CSE 473: Introduction to Artificial Intelligence

Introduction

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[These slides were adapted from Dan Klein and Pieter Abbeel for CS188 Intro to AI at UC Berkeley. All materials at http://ai.berkeley.edu.]
Today

- Course Overview
- What is artificial intelligence?
- What can AI do?
- What is this course?
Textbook

- Not required, but for students who want to read more we recommend
  - Warning: Not a course textbook, so our presentation does not necessarily follow the presentation in the book.
Sci-Fi AI?
What is AI?

The science of making machines that:

- Think like people
- Act like people
- Think rationally
- Act rationally
What is AI?

The science of making machines that:

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- Act like people
- Think rationally
- Act rationally
We’ll use the term *rational* in a very specific, technical way:

- Rational: maximally achieving pre-defined goals
- Rationality 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 would be:

**Computational Rationality**
Maximize Your Expected Utility
A (Short) History of AI

Demo: HISTORY – MT1950.wmv
A Historic Idea....
A (Short) History of AI

1940-1950: Early days
- 1943: McCulloch & Pitts: Boolean circuit model of brain
- 1950: Turing’s “Computing Machinery and Intelligence”

I propose to consider the question, "Can machines think?" This should begin with definitions of the meaning of the terms "machine" and "think." The definitions might be framed...

-Alan Turing
A (Short) History of AI

- **1940-1950: Early days**
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- **1950—70: Excitement: Look, Ma, no hands!**
  - 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
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- **1970—90: Knowledge-based approaches**
  - 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"
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  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems… “AI Spring”?

Every time I fire a linguist, the performance of the speech recognizer goes up. – Frederick Jelinek, IBM
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- **2010—: Where are we now?**
What Can AI Do?

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

- ✔ Play a decent game of table tennis?
- ✔ Play a decent game of Jeopardy?
- ✔ Drive safely along a curving mountain road?
- ➔ Drive safely along University Avenue?
- ✔ Buy a week's worth of groceries on the web?
- ➔ Buy a week's worth of groceries at QFC?
- ➔ Discover and prove a new mathematical theorem?
- ✗ Converse successfully with another person for an hour?
- ➔ Perform a surgical operation?
- ✔ Put away the dishes and fold the laundry?
- ✔ Translate spoken Chinese into spoken English in real time?
- ✗ Write an intentionally funny story?
One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe walked to the oak tree. He ate the beehive. The End.

Henry Squirrel was thirsty. He walked over to the river bank where his good friend Bill Bird was sitting. Henry slipped and fell in the river. Gravity drowned. The End.

Once upon a time there was a dishonest fox and a vain crow. One day the crow was sitting in his tree holding a piece of cheese in his mouth. He noticed that he was holding the piece of cheese. He became hungry, and swallowed the cheese. The fox walked over and asked the crow for the cheese. The crow opened his mouth and the cheese fell out. The fox ate the cheese. The End.

[Shank, Tale-Spin System, 1984]
Natural Language

- **Speech technologies (e.g. Siri)**
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems

- **Language processing technologies**
  - Question answering
  - Machine translation

- **Web search**
- Text classification, spam filtering, etc...
Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification

Images from Erik Sudderth (left), wikipedia (right)

Demo1: VISION – lec_1_t2_video.flv
Demo2: VISION – lec_1_obj_rec_0.mpg
Object Some Recent Results

Slides from Jeff Dean at Google
Number Detection

Slides from Jeff Dean at Google
Good Generalization

Both recognized as a “meal”

Slides from Jeff Dean at Google
Robotics

- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!

- Technologies
  - Vehicles
  - Rescue
  - Soccer!
  - Lots of automation...

- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control

Images from UC Berkeley, Boston Dynamics, RoboCup, Google

Demo 1: ROBOTICS – soccer.avi
Demo 2: ROBOTICS – soccer2.avi
Demo 3: ROBOTICS – gcar.avi
Demo 4: ROBOTICS – laundry.avi
Demo 5: ROBOTICS – petman.avi
Robot Soccer
Robot Soccer
Google Car
Logic

- **Logical systems**
  - Theorem provers
  - NASA fault diagnosis
  - Question answering

- **Methods:**
  - Deduction systems
  - Constraint satisfaction
  - Satisfiability solvers (huge advances!)

Image from Bart Selman
Game Playing

- **Classic Moment: May, '97: Deep Blue vs. Kasparov**
  - First match won against world champion
  - “Intelligent creative” play
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - Can do about the same now with a PC cluster

- **Open question:**
  - How does human cognition deal with the search space explosion of chess?
  - Or: how can humans compete with computers at all??

- **1996: Kasparov Beats Deep Blue**
  “I could feel --- I could smell --- a new kind of intelligence across the table.”

- **1997: Deep Blue Beats Kasparov**
  “Deep Blue hasn't proven anything.”

- **Huge game-playing advances recently, e.g. in Go!**

Text from Bart Selman, image from IBM's Deep Blue pages
"I misjudged the capabilities of AlphaGo and felt powerless.", quote after game 3
Decision Making

Applied AI involves many kinds of automation

- Scheduling, e.g. airline routing, military
- Route planning, e.g. Google maps
- Medical diagnosis
- Web search engines
- Spam classifiers
- Automated help desks
- Fraud detection
- Product recommendations
- ... Lots more!
Designing Rational Agents

- An **agent** is an entity that *perceives* and *acts*.
- A **rational agent** selects actions that maximize its (expected) **utility**.
- Characteristics of the **percepts**, **environment**, and **action space** dictate techniques for selecting rational actions.
- **This course** is about:
  - General AI techniques for a variety of problem types
  - Learning to recognize when and how a new problem can be solved with an existing technique
Pac-Man as an Agent

Agent
Sensors

Actuators

Environment

Pac-Man is a registered trademark of Namco-Bandai Games, used here for educational purposes.
Types of Environments

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

Can the agent observe the complete state of the environment?

VS.
Single agent vs. Multiagent

Is the agent the only thing acting in the world?
Deterministic vs. Stochastic

Is there uncertainty in how the world works?

vs.
Static vs. Sequential

Does the agent take more than one action?

VS.
Discrete vs. Continuous

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

- **Part I: Making Decisions**
  - Fast search / planning
  - Constraint satisfaction
  - Adversarial and uncertain search

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

- **Throughout: Applications**
  - Natural language, vision, robotics, games, ...
Assignments: Pac-man

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
To Do

- Look at the course website: https://courses.cs.washington.edu/courses/cse473/19sp/
- Do the python tutorial (not graded)