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*

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

• 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”
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...

Special reports
Intelligent Machines
The dawn of artificial intelligence
① 14 September 2015

BBC NEWS

TAROS 2015 EXHIBITION
Download exhibition flyer
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
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