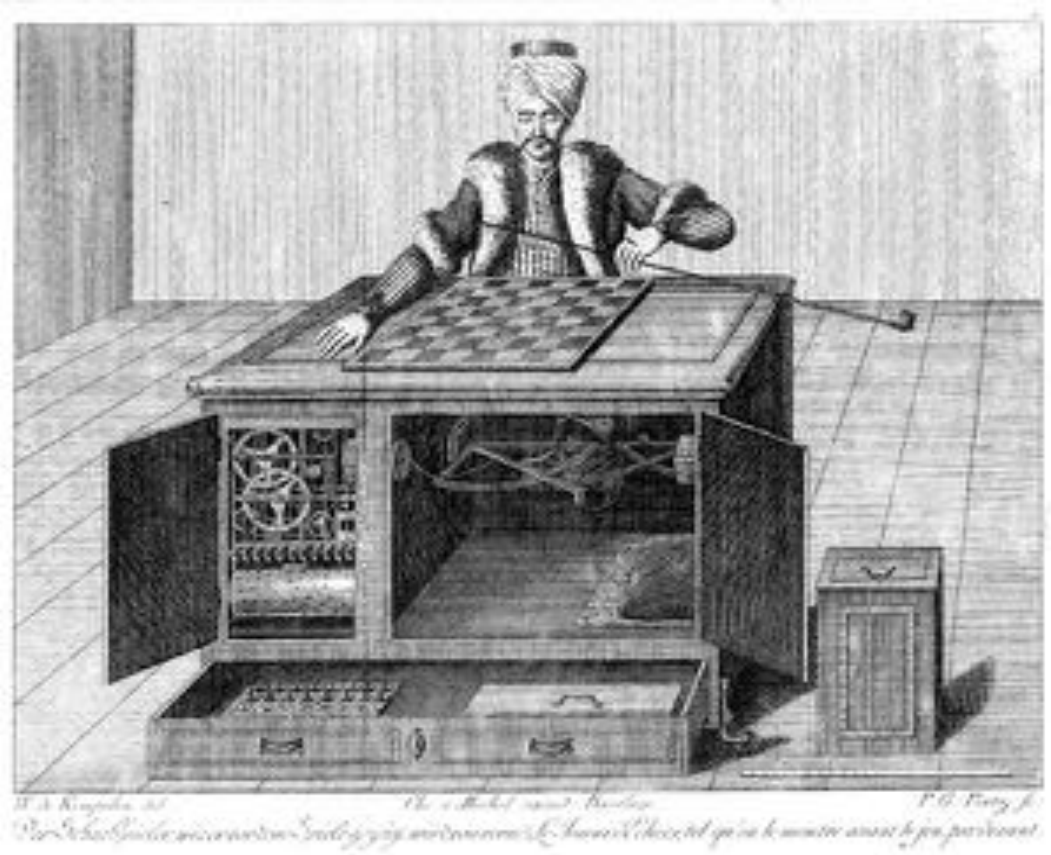
Windpowered Organ

18th century:

Clockwork animals:

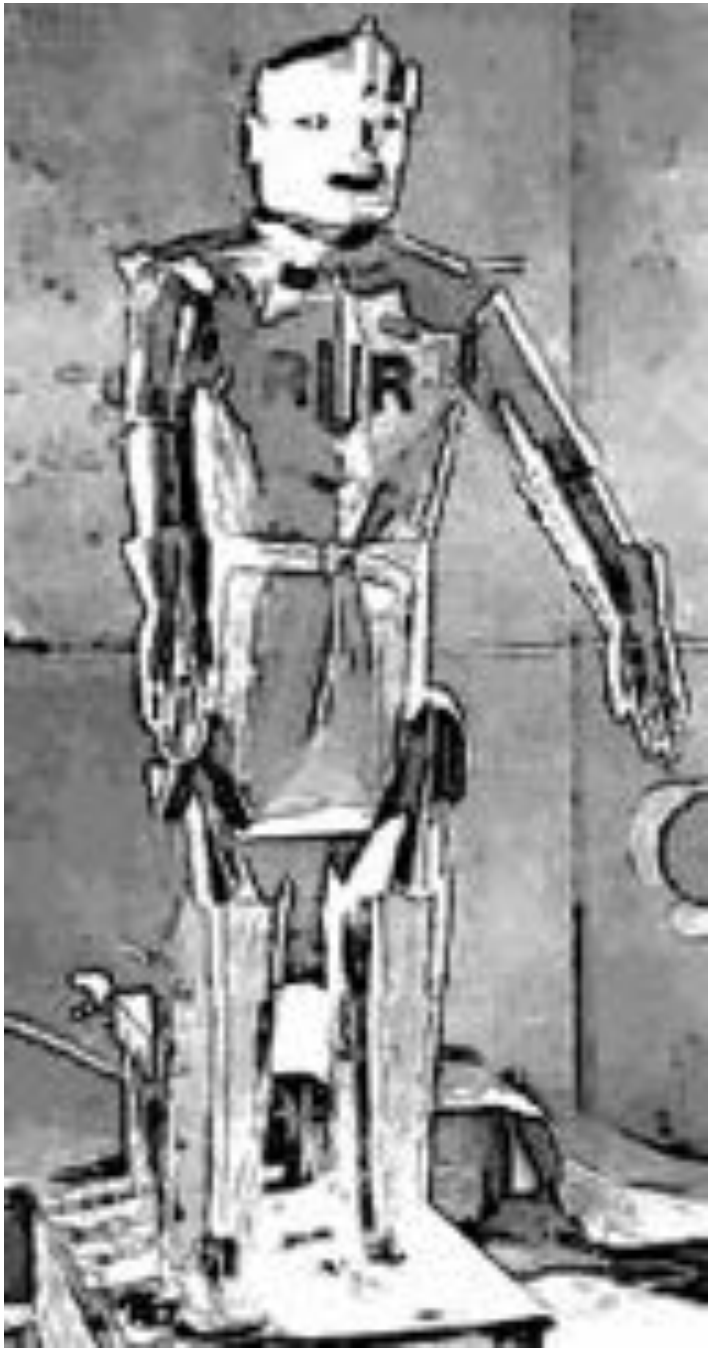
- Vaucanson's duck
- Mechanical Turk



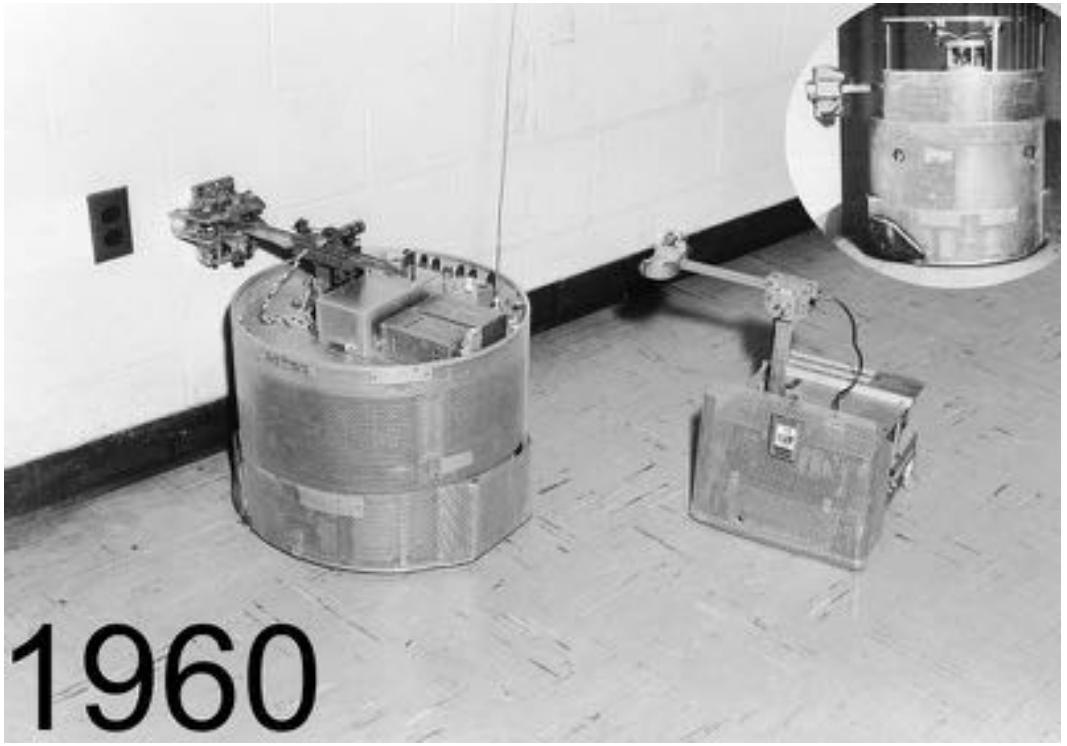


Early 20th century:

- Electronic devices for remote control (N. Tesla)
- Methods for transducing images into electrical signals
- ‘Robot’ used to describe artificial humanoid slaves
  - Karel Capek’s play “Rossum’s Universal Robots” 1920



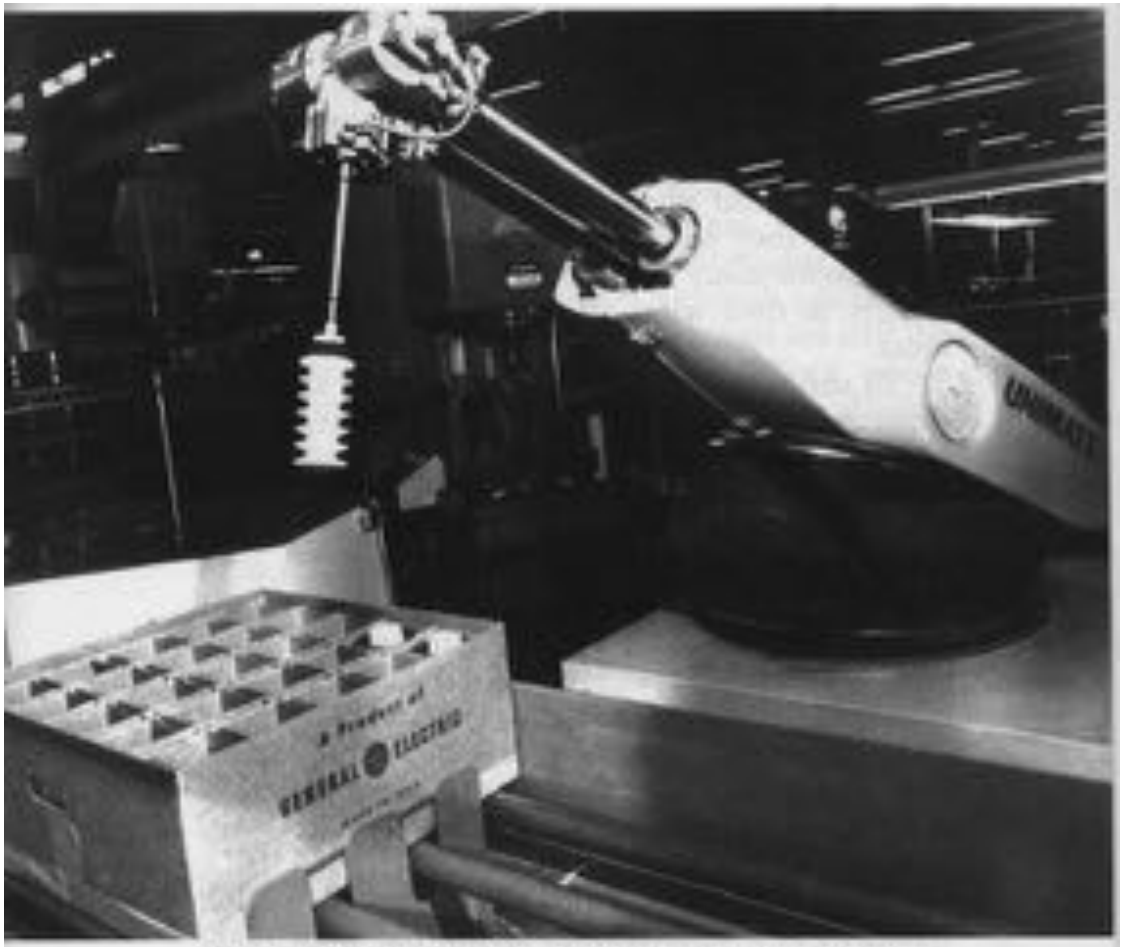
1940s –1950s:
Development of electronic computer and control theory



1960s:
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

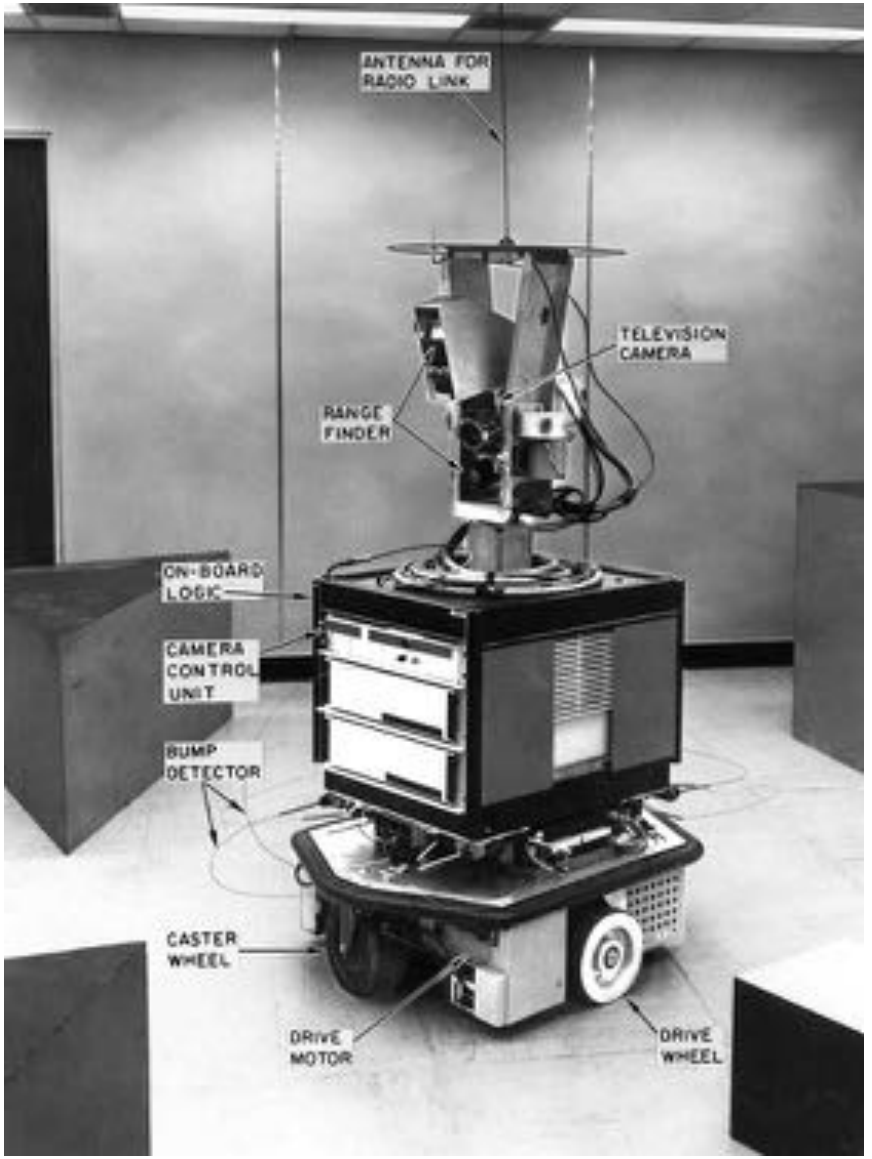


Armed for duty. A Unimate robot—really, just an arm—picks up and puts down parts in a General Electric factory.

1970s

First Recognisable robots:

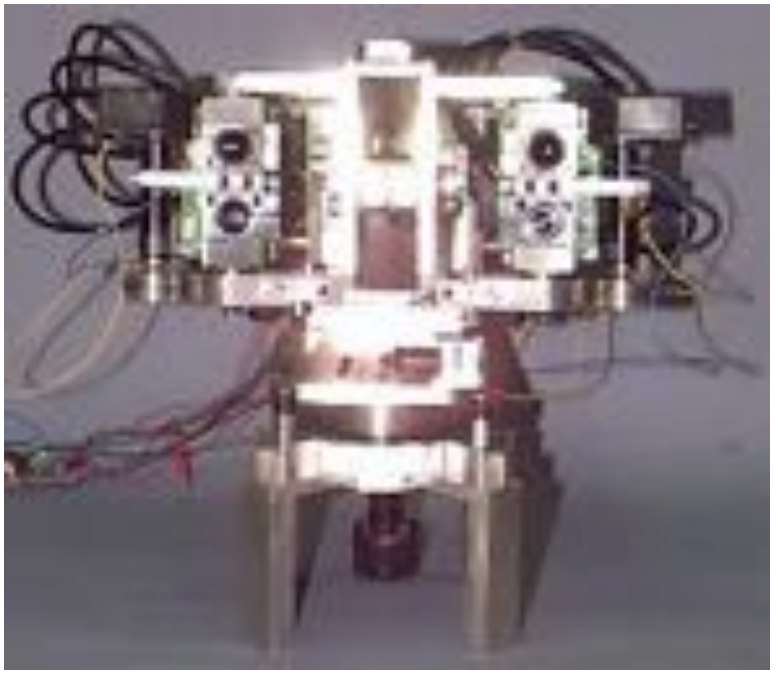
- Working in restricted domains
- Shakey in block world
- Freddy assembly task



1980s:

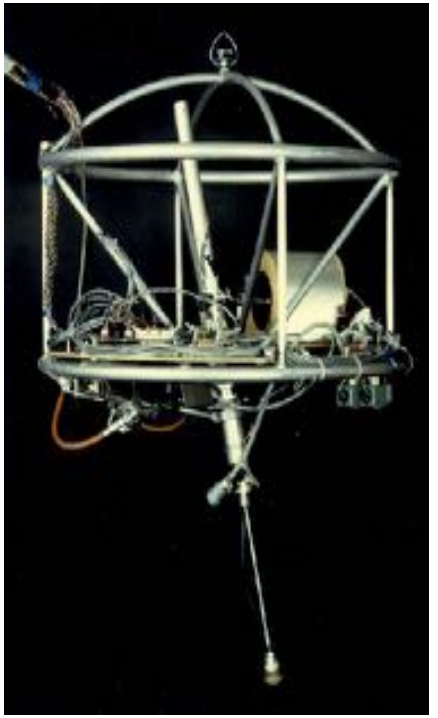
Tackling more realistic problems:

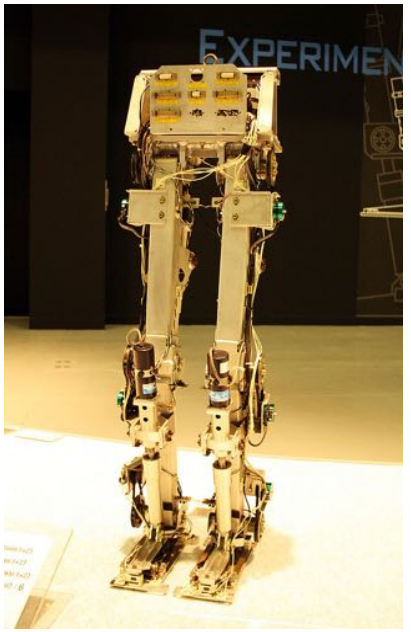
- Natural scene analysis
- Face recognition
- Dynamic locomotion
- Significant impact in manufacturing
- Active vision



Leg Lab (CMU 1980, MIT 1986 onwards)

2000s: Asimo, Nao, Atlas, iCub, Valkyrie, PR2 ...





Honda E1 (1987) Asimo (2011)

Legged Locomotion

Atilla & Ghengis
MIT Brooks Lab c. 1990

HAL CyberDyne

BigDog & Atlas
Boston Dynamics

RoboCup: Robot Soccer (since 1997)

Edinferno (2010)

Autonomous driving

- NavLab: CMU from 1987
- 1995 ‘No hands across America’ 98% autonomous
- 2005 DARPA Grand Challenge
  - 2007 Urban Challenge
- Several U.S. states have passed laws permitting driverless cars: NV, FL, CA, MI
- 2014 Google Self-Driving Car: "fully functional" prototype
  - Tesla, Uber, Apple, Zook, NuTonomy

Drones: Unpiloted aerial vehicles

Usually remotely piloted
Can be airborne for several days

Applications:

- Military
- Exploration
- Transport
- Archaeology
- ….

Manipulation

KUKA robot (6 DoF)

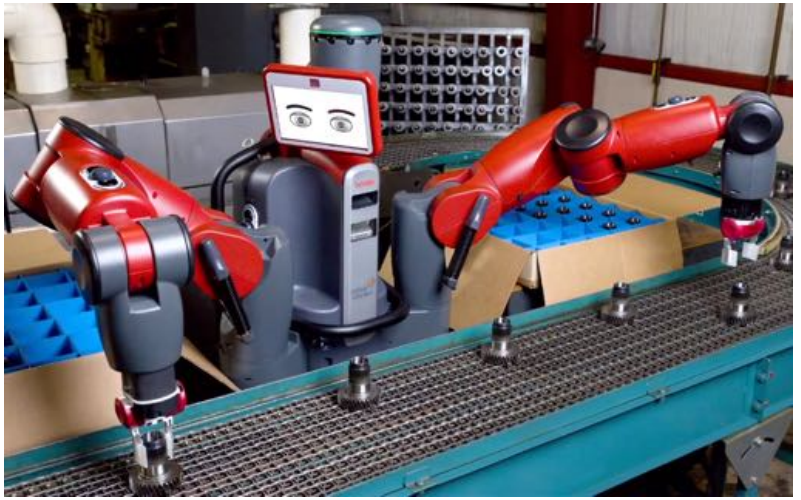
Barrett Gripper (7 DoF)

“Michelangelo” hand (4 DoF)

Shadow hand (20 DoF)

EDINBURGH CENTRE FOR ROBOTICS

Edinburgh Centre for Robotics



Introduction to Vision and Robotics

Vision Topics:

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

Robotics Topics:

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

- **Note:** Vision for Robots removed from syllabus this year. Active Vision will still be on the course

Overview of the course:

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

- Pract 1: Assessed vision practical (20%)
- Pract 2: Assessed robotics practical (20%)

Assessment

60%

20%

20%

Flipped Classroom Concept

- Videos of Lectures and all Lecture Notes are stored on/accessed on **Learn**:
  - https://www.learn.ed.ac.uk
  - No lectures in the traditional sense.

- More control of your education in this course.
  - 25 short videos on different topics.
  - Watch the videos in your own time

- Distance Learning: Course being delivered to a group of remote students via live streaming (using **Collaborate**)
  - Course unmodified for local students

- 4 interim in-class quizes:
  - Informal. Not used for final assessment

Flipped Classroom Concept

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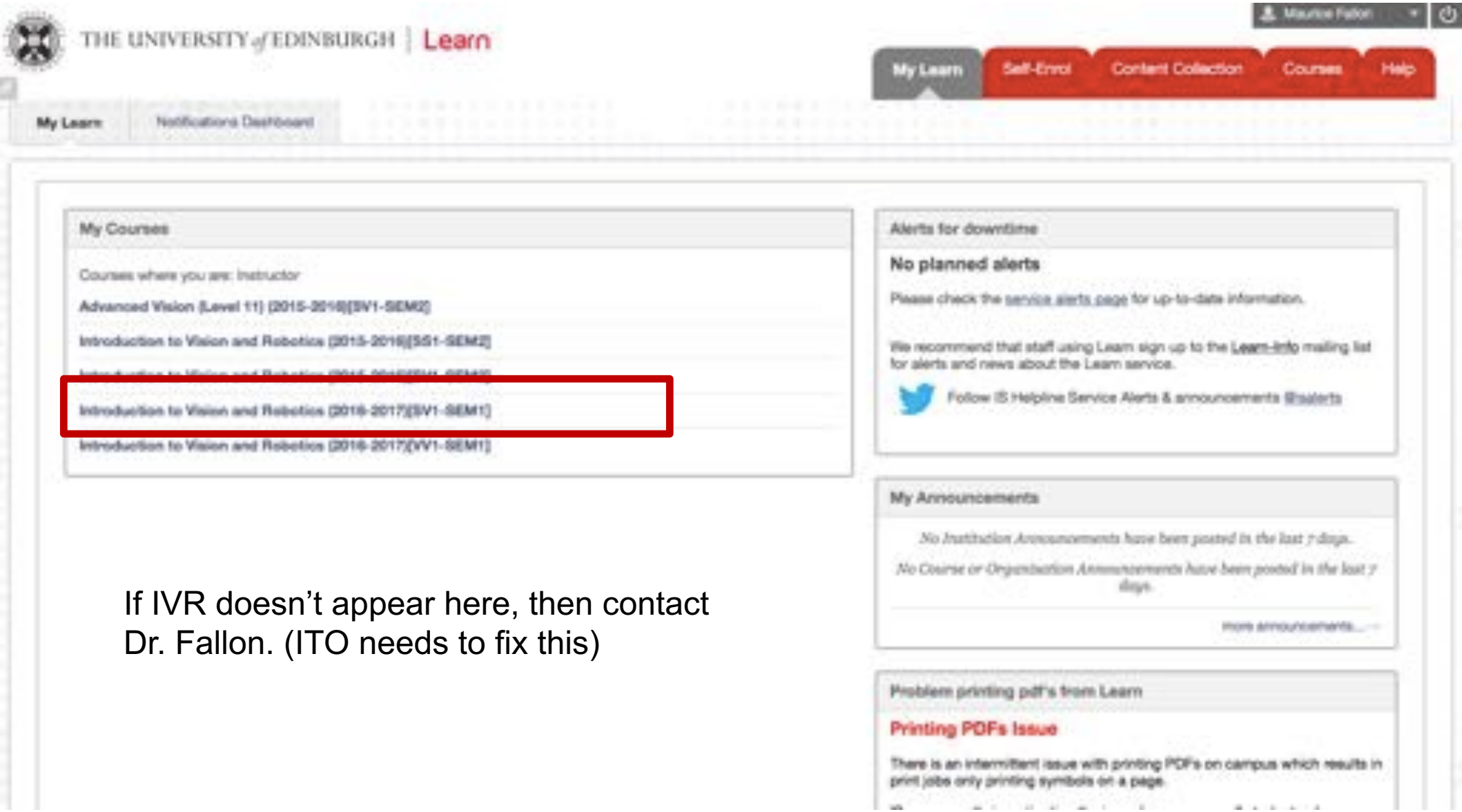
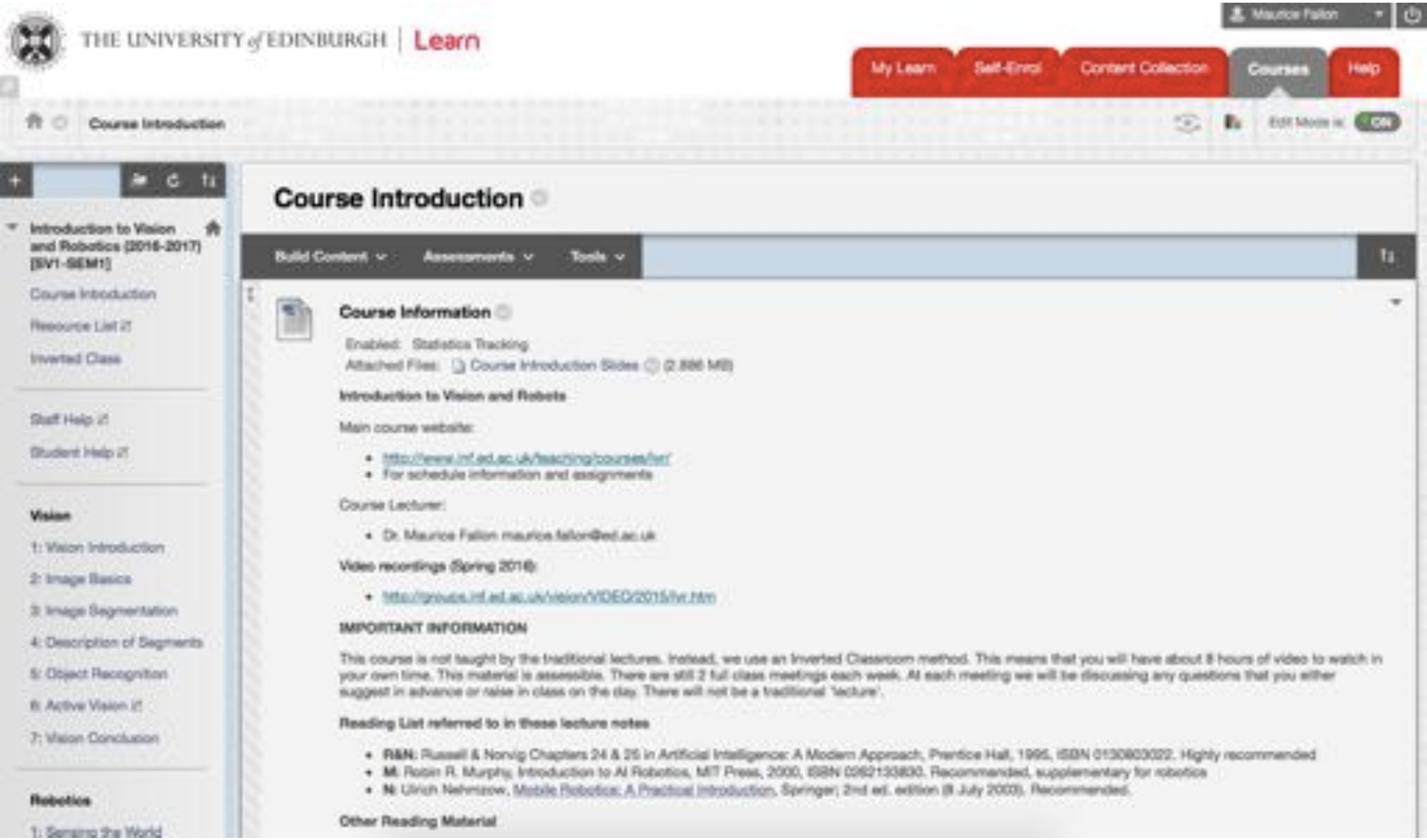
- Video Lectures recorded by:
  - Prof. Bob Fisher and Dr. Michael Herrmann
  - They are not involved in delivery of this class. Please don't contact them

Learn: My Learn Page

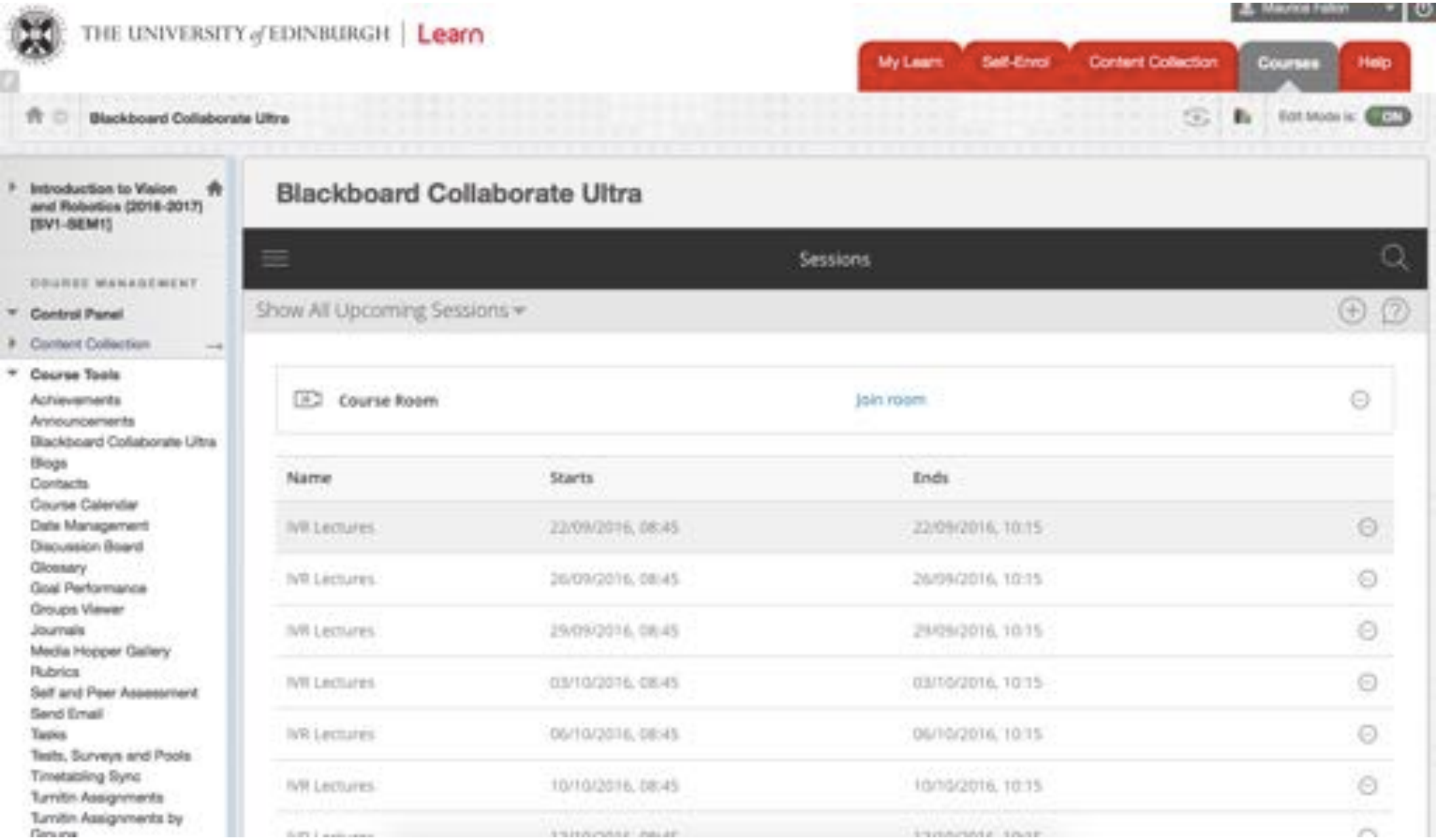


If IVR doesn't appear here, then contact Dr. Fallon. (ITO needs to fix this)

Learn – IVR Pages:
Video and Lecture Notes



Lecture Streaming:
Blackboard Collaborate Ultra



Introduction to Vision and Robotics

Two Assignments:

- **Vision:** detecting objects from a series of images, training classifiers and feature detectors.
  - Programming in MATLAB

- **Robotics:** build a robot using Lego EV3. Develop a motor controller, sensor perception, carry out navigation tasks
  - Programming in Python
  - New assignment/interface this year

Both assignments examined using demonstration

Lab Groups

LABORATORY GROUP 2 FH
Room 3.D02, Tue 09:00-11:00 (26 students)
Alex Wilson
Andra Zaharia
Andreea Cucu
Arthur Wilcke
Becca Bonham-Carter
Catalina Rotaru
Dimitar Vashkov
Eliisabet Hein
Georgi Hristov
Giuseppe Li
Hanne Carlsson
Jessica Kelly
Justin Alisauskas
Justin Reigis
Matthew Martin
Oliver Morgan
Oscar Postlethwaite
Peter Galer
Pierre Gianferrara
Povilas Pazera
Ramona Comanescu
Siim Sammul
Stiliyan Emanuilov
Vladimir Stepanov
Weiting Goh
Yanitsa Mihaylova

LABORATORY GROUP 3 FH
Room 3.D02, Thu 14:10-16:00 (11 students)
Alex Zhang
Dainius Cerniauskas
Julian Xu
Kexin Huang
Onji Bae
Peter Carragher
Teodor Todorov
Tom Bock
Tom Lutzeyer
Tudor Ferariu
Vanessa Chang

LABORATORY GROUP 1 FH
Room 3.D02, Fri 13:10-15:00 (14 students)
Brynnagh Mulherin
Dylan Angus
Ink Pansuwan
Ivan Georgiev
Jake Houston
Karen Xu
Kendeas Theofanous
Levi Fussell
Philip Igbaro
Robert Mitchell
Saumya Jain
Stefan Ivanov
Vesko Stefanov
Zhuyun Zhao

Theon under lab groups:

https://portal.theon.inf.ed.ac.uk/reports/upt/open/TP082_Laboratory_Groups/

Lab Location: Forrest Hills

Located in:

5 Forrest Hill, Edinburgh EH1 2QL
(off of Forrest Road)

Third floor lab

Introduction to Vision and Robotics: Demonstration Assessments

Both assignments examined using demonstration

Sign up in pairs for the vision assignment **NOW**

- http://tinyurl.com/ivr-labs

Also choose the timeslot for lab demonstration on 28 October

Further reading:

Russell & Norvig 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/

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