CSC384
Introduction to Artificial Intelligence

Fall 2019

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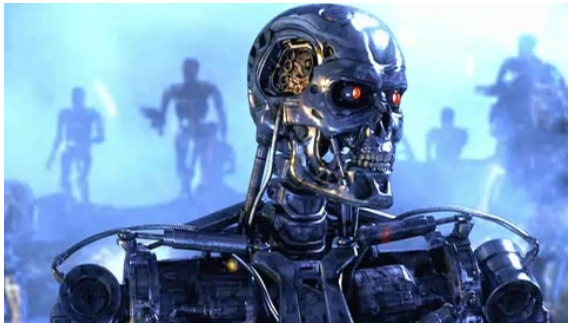
Sci-Fi AI?



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Artificial Intelligence

- A branch of Computer Science.
  Utilizes computational ideas.
- Examines how we can achieve intelligent behaviour through computation.
- **What kind of behavior?**

Rational Action/Rational Decisions

- Formal view of **rational.**
  - Taking actions making decisions that increase the chance of achieving pre-defined goals
  - Rationality is measured by the outcome—the decision/action that is made—not the process of computing the decision.
  - One common approach is to measure the **utility** of the outcome of the decision/action.
  - Being rational → trying to maximize expected utility.

Rational Action/Rational Decisions

- **Trying/expectation**—these arise from the fact that
  a) we often don't have full control or knowledge of the world (or the part of the world we are interacting with
  b) We don't usually know precisely what the effects of our actions will be.
- In some contexts we can simplify the computational task by assuming that we do have full knowledge/control.

Rational Action/Rational Decisions

- In certain controlled environments this can still lead to rational decisions.

Computational Intelligence

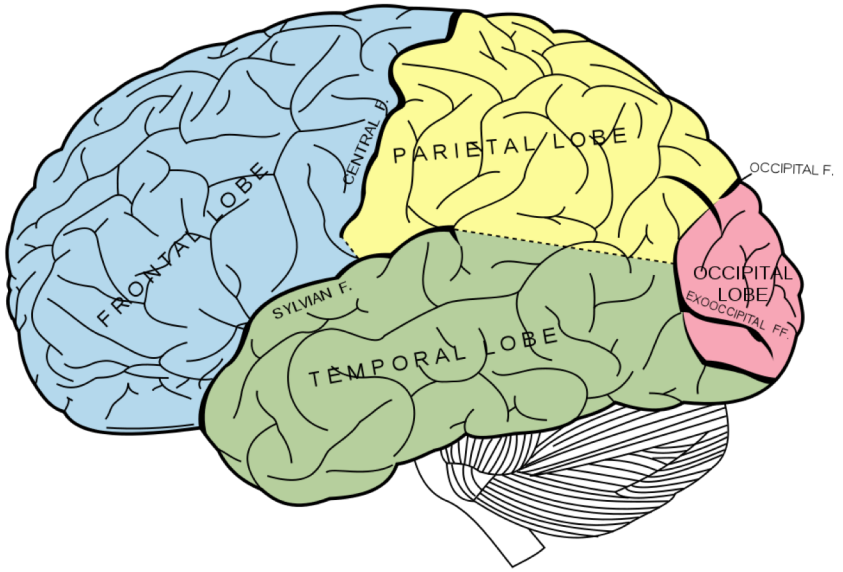
- *AI tries to understand and model intelligence as a computational process.*

- Thus we try to construct systems whose computation achieves or approximates the desired notion of rationality.

- Hence AI is part of Computer Science.
  - Other areas interested in the study of intelligence lie in other areas or study, e.g., cognitive science which focuses on human intelligence. Such areas are very related, but their central focus tends to be different.

What About the Brain?

- Brains (human minds) are very good at making rational decisions, but not perfect
- Brains aren't as modular as software, so hard to reverse engineer!
- Lessons learned from the brain: memory and simulation are key to decision making
  - Perceptual tasks (vision, sound, etc.) are effectively accomplished by architectures related to the way the brain works (deep neural networks).



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Short History of AI

- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's “Computing Machinery and Intelligence”
- 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
- 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”
- 1990—: Statistical approaches
  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems… “AI Spring”?
- 2000—: Where are we now?

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What Can AI Do?

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

- ✓ Play a decent game of table tennis?
- ✓ Play a winning game of Jeopardy?
- ✓ Drive safely along a curving mountain road?
- ✓ Buy a week's worth of groceries on the web?
- ✓ Discover and prove an new mathematical theorem?
- ✗ Discover and prove a **interesting** new mathematical theorem?
- ✗ Converse successfully with another person for an hour? Turing test.
- ? Perform a surgical operation?
- ✓ Put away the dishes and fold the laundry?
- ✓ Translate spoken Chinese into spoken English in real time?

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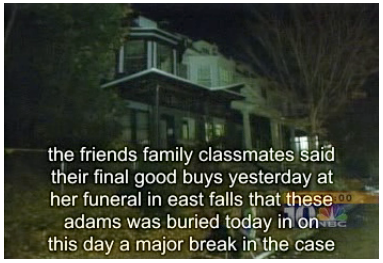
Laundry Robot/Geminoid Robot

- https://youtu.be/uFkIHPrzS_8
- https://youtu.be/CY1WIfPJHqI

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…

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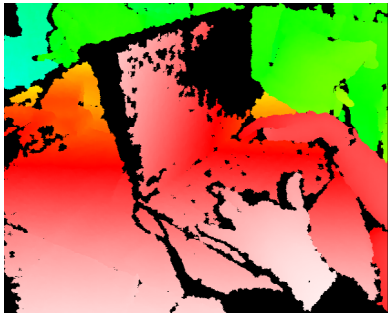
Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification



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

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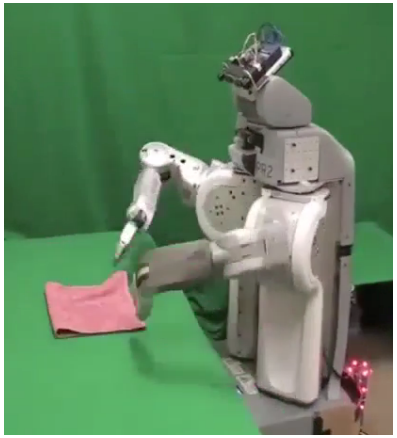
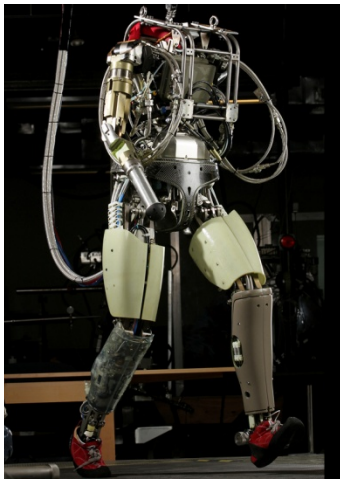
Robotics

- 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

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Logic

- Logical systems
  - Theorem provers
  - NASA fault diagnosis
  - Question answering
- Methods:
  - Deduction systems
  - Constraint satisfaction
  - Satisfiability solvers (huge advances!)

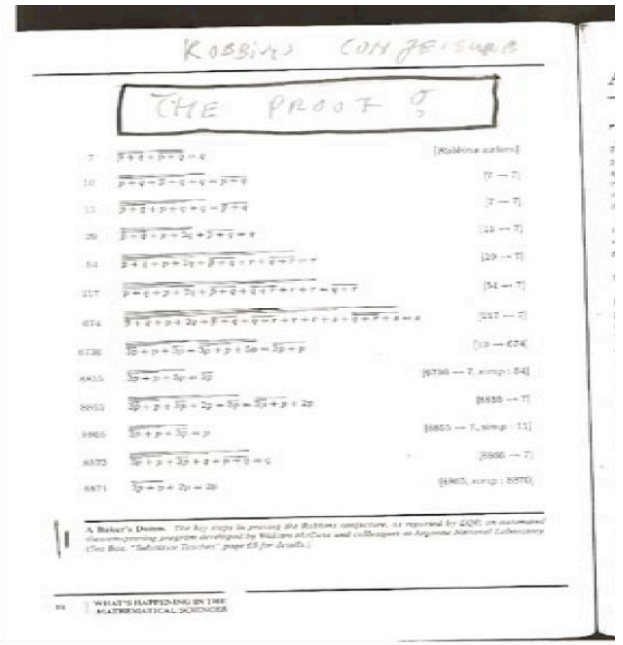

Image from Bart Selman

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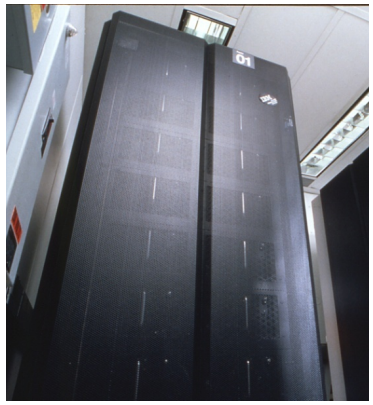
Game Playing

- 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

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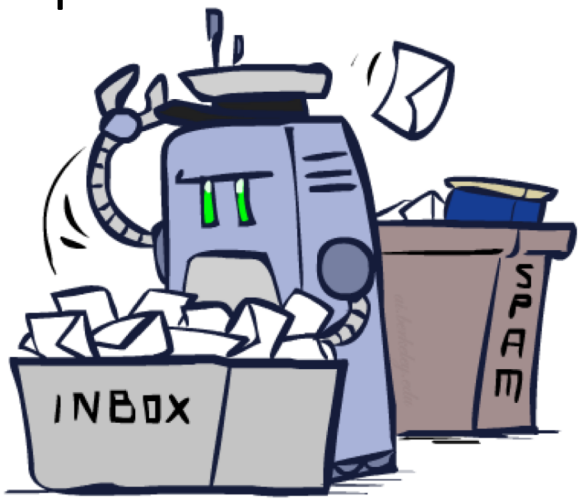
Decision Making

– 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!



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AI Still has a long way to go!

- Many of these successes have been due to advanced Machine learning techniques, that do not consider higher level structure.
- E.g., translation by looking at narrow windows of words—no **common sense** understanding about if the translation makes sense.
- E.g., Neural Nets can be fooled

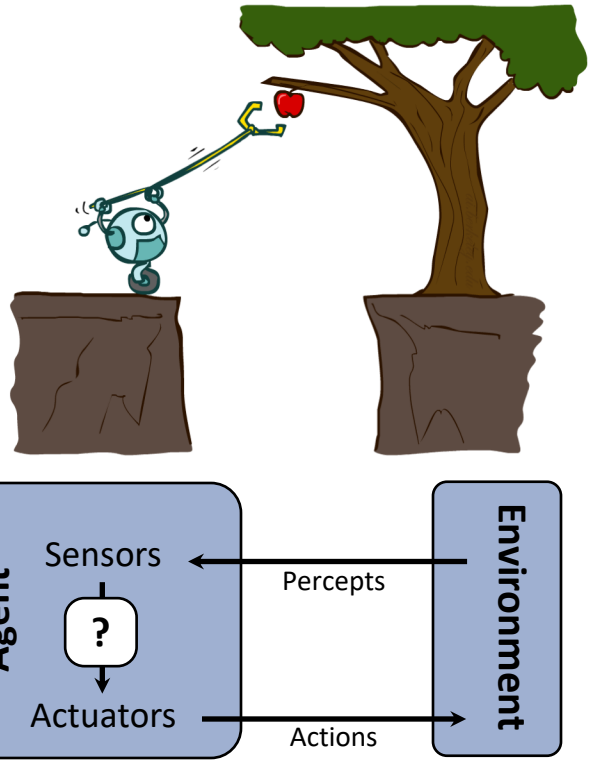
  https://youtu.be/M2IebCN9Ht4

Many applications

- Nevertheless many useful applications are possible with current AI techniques.

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



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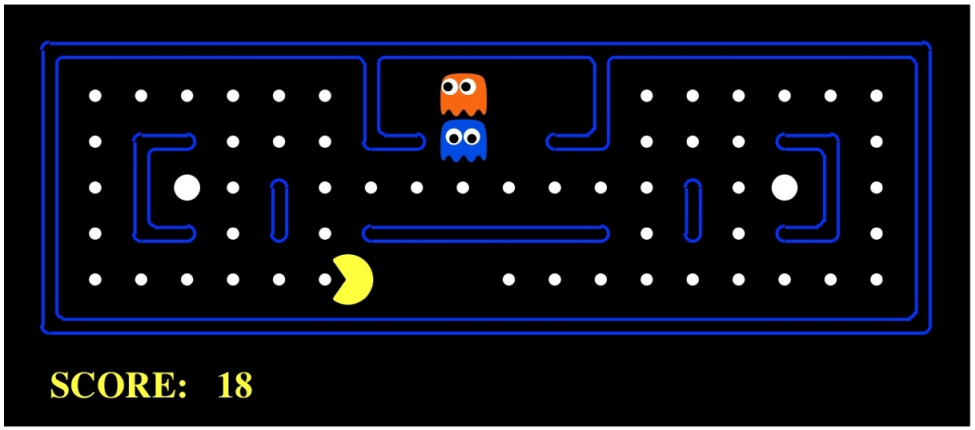
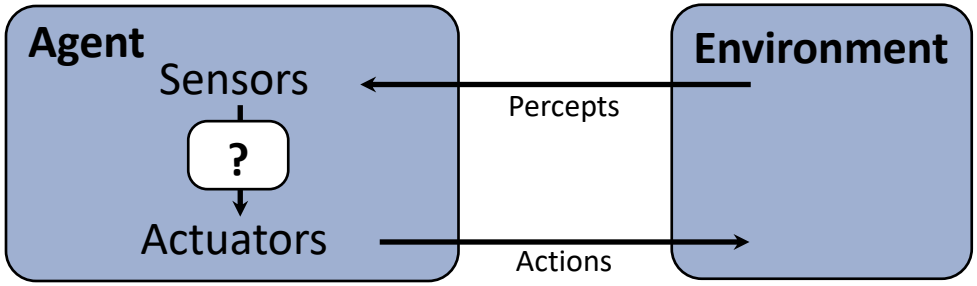
Pac-Man as an Agent





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Subareas of AI

- Perception: vision, speech understanding, etc.
- Machine Learning, Neural networks
- Robotics
- Natural language processing
- Reasoning and decision making
  - **Knowledge representation**
  - **Reasoning** *(logical, probabilistic)*
  - **Decision making** *(search, planning, decision theory)*

Subareas of AI

- Many of the popular recent applications of AI in industry have been based on Machine Learning, e.g., voice recognition systems on your cell phone.

- This course will not focus on machine learning, although the last part of the course will introduce Bayes Nets a form of probabilistic graphical model that can be used to represent and reason with probabilistic information.

- Probabilistic graphical models are fundamental in machine learning.

Subareas of AI

- Nor will we discuss Computer Vision nor Natural Language to any significant extent.
- All of these areas have developed a number of specialized theories and methods specific to the problems they study.
- The topics we will study here are fundamental techniques used in various AI systems, and often appear in advanced research in many other sub-areas of AI.
- In short, what we cover here is not sufficient for a deep understanding of AI, but it is a good start.

Further Courses in AI

- Perception: vision, speech understanding, etc.
  - CSC487H1 “Computational Vision”
  - CSC420H1 “Introduction to Image Understanding”
- Machine Learning, Neural networks
  - CSC321H “Introduction to Neural Networks and Machine Learning”
  - CSC411H “Machine Learning and Data Mining”
  - CSC412H1 “Uncertainty and Learning in Artificial Intelligence”
- Robotics
  - Engineering courses
- Natural language processing
  - CSC401H1 “Natural Language Computing”
  - CSC485H1 “Computational Linguistics”
- Reasoning and decision making
  - CSC486H1 “Knowledge Representation and Reasoning”
    - Builds on this course

What we will cover in CSC384

- Search
  - Heuristic Search
  - Adversarial Tree Search
  - Backtracking Search (CSPs)
- Knowledge Representation
  - First order logic for more general knowledge
  - Inference in First-Order Logic

What we will cover in CSC384

- Probabilistic Reasoning using Bayes Nets
- Tracking the environment using HMMs.