CSCE 580: Artificial Intelligence

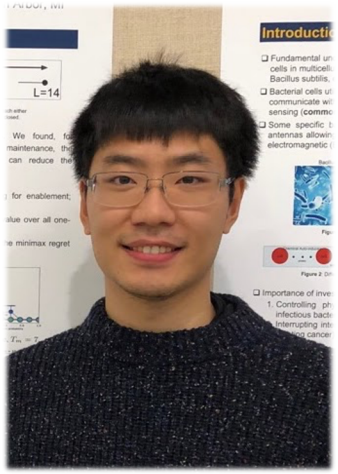
Introduction

Instructor: Qi Zhang

University of South Carolina

Course staff

Instructor



Qi Zhang

(No TAs)

To students:

Welcome!

Course overview

- Introductory course to AI
  - Search
  - Game playing
  - Constraint satisfaction
  - Graphical models
  - Machine learning

- Blended
  - Online meetings on Microsoft Teams/Blackboard Collaborate Ultra
  - Face-to-face meetings in the classroom

Blended course format

- Online meetings
  - Microsoft Teams/BB Collaborate Ultra
  - Lectures
    - Streamed in a synchronous format
    - Recordings posted afterwards
  - Supplementary to lectures
    - Homework discussion
    - Examples and demos
    - Selected topics
    - Q & A
- Face-to-face meetings
  - <Classroom Number>
  - Supplementary to online teaching, Office hours
  - Keep social distance and wear masks

Communication

- Microsoft Teams/BB Collaborate Ultra for online meetings
  - A virtual classroom
- Blackboard for course materials
  - Announcements
  - Assignments distribution and submission
  - Lecture slides/recordings
- Piazza for discussion
  - General Q&A
  - Discussions/clarifications about lectures, assignments
  - Student questions to each other
- To contact the instructor privately, use email
- Anonymous Feedback: Piazza, or here https://forms.gle/urWoB2rChNHos62T9

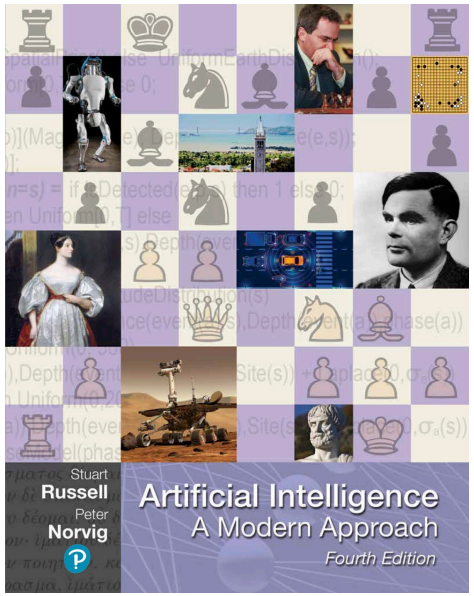
Attendance and participation

- Attendance to online meetings is expected
  - You will get credit by active participation
    - Ask/answer meaningful questions
    - Answer quizzes
    - Correct my mistakes
    - …
- Attendance to face-to-face meetings is optional
  - It will not negatively affect your grade
- Participation on Piazza is encouraged
  - You will get credit by active participation
    - Post/answer questions in a substantial and helpful way

Textbook

- No required textbooks
  - Should be able to learn everything from the lectures and assignments

- A good reference:
  - Stuart Russell and Peter Norvig (2020). Artificial Intelligence: A Modern Approach



Prerequisites

- Math
  - Discrete math
  - Probability and Optimization
- Programming
  - Prior programming experience, preferably in Python
- Self-check with Assignment 0

Assignments

- ~7 assignments
  - For written questions, use LaTex
  - For programming questions, use Python
- Submit your own work
- Late days
  - You have 7 late days in total to be distributed among the assignments
  - Penalization of 25% per day after using up all the late days

Exam

- A remote final exam
  - No mid-term exams
- Details TBD

Course project

- You can work individually or in a team of up to three
- You can choose one of the following three:
  - Replicate an existing paper in AI
  - Investigate deeply a topic from the course materials
  - Design an AI system to a setting that you're interested in
- Details TBD
- How it affects your grade
  - Graduate students cannot get “A” without credit on the course project
  - Undergraduate students receives extra credit for doing a course project

Grades

- Undergraduates
  - Assignments (60%)
  - Exam (30%)
  - Attendance and Participation (10%)
  - Course Project (**extra** 20%)

- Graduates
  - Assignments (50%)
  - Exam (20%)
  - Attendance and Participation (10%)
  - Course Project (20%)

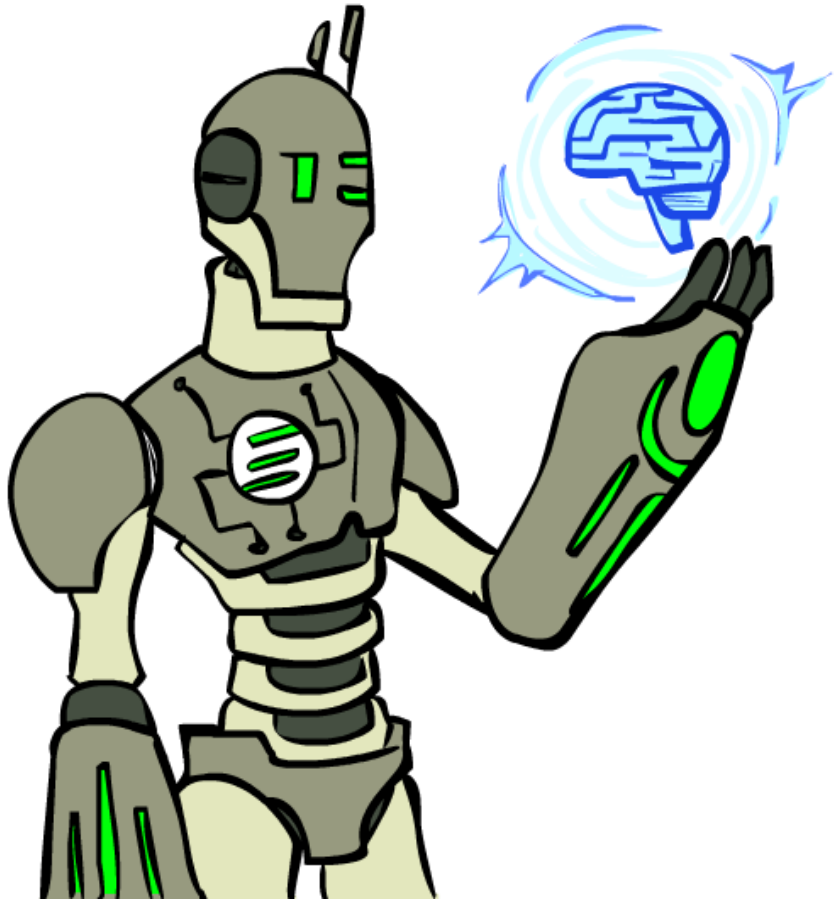
The honor code

- As a Carolinian, I will practice personal and academic integrity.
- Do collaborate and discuss together, but write up and code independently.
- Do not look at anyone else's writeup or code.
- Do not show anyone else your writeup or code or post it online (e.g., GitHub).

Acknowledgements

- Staff of Berkeley's AI courses
  - Dan Klein, Pieter Abbeel, …
- Staff of Stanford's AI courses
  - Percy Liang, Dorsa Sadigh, …
- Courses taught in previous semesters
  - Pooyan Jamshidi

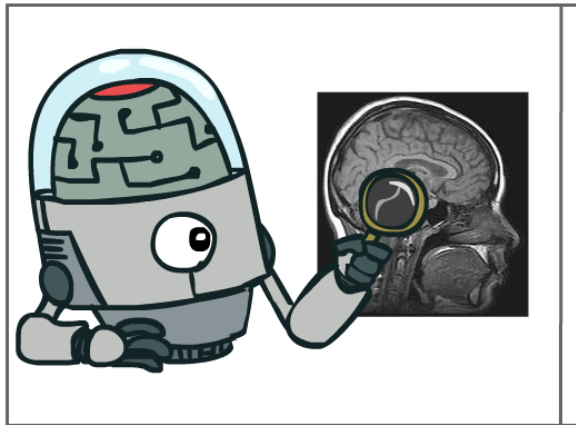
- What is artificial intelligence (AI)?
  - What is this course about?
- Where did it come from?
  - History of AI
- What can AI do?



What is AI?

The science of making machines that:

Think like people



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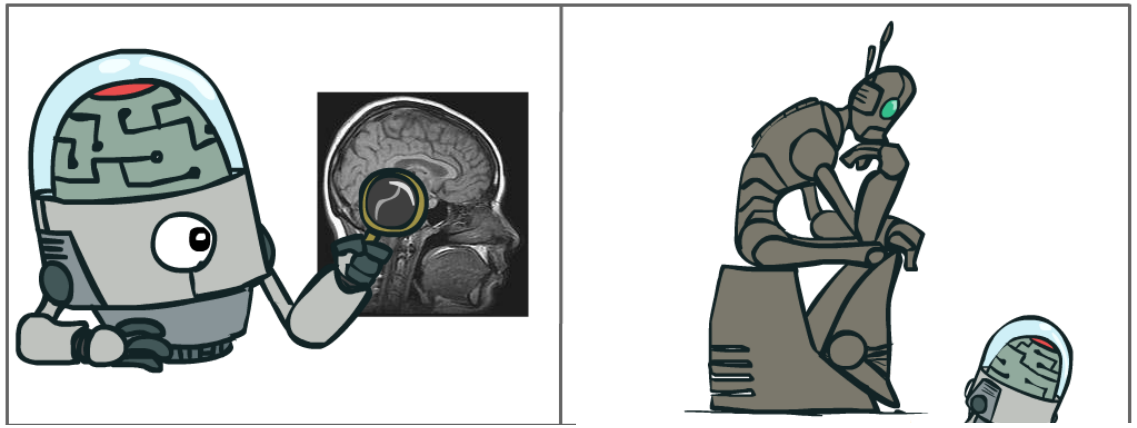

Think rationally

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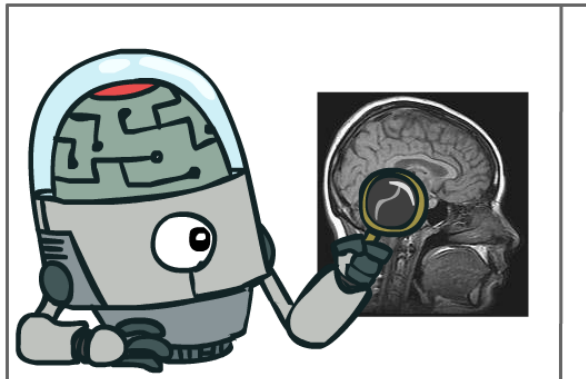

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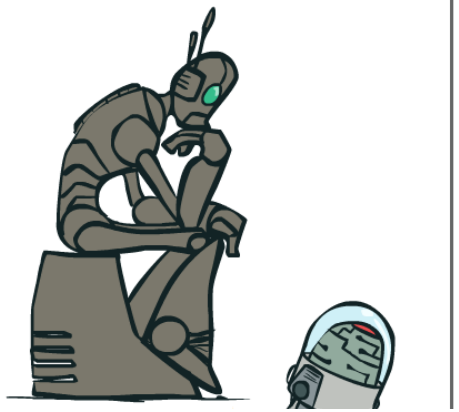
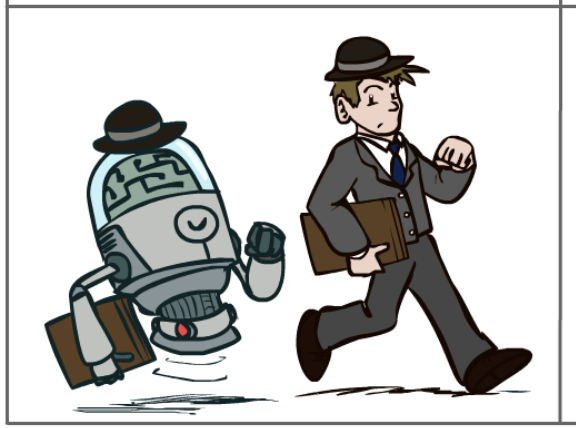


Act like people



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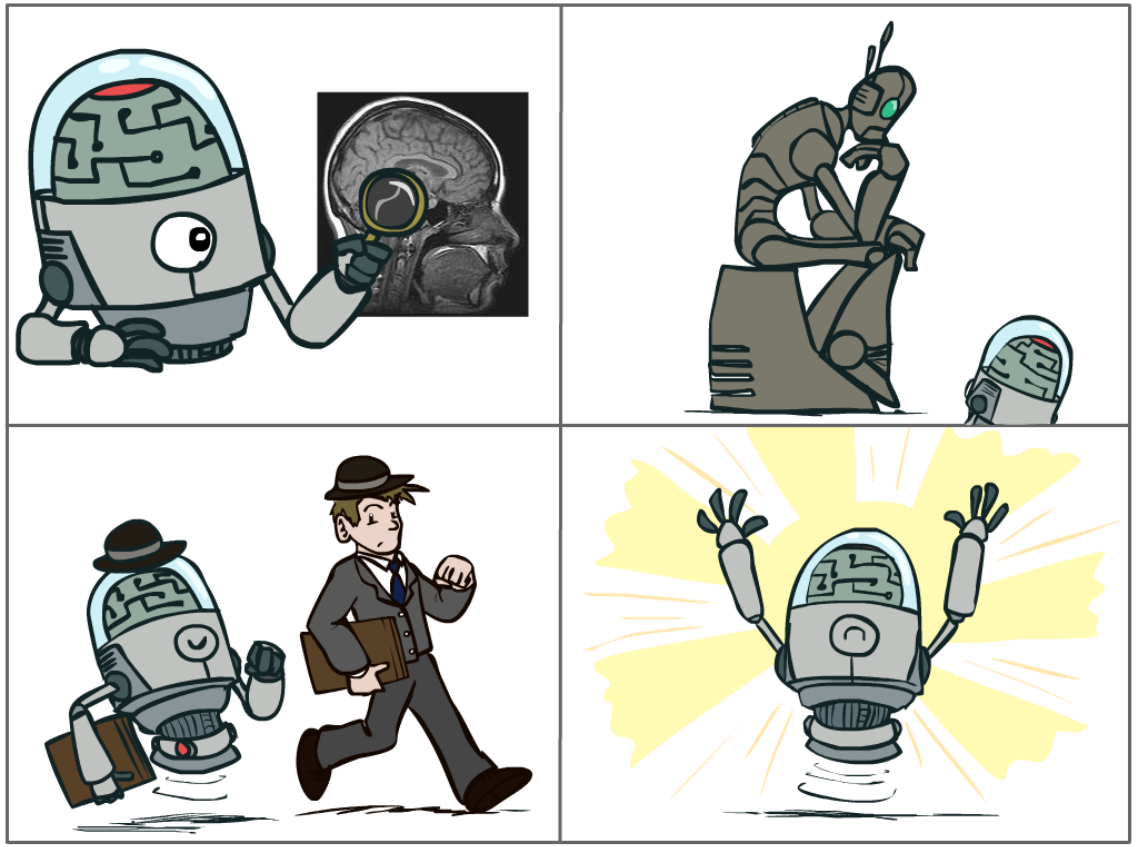


Think rationally

Act like people

Act rationally

Rationality

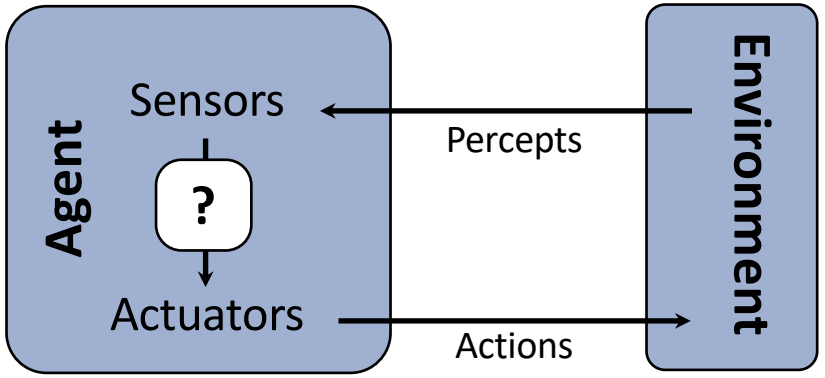
- We'll use the term **rational** in a very specific, technical way:
  - Rational: maximally achieving pre-defined goals
  - Rationality only concerns what decisions are made
  - (not the thought process behind them)
  - Goals are expressed in terms of the **utility** of outcomes
  - Being rational means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

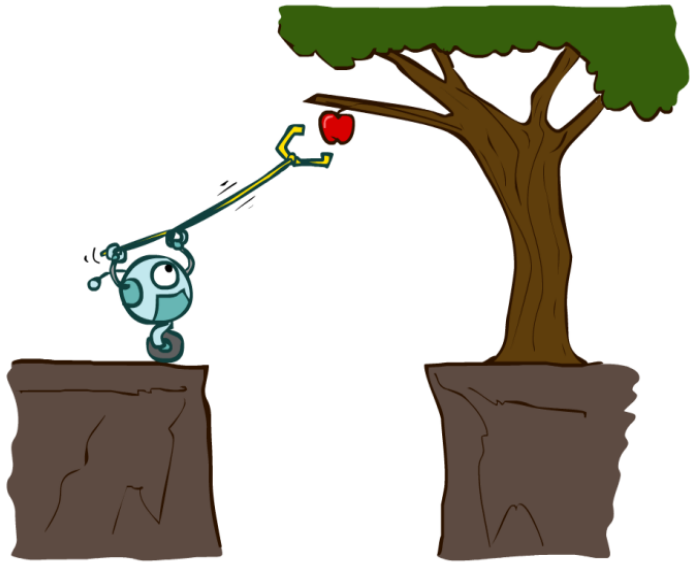
A better title for this course would be:

Computational Rationality

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





History of AI

Wikipedia: history of artificial intelligence
https://en.wikipedia.org/wiki/History_of_artificial_intelligence

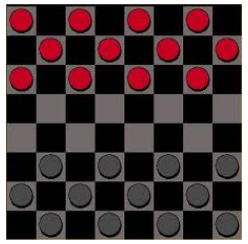
Birth of AI, 1956

1956: Workshop at Dartmouth College; attendees: John McCarthy, Marvin Minsky, Claude Shannon, etc.

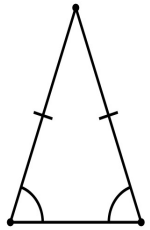
Aim for **general principles**:

Every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it.

Birth of AI, early successes



Checkers (1952): Samuel's program learned weights and played at strong amateur level



Problem solving (1955): Newell & Simon's Logic Theorist: prove theorems in Principia Mathematica using search + heuristics; later, General Problem Solver (GPS)

Overwhelming optimism...

Machines will be capable, within twenty years, of doing any work a man can do. —Herbert Simon, 1965

Within a generation ... the problem of creating 'artificial intelligence' will substantially be solved. —Marvin Minsky, 1967

I visualize a time when we will be to robots what dogs are to humans, and I'm rooting for the machines. —Claude Shannon

1956–1974: the golden years

...underwhelming results

Example: machine translation

The spirit is willing but the flesh is weak.

↓

(Russian)

↓

The vodka is good but the meat is rotten.

ALPAC report cut off government funding for machine translation in 1966.

1974–1980: The first AI winter

Expert systems (70-80s)

Expert systems: elicit specific domain knowledge from experts in form of rules:

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if [premises] then [conclusion]
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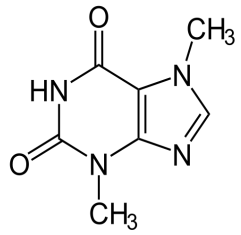
Expert systems



DENDRAL: infer molecular structure from mass spectrometry

MYCIN: diagnose blood infections, recommend antibiotics

XCON: convert customer orders into parts specification; save DEC $\$40$ million a year by 1986

Expert systems

Contributions:

- First **real application** that impacted industry
- Knowledge helped curb the exponential growth

Problems:

- Knowledge is not deterministic rules, need to model **uncertainty**
- Requires considerable **manual effort** to create rules, hard to maintain

1987—93: Expert systems industry busts, the second AI winter

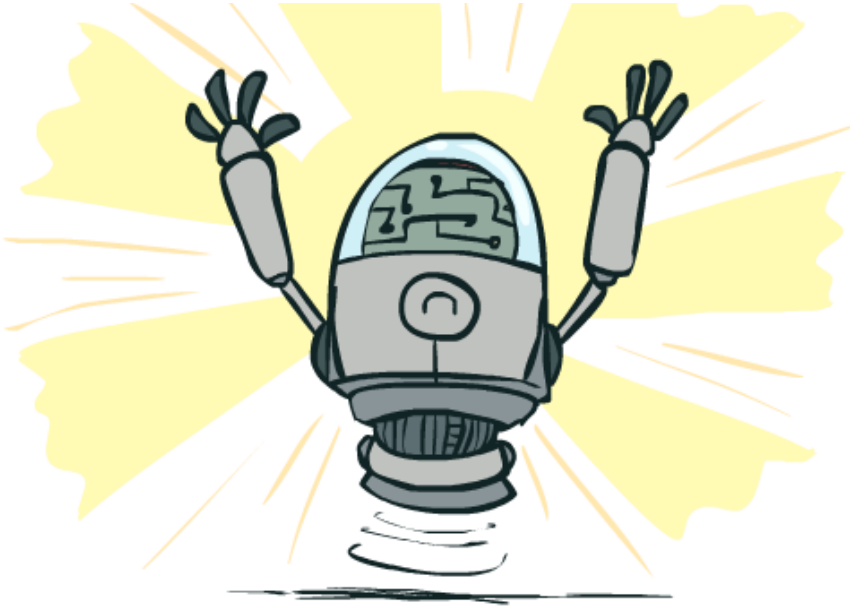
Modern AI (90s-present)

- 1993— 2011: Statistical approaches + subfield expertise
  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems
  - Milestones
    - 1997: IBM's Deep Blue, chess playing
    - 2005: a Stanford robot won the DARPA Grand Challenge by driving autonomously for 131 miles along an unrehearsed desert trail
    - 2011: IBM's Watson, question answering
- 2011— present: Deep learning
  - Big data, big compute, neural networks
  - AI used in many industries

A melting pot

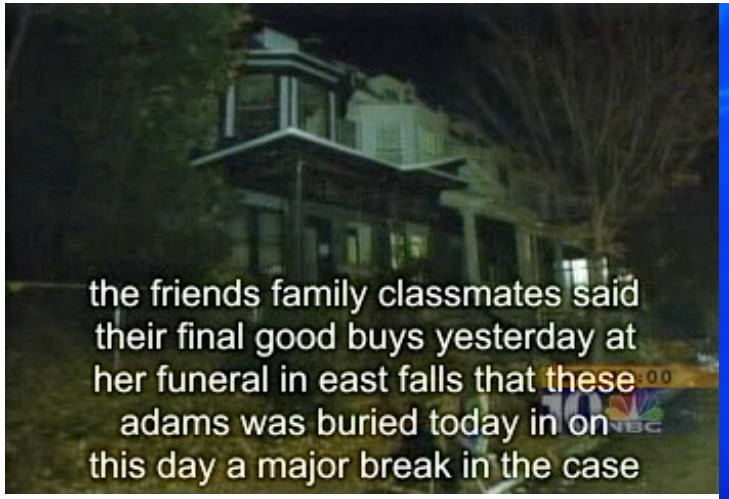
- Bayes rule (Bayes, 1763) from **probability**
- Least squares regression (Gauss, 1795) from **astronomy**
- First-order logic (Frege, 1893) from **logic**
- Maximum likelihood (Fisher, 1922) from **statistics**
- Artificial neural networks (McCulloch/Pitts, 1943) from **neuroscience**
- Minimax games (von Neumann, 1944) from **economics**
- Stochastic gradient descent (Robbins/Monro, 1951) from **optimization**
- Uniform cost search (Dijkstra, 1956) from **algorithms**
- Value iteration (Bellman, 1957) from **control theory**

What can AI do?



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…

Computer vision

"man in black shirt is playing guitar."

"construction worker in orange safety vest is working on road."

"two young girls are playing with lego toy."

"boy is doing backflip on wakeboard."

"girl in pink dress is jumping in air."

"black and white dog jumps over bar."

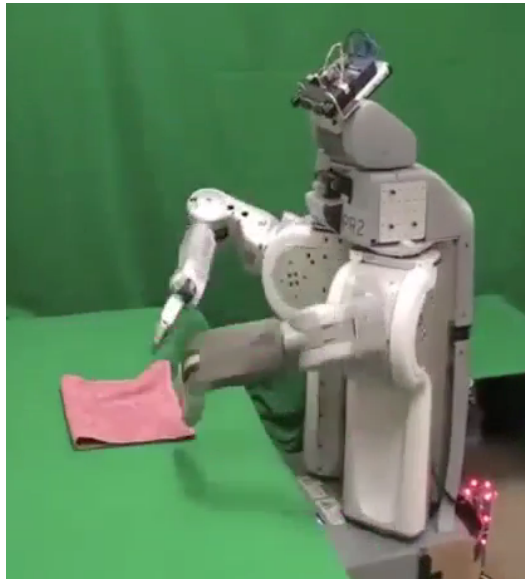
"young girl in pink shirt is swinging on swing."

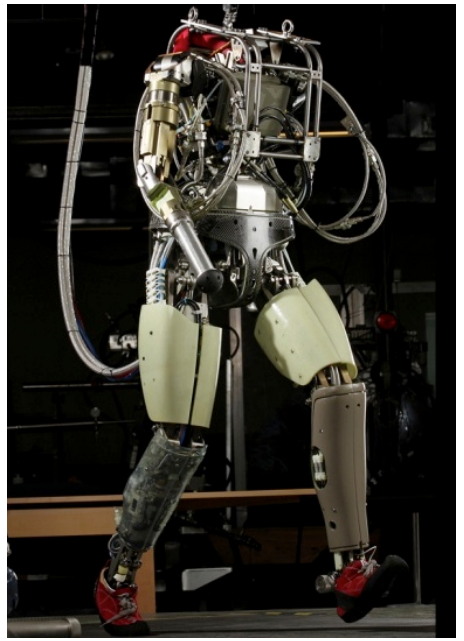
"man in blue wetsuit is surfing on wave."

Karpathy & Fei-Fei, 2015; Donahue et al., 2015; Xu et al, 2015; many more

Robotics

- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!
- Technologies
  - Vehicles
  - Rescue
  - Help in the home
  - Lots of automation…
- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control

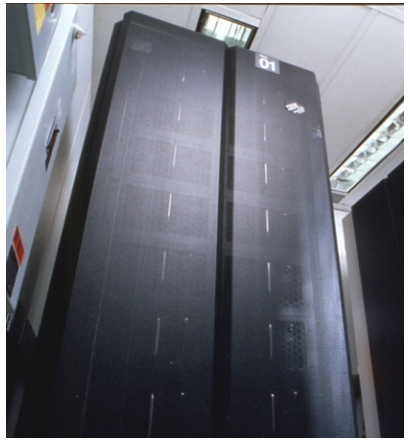




Images from UC Berkeley, Boston Dynamics, RoboCup, Google

Game playing

- Classic Moment: May, 1997: Deep Blue vs. Kasparov
  - First match won against world champion
  - 8000 handcrafted chess features
  - High performance parallel alpha-beta search
  - Searched 200 million positions/second
  - Looked ahead 16-40 rounds of play
  - Defeated human champion Garry Kasparov 4-2 (1997)

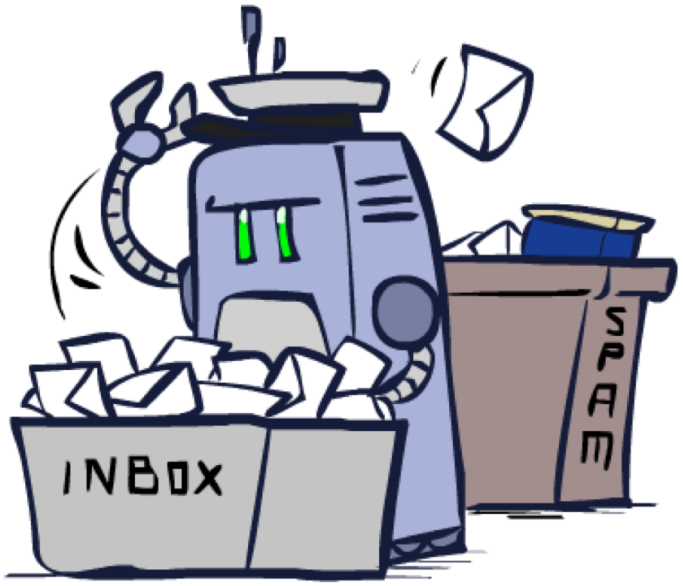


- 2016: AlphaGo beats Lee Sedol

AI is starting to be everywhere…

- Applied AI automates all kinds of things
  - Search engine
  - Route planning, e.g. maps, traffic
  - Logistics, e.g. packages, inventory
  - Medical diagnosis
  - Automated help desks
  - Spam / fraud detection
  - Smarter devices, e.g. cameras
  - Product recommendations

  - Lots more!



Course topics

- Search and Planning
  - A* Search
  - Markov Decision Processes
- Game Playing
  - Games, Adversarial Search
- Graphical models
  - Constraint Satisfaction Problems
  - Bayesian Networks
  - Hidden Markov Models
- Machine learning
  - Reinforcement Learning
  - Naïve Bayes, Linear Predictors, Neural Networks
  - (Decision Trees)
- Applications
  - Natural language, vision, robotics, games

End