CSE 573: Artificial Intelligence
Winter 2017
Introduction & Agents

Dan Weld
TBD

Gagan Bansal
Mon 2:00pm (starting 1/23)

With slides from
Dieter Fox, Dan Klein, Stuart Russell, Andrew Moore, Luke Zettlemoyer
Course Logistics

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

**Work:**
- Programming Assignments
- Final Exam
- Mini-project
- Paper Reviews &
- Class participation

Pacman, autograder
Today

- What is (AI)?
- Agency
- What is this course?
Brain: Can We Build It?

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

vs.

10^9 transistors
10^{12} bits of RAM
cycle time: 10^{-9} sec
What is AI?

The science of making machines that:

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<thead>
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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**
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*:

  ![Diagram of the Imitation Game](image)

- Suggested major components of AI: knowledge, reasoning, language understanding, learning
1950-1970: Excitement about Search

- **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 Felgenbaum 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

- 1990-2000: Machine learning takes over subfields:
  Vision, Natural Language, etc.

"Every time I fire a linguist, the performance of the speech recognizer goes up"
- Fred Jelinek, IBM Speech Team
2015 Deep NN Tsunami

“Deep Learning waves have lapped at the shores of computational linguistics for several years now, but 2015 seems like the year when the full force of the tsunami hit the major Natural Language Processing (NLP) conferences.”

– Chris Manning
Milestones
“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
Robocup (Stockholm ‘99)
Robocup
2005

Stanford Car
DARPA Grand Challenge
Google Self-Driving Car 2014

https://www.youtube.com/watch?v=TsaES--OTzM

2016
Recommendations,
Search result ordering
Ad placement,
AlphaGo deep RL defeats Lee Sedol (4-1)
2014 = Momentous Times!

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

Eugene Goostman, a computer programme pretending to be a young Ukrainian boy, successfully duped enough humans to pass the iconic test

ANDREW GRIFFIN | Sunday 08 June 2014

A programme that convinced humans that it was a 13-year-old boy has become the first computer ever to pass the Turing Test. The test — which requires that computers are indistinguishable
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”?
Summary Status of AI

- Where are we?
What is AI?

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• 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.
CSE 573 vs…?

- CSE 515 – Stat methods
- CSE 517 – NLP
- CSE 546,7 – ML
- CSE 571 – Robotics
- CSE 574
- CSE 576,7 – Vision
Actions? Perceps?
Actions? Perce...
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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- Characteristics of the *percepts, environment, and action space* dictate techniques for selecting rational actions.
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
Goal Based Agents

- Plan ahead
- Ask “what if”

- Decisions based on (hypothesized) consequences of actions
- Uses 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

Originally developed at UC Berkeley:
http://www-inst.eecs.berkeley.edu/~cs188/pacman/pacman.html
Goal:
• Help Pac-man find its 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 Iteration
• 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
Paper Reviews

- Historical & breaking papers
  - Online review before class
  - Discussion
Mini-Project

- Groups welcome to propose ideas (early!)
- Must exercise course material
  - Ideally MDP, POMDP, RL
- Default: Deep Q-learning / Atari

https://www.youtube.com/watch?v=V1eYniJ0Rnk
Course Topics

- **Part I: Making Decisions**
  - Fast search / planning
  - Constraint satisfaction
  - Adversarial and uncertain search
  - Markov decision processes
  - Reinforcement learning
  - POMDPs

- **Part II: Reasoning under Uncertainty**
  - Bayes’ nets
  - Decision theory
  - Machine learning

- **Throughout: Applications**
  - Natural language, vision, robotics, games, …