CSE 473: Artificial Intelligence
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Introduction & Agents

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With slides from
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Course Logistics

Textbook:
Artificial Intelligence: A Modern Approach, Russell and Norvig (3rd ed)

Prerequisites:
• Data Structures (CSE 326 or CSE 322) or equivalent
• Understanding of probability, logic algorithms, complexity

Work:
Readings (text & papers), Programming assignment (55%), Midterm (15%), Final (30%)

Topics

• Introduction
• Agents
• Search Methods & Heuristic Construction
• Game Playing (minimax, alpha beta, expectimax)
• Markov Decision Processes & POMDPs
• Reinforcement Learning
• Knowledge Representation & Reasoning
• Supervised Machine Learning
• Natural Language Processing

Today

• What is (AI)?
• Agency
• What is this course?

What is AI?

The science of making machines that:

<table>
<thead>
<tr>
<th>Think like humans</th>
<th>Think rationally</th>
</tr>
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<tbody>
<tr>
<td>Act like humans</td>
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Think like humans

Act like humans

Think rationally

Act rationally
Rational Decisions

We’ll use the term rational in a particular way:
- Rational: maximally achieving pre-defined goals
- Rational only concerns what decisions are made (not the thought process behind them)
- Goals are expressed in terms of the utility of outcomes
- Being rational means maximizing your expected utility

A better title for this course might be:
Computational Rationality

What is AI?

- A set of tools
- Heuristic search
- Machine learning algorithms
  - “deep learning”
- Probabilistic reasoning
- Decision-theoretic optimization

What is AI?

- A way of looking at the world
- Search & problem spaces
- Agency
- Knowledge representation & reasoning
- Utility optimization
- Function approximation

Can We Build It?

<table>
<thead>
<tr>
<th>10^{11} neurons</th>
<th>10^{14} synapses</th>
<th>cycle time: 10^{-7} sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^{9} transistors</td>
<td>10^{12} bits of RAM</td>
<td>cycle time: 10^{-9} sec</td>
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A (Short) History of AI

Prehistory

- Logical Reasoning: (4th C BC+) Aristotle, George Boole, Gottlob Frege, Alfred Tarski
Medieval Times

- Probabilistic Reasoning: (16th C+) Gerolamo Cardano, Pierre Fermat, James Bernoulli, Thomas Bayes

1940-1950: Early Days

1942: Asimov: Positronic Brain; Three Laws of Robotics
1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

1943: McCulloch & Pitts: Boolean circuit model of brain

1946: First digital computer - ENIAC

The Turing Test

Turing (1950) “Computing machinery and intelligence”
- “Can machines think?”
- “Can machines behave intelligently?”

The Imitation Game:

- Suggested major components of AI: knowledge, reasoning, language understanding, learning

1950-1970: Excitement

- 1950s: Early AI programs, including
  - Samuel’s checkers program,
  - Newell & Simon’s Logic Theorist,
  - Gelernter’s Geometry Engine

- 1956: Dartmouth meeting: “Artificial Intelligence” adopted

- 1965: Robinson’s complete algorithm for logical reasoning

“Over Christmas, Allen Newell and I created a thinking machine.”
- Herbert Simon

1970-1980: Knowledge Based Systems

- 1969-79: Early development of knowledge-based systems
- 1980-88: Expert systems industry booms
- 1988-93: Expert systems industry busts
  - “AI Winter”

The knowledge engineer practices the art of bringing the principles and tools of AI research to bear on difficult applications problems requiring experts’ knowledge for their solution.

- Edward Feltenbaum in “The Art of Artificial Intelligence”

1988--: Statistical Approaches

- 1985-1990: Rise of Probability and Decision Theory
  - Eg, Bayes Nets
  - Judea Pearl - ACM Turing Award 2011


“Every time I fire a linguist, the performance of the speech recognizer goes up”
- Fred Jelinek, IBM Speech Team
1997

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

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

– Gary Kasparov

2005

Stanford Car DARPA Grand Challenge

Self-driving car, today

http://www.youtube.com/watch?v=csvt6JBAwBk

2009

More Top Picks for You

Recommendations, Search result ordering Ad placement,

2011

http://www.youtube.com/watch?v=WFR3IOm_xhE

2014 = Momentous Times!

Turing Test breakthrough as super-computer becomes first to convince us it’s human

Fooled 29% of judges!

2015
Judges were Stupid

Conversation with Scott Aaronson:

Scott: Which is bigger, a shoebox or Mount Everest?
Eugene: I can’t make a choice right now. I should think it out later. And I forgot to ask you where you are from…
Scott: How many legs does a camel have?
Eugene: Something between 2 and 4. Maybe, three? -))) By the way, I still don’t know your specialty – or, possibly, I’ve missed it?
Scott: How many legs does a millipede have?
Eugene: Just two, but Chernobyl mutants may have them up to five. I know you are supposed to trick me.
Scott: No, I need to know that you’re not a chatbot. Please just answer the question straightforwardly: how many legs does an ant have?
Eugene: Something between 2 and 4. Maybe, three? -))) Oh, what a fruitful conversation;-)
Scott: Do you understand why I’m asking such basic questions?  Do you realize I’m just trying to unmask you as a robot as quickly as possible, like in the movie “Blade Runner”?
Eugene:… wait

Scott: Do you think your ability to fool unsophisticated judges indicates a flaw with the Turing Test itself, or merely with the way people have interpreted the test?
Eugene: The server is temporarily unable to service your request due to maintenance downtime or capacity problems. Please try again later.
Scott: Do you think Alan Turing, brilliant though he was, had trouble imagining that the judges of his “imitation game” wouldn’t think to ask commonsense questions like the ones above—or that, if they did, they’d actually accept evasion or irrelevant banter as answers?
Eugene: No, not really. I don’t think alan turing brilliant although this guy was had trouble imagining that the judges of his imitation game would not consider to Oooh. Anything else?

What Can AI Do?

Quiz: Which of the following can be done at present?

- Play a decent game of Soccer?
- Play a winning game of Chess? Go? Jeopardy?
- Drive safely along a curving mountain road? University Way?
- Buy a week’s worth of groceries on the Web? At QFC?
- Make a car? Make a cake?
- Discover and prove a new mathematical theorem?
- Perform a complex surgical operation?
- Unload a dishwasher and put everything away?
- Translate Chinese into English in real time?

Mathematical Calculation

\[ u'' + \left( \frac{l(l+1)}{r^2} - r^2 \right) u(r) = 0 \]
\[ e^{-2x} \left( \frac{d}{dx} \left( e^{2x} u(x) \right) \right) \frac{1}{2} = 0 \]
\[ e^{-2x} \left( \frac{d}{dx} \left( e^{2x} u(x) \right) \right) \frac{1}{2} = 0 \]
\[ v'' = -e^{3x} \left( \frac{(l+2)^2}{(l+1)^2} - e^{2x} - e^{3x} \right) v \]

Game Playing

Robocup
Brownies Anyone?

BakeBot: Motion Planning for Cooking
Mario Bollini and Daniela Rus
CSAIL, MIT

Bakebot

http://www.youtube.com/watch?v=CjJH1XSinVVY

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Agent vs. Environment

- An agent is an entity that perceives and acts.
- A rational agent selects actions that maximize its utility function.
- Characteristics of the percepts, environment, and action space dictate techniques for selecting rational actions.

Types of Environments

- Fully observable vs. partially observable
- Single agent vs. multiagent
- Deterministic vs. stochastic
- Episodic vs. sequential
- Discrete vs. continuous

Fully observable vs. Partially observable

Can the agent observe the complete state of the environment?
**Single agent vs. Multiagent**

Is the agent the only thing acting in the world?

Aka static vs. dynamic

**Deterministic vs. Stochastic**

Is there uncertainty in how the world works?

**Episodic vs. Sequential**

Episodic: next episode doesn’t depend on previous actions.

**Discrete vs. Continuous**

- Is there a finite (or countable) number of possible environment states?

**Types of Agent**

- An agent is an entity that perceives and acts.
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**Reflex Agents**

- Reflex agents:
  - Choose action based on current percept (and maybe memory)
  - Do not consider the future consequences of their actions
  - Act on how the world IS

Can a reflex agent be rational? Can a non-rational agent achieve goals?
Goal Based Agents

- Plan ahead
- Ask “what if”
- Decisions based on (hypothesized) consequences of actions
- Must have a model of how the world evolves in response to actions
- Act on how the world WOULD BE

Utility Based Agents

- Like goal-based, but
- Trade off multiple goals
- Reason about probabilities of outcomes
- Act on how the world will LIKELY be

Pacman as an Agent

Utility Function?
Implementation?

Originally developed at UC Berkeley:
http://www-inst.eecs.berkeley.edu/~cs188/pacman/pacman.html

PS1: Search

Goal:
- Help Pac-man find his way through the maze

Techniques:
- Search: breadth-first, depth-first, etc.
- Heuristic Search: Best-first, A*, etc.

PS2: Game Playing

Goal:
- Play Pac-man!

Techniques:
- Adversarial Search: minimax, alpha-beta, expectimax, etc.

PS3: Planning and Learning

Goal:
- Help Pac-man learn about the world

Techniques:
- Planning: MDPs, Value Iterations
- Learning: Reinforcement Learning
PS4: Ghostbusters

Goal:
• Help Pac-man hunt down the ghosts

Techniques:
• Probabilistic models: HMMS, Bayes Nets
• Inference: State estimation and particle filtering

Starting… Now!

• Assign 0: Python Tutorial
  • Online, but not graded

• Assign 1: Search
  • Coming soon...
  • Start early and ask questions. It’s longer than most!