COMP219: Artificial Intelligence

Lecture 2: AI Problems and Applications

Introduction

- Last time
  - General module information
  - Characterisation of AI and what it is about

- Today
  - Overview of some common AI techniques we will study during the module
  - Typical AI applications

- Learning outcome covered today:

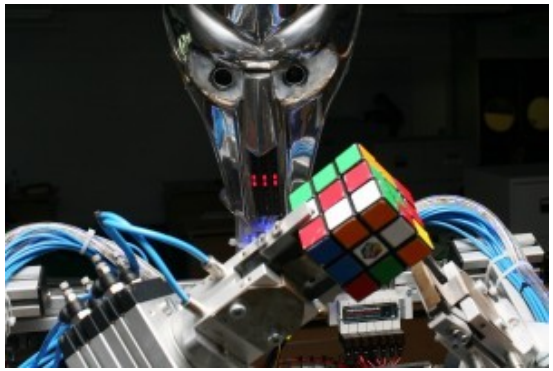
  Identify or describe some of the major applications of AI

“Expert” tasks

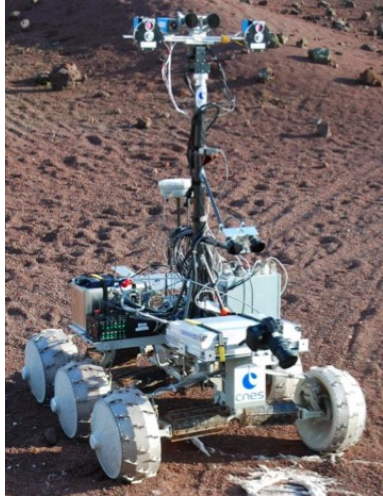
- Many tasks require a human expert
  - medical diagnosis
  - equipment repair
  - computer configuration
  - legal advice
  - financial planning
- Everyday tasks (recognising faces, understanding speech) in general are much harder for a machine
- Expert systems have been successfully developed in the areas of the expert tasks

Typical AI Application Areas

- natural language processing - understanding, generating, translating
- planning
- vision - scene recognition, object recognition, face recognition
- robotics; car driving
- theorem proving
- speech recognition
- game playing
- problem solving
- expert systems etc.



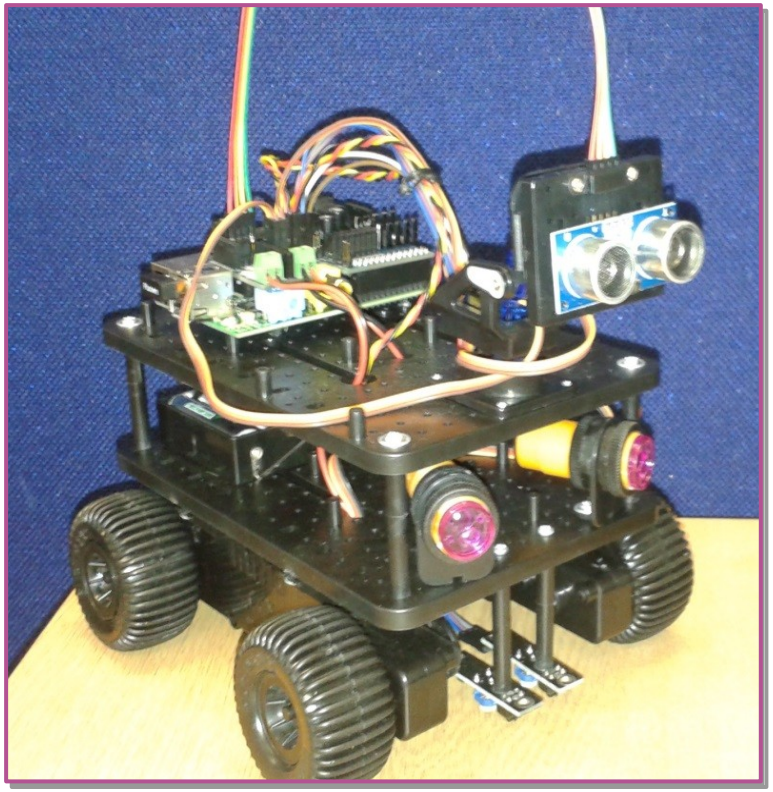
State of the Art

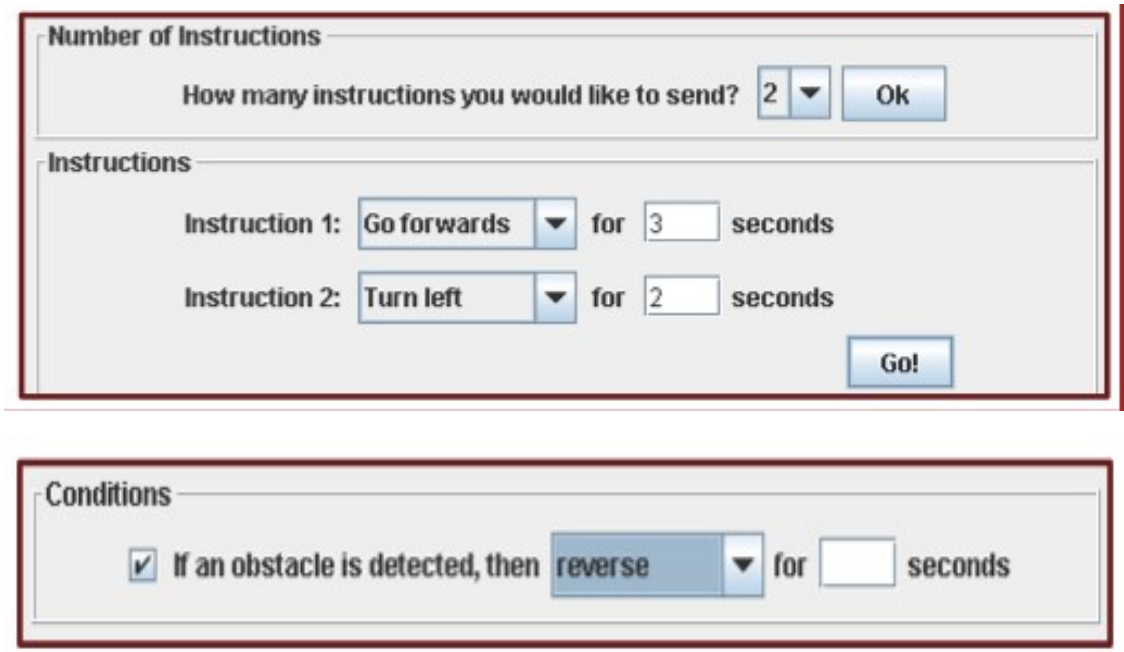


- Autonomous planning and scheduling
  - Route planning
  - Automated scheduling of actions in spacecrafts
- Diagnosis
  - Evidence of human level performance
- Autonomous control
  - Space exploration
    - e.g. ExoMars Rover (see photo)
  - Automated car steering
    - DARPA 'Urban Challenge'
    - Google's Self-driving Cars

http://archive.darpa.mil/grandchallenge/

A Raspberry-Pi based Mars rover simulator robot

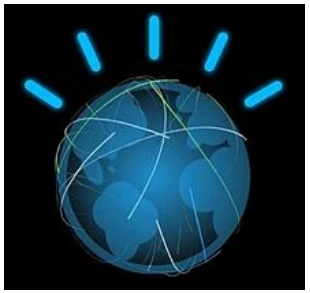




Courtesy of Rebecca Fair, UoL

State of the Art

- Game playing
  - 1997: IBM's Deep Blue defeated G.Kasparov (the human world chess champion)
  - 2002: The chess program FRITZ running on an *ordinary PC* drew with V.Kramnik (the human world champion)
  - 2011: IBM's Watson defeats former human champions competed on *Jeopardy!*
  - Poker (fixed limit) now a match for the world's best
  - Researchers have recently started to develop intelligent Angry Birds



State of the Art

- Logistic planning
  - Defence Advanced Research Project Agency (US) stated that this single application more than paid back DARPA's 30-year investment in AI

www.wikipedia.org

www.universityhospitalfoundation.ab.ca

- Robotics
  - Microsurgery
  - RoboCup — "By the middle of the 21st century, a team of fully autonomous humanoid robot soccer players shall win a soccer game, complying with the official rules of FIFA, against the winner of the most recent World Cup"

www.robocup.org

State of the Art

- Robocup competition has different leagues

  A few are:

  - Soccer
    - Humanoid robots league
    - Small robots league
  - Rescue
    - Robot
    - Simulation
  - Robocup@Work
    - Targets the use of robots in work-related scenarios
    - Computer Science at UoL participates in this league…

State of the Art

July 2014

smARTLab@work wins world title at RoboCup 2014 competition

After winning the German Open Robocup@work competition earlier this year (in April) the smARTLab@work team succeeded in its ultimate goal: winning the world title at RoboCup 2014 in Brazil, Joao Pessoa.

smARTLab (swarms, multi-agent and robot technologies, and learning lab) is the robotics lab associated with the Agent ART group of the Department of Computer Science at the University of Liverpool (http://robocup2014-results.herokuapp.com/live/#category=atwork.demo&id=53cd20097dce64d4103250b9). The team has now won the world title two times in a row, after winning the @work competition in 2013 in Eindhoven, the Netherlands. This is a splendid achievement for smARTLab@work.

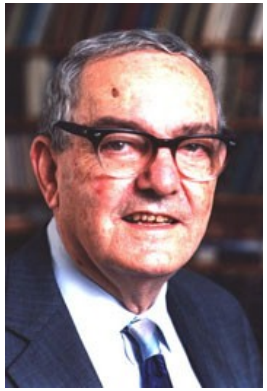
State of the Art

- AI is starting to receive more media and public interest…

State of the Art

"Machines will be capable, within twenty years, of doing any work that a man can do"

Said in ***1965*** – Herb Simon (one of the founders of AI)



Basic AI Building Blocks

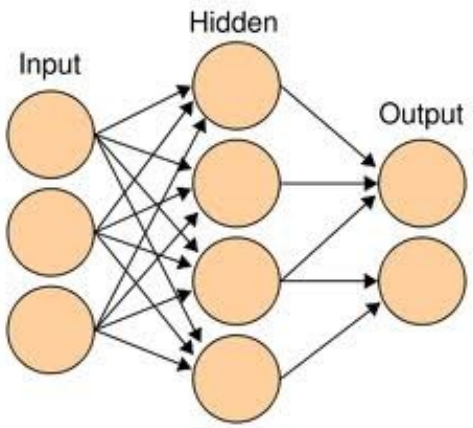
- Symbolic AI
  - Problem solving by *searching*
  - Ability to represent *knowledge*
  - Ability to *reason*
  - …many more…
  - AI programming languages
- Sub Symbolic AI
  - Artificial neural networks
  - Connectionism

```
/* Family Tree */

parent(pete,ian).      % Pete is a parent of Ian
parent(ian,peter).
parent(ian,lucy).
parent(lou,pete).
parent(lou,pauline).
parent(cathy,ian).

female(cathy).         % Cathy is female.
female(lucy).
female(pauline).
female(lou).

male(ian).             % Ian is male.
male(pete).
male(peter).
```

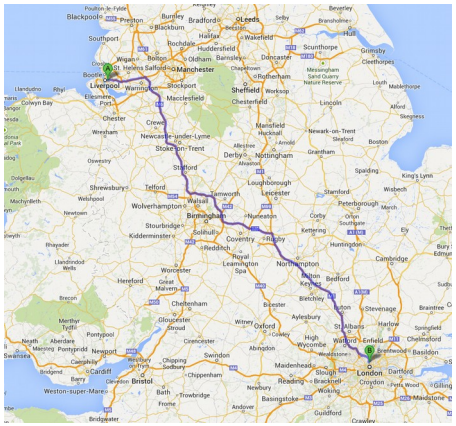


Search

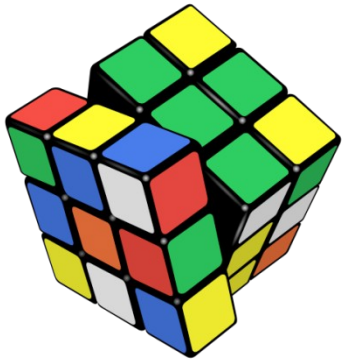
- Often no direct way to solve a problem
- You may know what moves are allowed but not *how to* put the moves into a sequence to solve a problem
- Can generate possibilities for next step and so on
- Considering full search space often too expensive; too many possibilities (even for computers), so heuristics are needed

Search Examples

- Planning
  - Route finders
  - Timetabling
- Games
  - Noughts and crosses
  - Chess
  - Go
- Puzzles



Rubik's Cube



- 43,252,003,274,489,856,000 combinations
- Up to 481,229,803,398,374,426,442,198,455,156,736 brute-force solution attempts
- More than 15,259,696,962,150,381 years
- Need to look at heuristics or strategies, i.e. selecting the best options to lead to a solution
  - Robots now faster than humans
  - Compare 2008 to 2014

Knowledge Representation

- How do we represent the states of a Rubik's cube, and the operations that can be performed to allow us to solve the problem?

- A good knowledge representation should
  - make the processing easy
  - turn unfamiliar problems into familiar ones
- So it must fit
  - the domain - the knowledge to be represented
  - the task - what we want to do with the knowledge

Knowledge Representation

- Example: given the headline “Obama wins election”, could a machine answer the question “Who is the president?”?
  - Background knowledge is necessary
  - How is this knowledge written down, or encoded so a computer can use it?
  - How can it be written down efficiently? We can’t write everything down
  - What do the formal representations mean? Semantics

Knowledge Representation Techniques

- Rules
  - Production systems
  - Logic programming (Prolog)
- Relationships
  - Semantic networks
  - Ontologies
- Objects
  - Frames
  - Objects
  - Agents
- Idealised and formalised knowledge
  - Mathematical equations
  - Various logics, first order, temporal, epistemic, description logics…

Reasoning and Inference

- If we know that elephants are mammals with four legs and that Barbar is an elephant, can we conclude that Barbar is a mammal with four legs?
- If we use formal *logic* as a *knowledge representation language*, logical proof can be used to allow us to infer new facts
- But how do we deal with exceptions: Celeste is an elephant (and a mammal) but only has three legs?

Learning

- Why do we want an agent to learn?
  - Cannot anticipate all situations (e.g. navigating new space)
  - Cannot predict changes over time (e.g. react to the stock market)
  - Don’t know how to design some solutions (e.g. recognising faces)
  - Time; knowledge engineering, writing rules, writing scripts

Applications of Learning

- Natural language processing (A.L.I.C.E.)
- Speech/character/face recognition
- Spam detection, serving advertisements, Google PageRank
- Computer vision (iPhone barcode app)
- Recommendation systems (NetFlix prize)
- Gene discovery
- Computational finance

AI Programming Languages

- Need a language good for symbolic manipulation (rather than numeric)
- LISP - short for List Processing. A functional programming language. Many AI systems have been written in LISP
- Prolog – studied in this module. Short for PROgramming in LOGic. Based on a proof method in logic called resolution. Easy to get started and good for symbolic manipulation
- But can be written in any general purpose language, e.g. C or Java. Particularly, as AI programs become components of other larger systems rather than stand alone systems

Summary

- Today
  - Rapid look at some applications, techniques and state-of-the-art in AI
- Next time
  - Introduction to Prolog