CSE 573
Artificial Intelligence

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Logistics:

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- Required Reading  
  Russell & Norvig "AIMA2"
  Papers from WWW
- Grading:  
  Class Discussion
  Mini Projects
  Reviews on Reading
  Midterm & Problem Sets

For You To Do

- Get on class mailing list
- Monitor class website for reading etc.
- Read  
  Ch 1 [History] is interesting, but optional
  Ch 2 [Agents] is easy, but important
  Ch 3 [Search] is crucial, but should be review

Goals of this Course

- To introduce you to a set of key:
  Paradigms & Techniques
- Teach you to identify when & how to use
  Heuristic search
  Constraint satisfaction
  Machine learning
  Logical inference
  Bayesian inference
  Policy construction
- Teach you how to evaluate (AI) papers
- Highlight directions for research

Outline

- Logistics
- Objectives
- What is AI?
- State of the Art
- Challenges
- Agents

Historical Perspective

- (4th C BC+) Aristotle, George Boole, Gottlob Frege, Alfred Tarski  
  formalizing the laws of human thought
- (16th C+) Gerolamo Cardano, Pierre Fermat, James Bernoulli, Thomas Bayes  
  formalizing probabilistic reasoning
- (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
**Hardware**

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

- 10^7 transistors
- 10^{10} bits of RAM
- cycle time: 10^{-9} sec

**Computer vs. Brain**

- All Things, Great and Small

**Evolution of Computers**

**Projection**

- In 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.

**What is Intelligence?**

**Dimensions of the AI Definition**

- human-like vs. rational
  - thought vs. behavior

<table>
<thead>
<tr>
<th>Systems that think like humans</th>
<th>Systems that think rationally</th>
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<tbody>
<tr>
<td>Systems that act like humans</td>
<td>Systems that act rationally</td>
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**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?

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**State of the Art**

“1 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

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**Mathematical Calculation**

\[
\begin{align*}
\phi'(u) &= \left( \frac{a + 1}{t^2} \right) u(s)
\end{align*}
\]

\[
\begin{align*}

\phi(0) &= \frac{1}{4} u(0)
\end{align*}
\]

\[
\begin{align*}

\phi(1) &= \left( 1 + \frac{1}{2} \right) \frac{e^{-3t} - e^{-2t}}{u(s)}
\end{align*}
\]

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**Shuttle Repair Scheduling**

Shuttle Repair Scheduling

**Deep Space One**

Start: January 1996
Launch: October 15th, 1998
Experiment: May 17-21
Compiled into 2,000 variable SAT problem
Real-time planning and diagnosis

2004 & 2009

Europa Mission ~ 2018

Credit Card Fraud Detection

Speech Recognition

Autonomous Navigation: NAVLAB 1
Limits of AI Today

- Today's successful AI systems operate in well-defined domains and 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
- Alternatives?

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 II

- 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 III

- 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?
Recurrent Themes IV

- Importance of Representation
  - Features in ML
  - Reformulation

Intelligent Agents

- Have sensors, effectors
- Implement mapping from percept sequence to actions

- Performance Measure

Defn: Ideal rational agent

“For each possible percept sequence, does whatever action is expected to maximize its performance measure on the basis of evidence perceived so far and built-in knowledge.”

- Rationality vs omniscience?
- Acting in order to obtain valuable information

Defn: Autonomy

An agent is autonomous to the extent that its behavior is determined by its own experience

Why is this important?

The parable of the dung beetle

Implementing ideal rational agent

- Table lookup agents
- Agent program
  - Simple reflex agents
  - Agents with memory
    - Reflex agent with internal state
    - Goal-based agents
    - Utility-based agents
Simple reflex agents

Environment

Agent

Sensors

What world is like now

Condition/Action rules

What action should I do now?

Effectors

Reflex agent with internal state

Environment

Agent

Sensors

What world was like

How world evolves

Condition/Action rules

What action should I do now?

Effectors

Goal-based agents

Environment

Agent

Sensors

What world was like

How world evolves

What my actions do

Goals

What it’ll be like if I do acts A1–A_n

Effectors

Utility-based agents

Environment

Agent

Sensors

What world was like

How world evolves

What my actions do

Utility function

How happy would I be?

What it’ll be like if I do acts A1–A_n

Effectors

Properties of Environments

- Observability: full vs. partial vs. non
- Deterministic vs. stochastic
- Episodic vs. sequential
- Static vs. ... vs. dynamic
- Discrete vs. continuous

- Travel agent
- WWW shopping agent
- Coffee delivery mobile robot