CSE 473
Artificial Intelligence

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www.cs.washington.edu/education/courses/cse473/08au

Goals of this Course

• To introduce you to a set of key:
  Paradigms &
  Techniques

• Teach you to identify when & how to use
  Agents & Problem Spaces
  Heuristic search
  Constraint satisfaction
  Knowledge representation
  Planning
  Uncertainty
  Machine learning
  Dynamic Bayesian networks & particle filters
  Robotics

AI as Science

Where did the physical universe come from? And what laws guide its dynamics?

How did biological life evolve? And how do living organisms function?

What is the nature of intelligent thought?

AI as Engineering

• How can we make software systems more powerful and easier to use?

  Speech & intelligent user interfaces
  Autonomic computing
  Mobile robots, softbots & immobots
  Data mining
  Medical expert systems...
What is Intelligence?

Hardware

- $10^{11}$ neurons
- $10^{14}$ synapses
- cycle time: $10^{-3}$ sec

- $10^8$ transistors
- $10^{12}$ bits of RAM
- cycle time: $10^{-8}$ sec

Computer vs. Brain

Evolution of Computers
Projection

• In the near future computers will have
  As many processing elements as our brain,
  But far fewer interconnections
  Much faster updates.

• Fundamentally different hardware
  Requires fundamentally different algorithms!
  Very much an open question.

Dimensions of the AI Definition

<table>
<thead>
<tr>
<th>thought vs. behavior</th>
<th>human-like vs. rational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems that think like humans</td>
<td>Systems that think rationally</td>
</tr>
<tr>
<td>Systems that act like humans</td>
<td>Systems that act rationally</td>
</tr>
</tbody>
</table>

Mathematical Calculation

\[
\begin{align*}
  e^{-\beta s} (\partial_x^2 - \partial_t^2) u(s) &= - \left[ E' - \left( l + \frac{1}{2} \right)^2 e^{-2s} - e^{2s} \right] u(s) \\
  e^{-\beta s} \left( e^{-\beta u(s)} \right)' &= \frac{1}{2} u(s) \\
  e^{-2s} \left( e^{-\beta u(s)} \right)' &= - \left[ E' - \left( l + \frac{1}{2} \right)^2 e^{-2s} - e^{2s} \right] u(s) \\
  u' &= - e^{2s} \left[ E' - \left( l + \frac{1}{2} \right)^2 e^{-2s} - e^{2s} \right] u
\end{align*}
\]

State of the Art

“I could feel – I could smell – a new kind of intelligence across the table”
-Gary Kasparov

Saying Deep Blue doesn’t really think about chess is like saying an airplane doesn’t really fly because it doesn’t flap its wings.
– Drew McDermott
Autonomous Systems

- In the 1990's there was a growing concern that work in classical AI ignored crucial scientific questions:
  - How do we integrate the components of intelligence (e.g., learning & planning)?
  - How does perception interact with reasoning?
  - How does the demand for real-time performance in a complex, changing environment affect the architecture of intelligence?

RoboCup

- Provide a standard problem where a wide range of technologies can be integrated and examined.
- By 2050, develop a team of fully autonomous humanoid robots that can win against the human world champion team in soccer.
Software Robots (softbots)

- Softbots: 'intelligent' program that uses software tools on a person's behalf.
- Sensors = LS, Google, etc.
- Effectors = RM, ftp, Amazon.com
- Software: not physical but not simulated.
- Active: not a help system (softbot safety!)

Deep Space One

Started: January 1996
Launch: October 15th, 1998
Experiment: May 17-21

courtesy JPL

Compiled into 2,000 variable SAT problem
Real-time planning and diagnosis

2004 & 2009
Europa Mission ~ 2018

Limits of AI Today

• Today's successful AI systems
  operate in well-defined domains
  employ narrow, specialize knowledge

• Commonsense Knowledge
  needed in complex, open-ended worlds
  • Your kitchen vs. GM factory floor
  understand unconstrained Natural Language

Role of Knowledge in Natural Language Understanding

• WWW Information Extraction
• Speech Recognition
  "word spotting" feasible today
  continuous speech - rapid progress
• Translation / Understanding
  limited progress
  *The spirit is willing but the flesh is weak.*
  (English)
  *The vodka is good but the meat is rotten.*
  (Russian)

How the heck do we understand?

• John gave Pete a book.
• John gave Pete a hard time.
• John gave Pete a black eye.
• John gave in.
• John gave up.
• John's legs gave out beneath him.
• It is 300 miles, give or take 10.
How to Get Commonsense?

• CYC Project (Doug Lenat, Cycorp)
  Encoding 1,000,000 commonsense facts about the world by hand
  Coverage still too spotty for use!
  (But see Digital Aristotle project)

• Machine Learning
• Open Mind
• Mining from Wikipedia & the Web
• ???

Recurrent Themes

• Representation vs. Implicit
  Neural Nets - McCulloch & Pitts 1943
  • Died out in 1960's, revived in 1980's
  • Simplified model of real neurons, but still useful: parallelism
  Brooks "Intelligence without Representation"

Recurrent Themes

• Logic vs. Probability
  In 1950's, logic dominates (McCarthy, ...
  • attempts to extend logic "just a little" (e.g. nomon)
  1988 - Bayesian networks (Pearl)
  • efficient computational framework
  Today's hot topic: combining probability & FOL

Recurrent Themes

• Weak vs. Strong Methods
  • Weak - general search methods (e.g. A* search)
  • Knowledge intensive (e.g. expert systems)
    • more knowledge ⇒ less computation
  • Today: resurgence of weak methods
  • desktop supercomputers
  • How to combine weak & strong?

• Importance of Representation
  • "In knowledge lies power"
  • Features in ML
  • Reformulation
Recurrence Themes

- Combinatorial Explosion
- Micro-world successes are hard to scale up.
- How to organize and accumulate large amounts of knowledge?

Historical Perspective

- (4th C BC+) Aristotle, George Boole, Gottlob Frege, Alfred Tarski
  formalizing the laws of logical reasoning
- (16th C+) Gerolamo Cardano, Pierre Fermat, James Bernoulli, Bayes
  formalizing probability
- (1950+) Alan Turing, John von Neumann, Claude Shannon
  thinking as computation
- (1956) John McCarthy, Marvin Minsky, Herbert Simon, Allen Newell
  start of the field of AI

Logistics:

- See website
  www.cs.washington.edu/education/courses/cse473/08au
- Two small projects
  Othello
  TBD
- Grading:
  60% homeworks and mini-projects
  10% midterm
  20% final
  10% class participation, extra credit, etc

For You To Do

- Get on class mailing list
  www.cs.washington.edu/education/courses/cse473/08au
- Dan's Suggestion:
  Start reading Ch 2 in text
  Ch 1 is good, but optional