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 20\textsuperscript{th} 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

1950
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
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:

- 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
- Pract 2: Assessed robotics practical

Assessment:
- Exam 75%
- Pract 1 12.5%
- Pract 2 12.5%
Further reading:


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


Some historical highlights:


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/