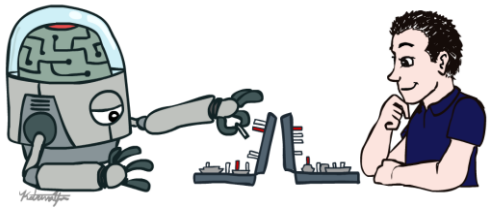
CSE 573:
Artificial Intelligence

Hanna Hajishirzi



slides adapted from
Dan Klein, Pieter Abbeel ai.berkeley.edu
And Dan Weld, Luke Zettlemoyer

Website

- Website
  - tentative schedule
  - lecture slides
  - course policies, etc.

  - https://courses.cs.washington.edu/courses/cse573/23wi/

Course Staff

- TAs:
  - Skyler Hallinan
  - Diya Joy

- Office hours
  - Schedule on the website
  - **TAs**: concepts, projects, homework
  - **Hanna**: concepts, high level guidance, homework

Logistics

- Canvas: grades, submitting programming assignments:
  - private matters – private messages
    - if your message is not answered promptly enough, use the staff email:
- GradeScope for written assignments
- Ed: Discussion board: ask and answer questions; announcements

Course Format

- Programming Assignments
  - 4 projects
  - Python
  - Autograded
  - Give you hands-on experience with the algorithms
  - I expect you to get 100% on projects
- Written homeworks
  - 2 written homeworks
  - Gives you a more conceptual understanding of the material

Course Format (continued)

- Paper report
  - Learn how to read and criticize research papers
- Final Project:
  - Encourage to pick a project related to your research or work
  - We will provide recommendations for picking projects
  - There will be a proposal day.

Prerequisites

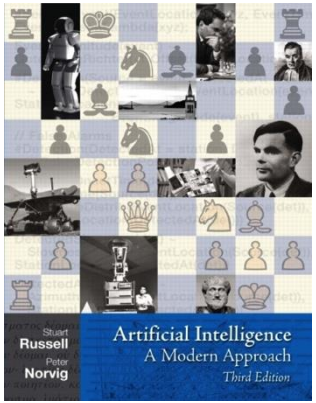
- Data Structure or Equivalent:
  CSE 332

- Math:
  - Basic exposure to probability and data structures

- Programming – Familiar with Python
  - There is a 0^{th} project (P0)

Textbook

- Not required, but for students who want to read more we recommend
  - Russell & Norvig, AI: A Modern Approach, 3rd Ed.



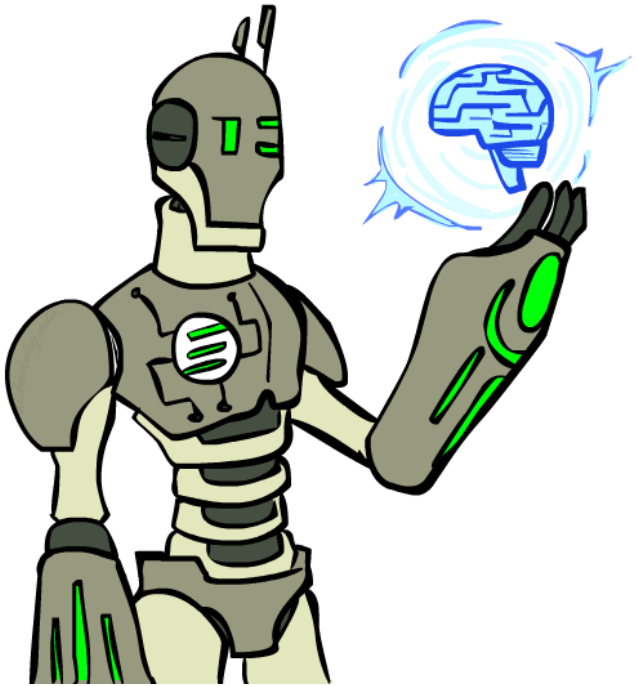
  - Warning: Not a course textbook, so our presentation does not necessarily follow the presentation in the book.

Course Policies

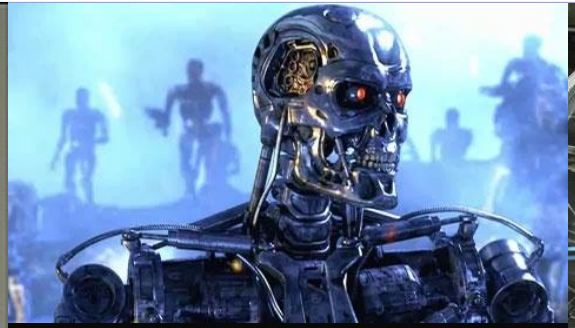
- Grade:
  - Your **grade** will be: 5% paper reports, 40% programming assignments, 25% homeworks, and 30% project.
- Assignments should be done individually unless otherwise specified.
- Late Policy: **Six** penalty-free late day for the whole quarter; maximum 4 days per assignment. No late day for the final.

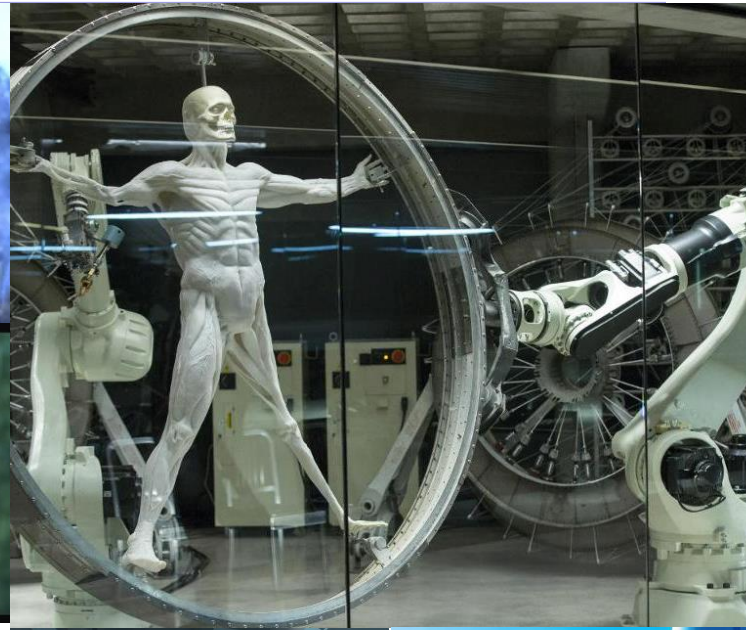
Today

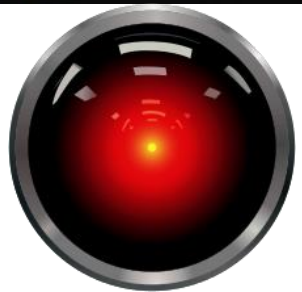
- What is artificial intelligence (AI)?
- What can AI do?
- What is this course?



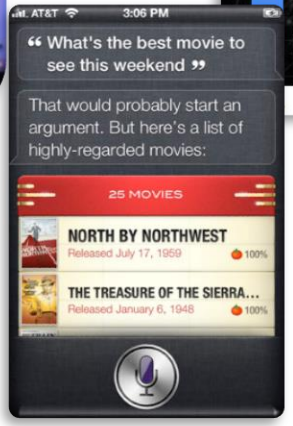
AI







Artificial Intelligence in Action




WAYMO


TUG
CAUTION
MAY CONTAIN
CHEMOTHERAPY DRUG

What is AI?

The science of making machines that:

Rational Decisions

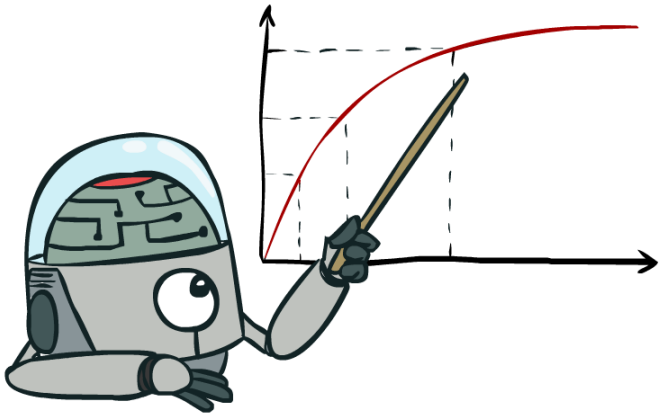
We'll use the term **rational** in a very specific, technical way:

- 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**

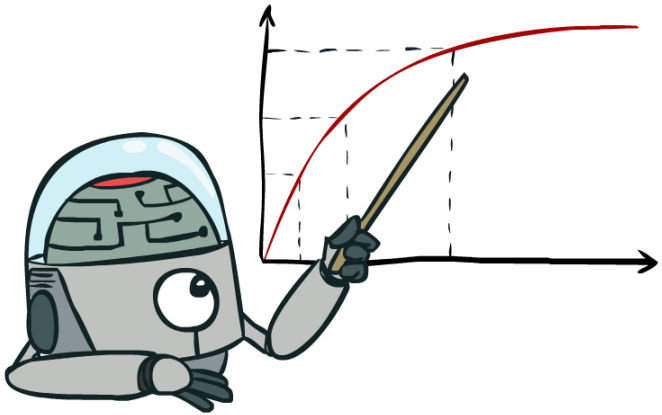
A better title for this course would be:

Computational Rationality

Maximize Your Expected Utility



Maximize Your Expected Utility



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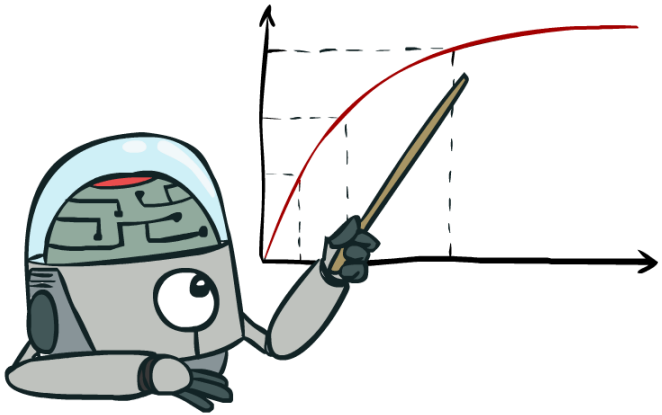

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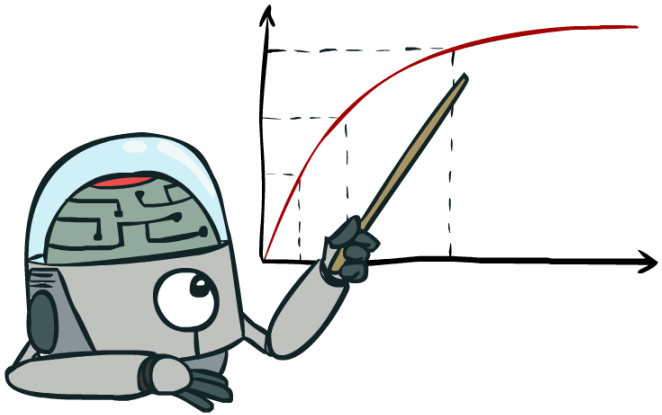
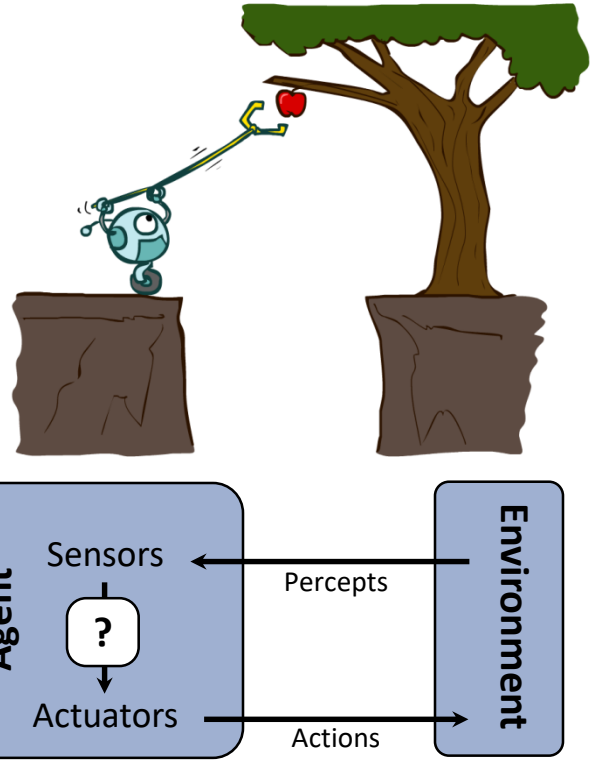


What About the Brain?

- 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!
- "Brains are to intelligence as wings are to flight"
- Lessons learned from the brain: memory and simulation are key to decision making

Designing Rational Agents

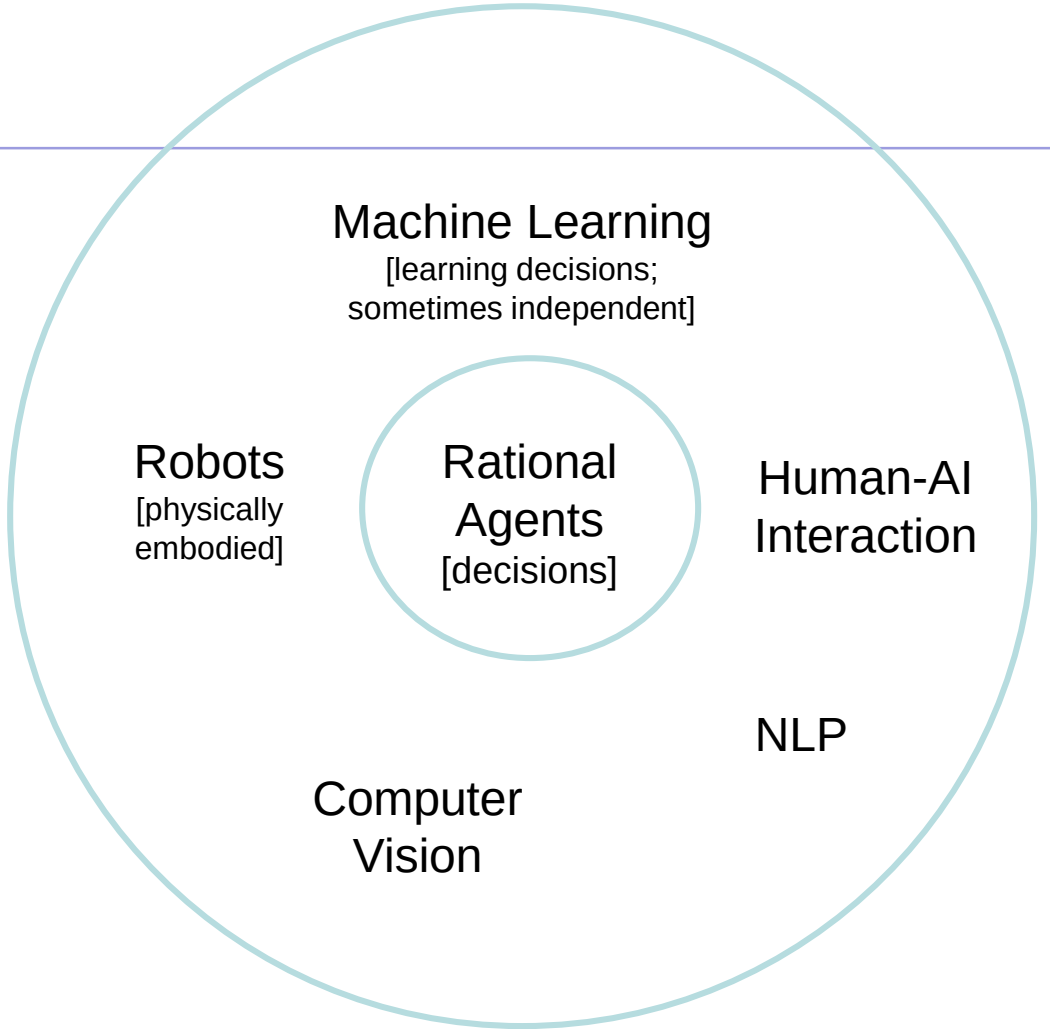
- An **agent** is an entity that *perceives* and *acts*.
- A **rational agent** selects actions that maximize its (expected) **utility**.
- Characteristics of the **percepts, environment,** and **action space** dictate techniques for selecting rational actions
- **This course** is about:
  - General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



Topics in This Course

- Part I: Intelligence from Computation
  - Fast search
  - Adversarial and uncertain search
- Part II: Reasoning under Uncertainty
  - Decision theory: Reinforcement Learning, Markov Decision Processes
  - Machine learning
  - Graphical Models - Bayes Nets; HMMs
- Throughout: Applications
  - Natural language, vision, robotics, games, …

This course w.r.t. Current AI Research



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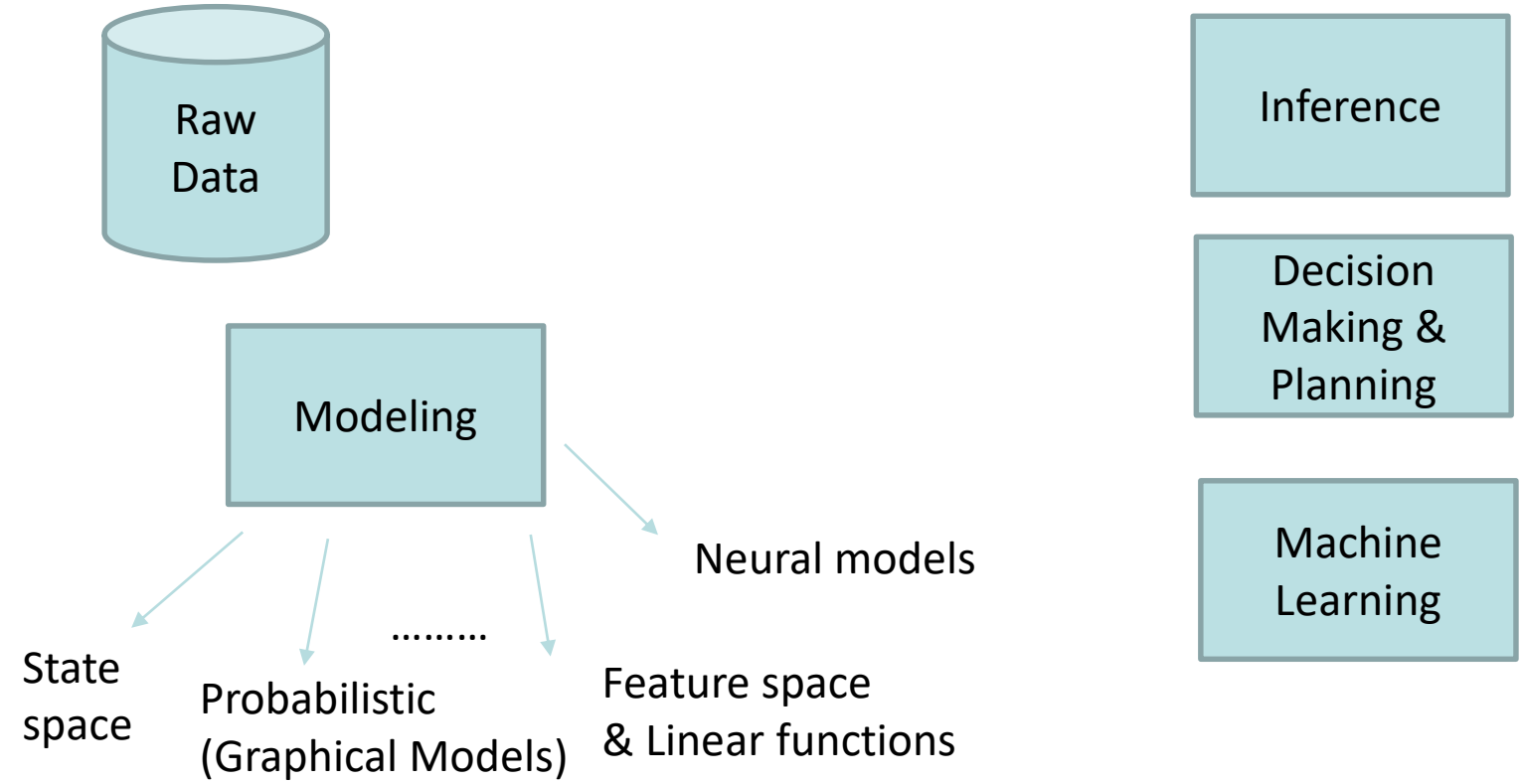
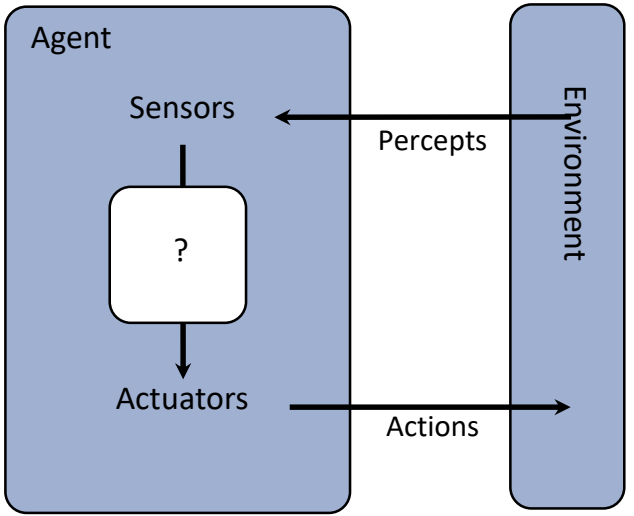


This course vs. others

- Stat methods
- NLP
- ML
- Robotics
- Vision
- Advanced RL
- Deep Learning



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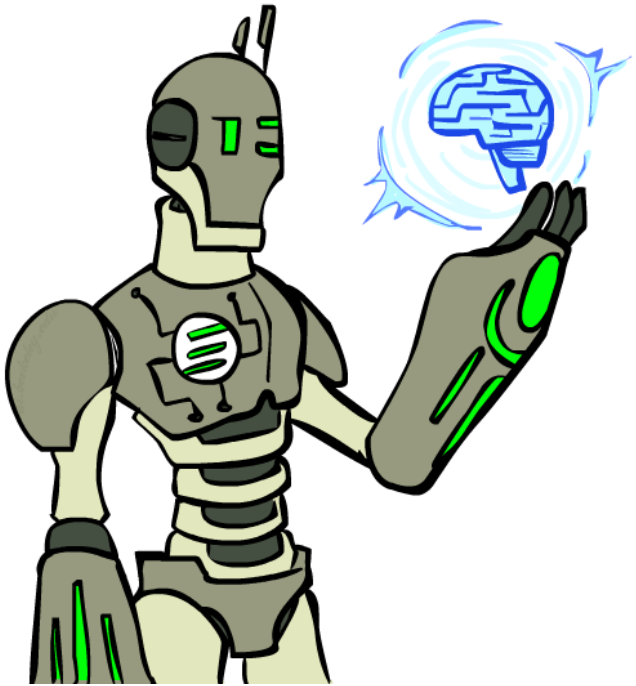
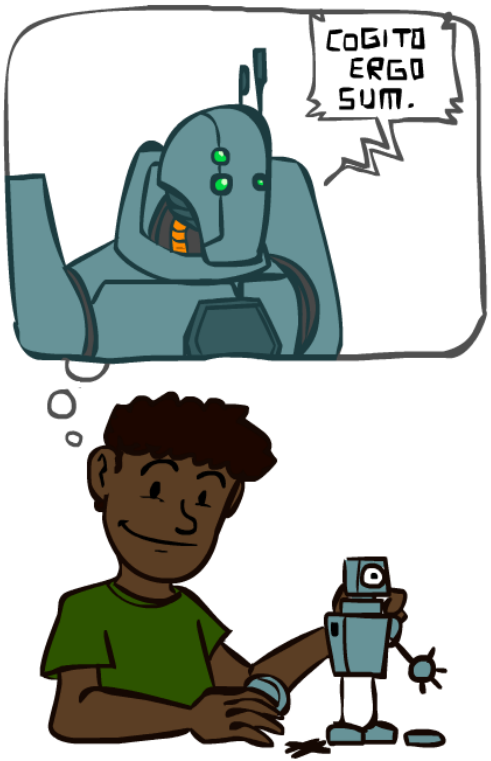
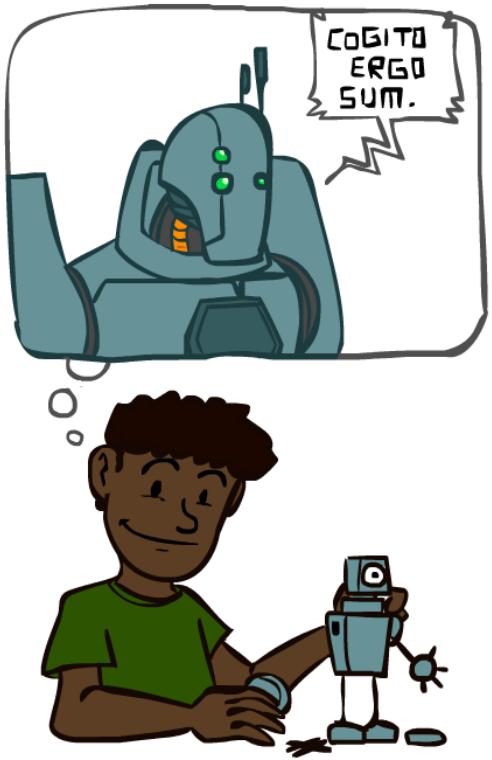


A (Short) History of AI



A (Short) History of AI

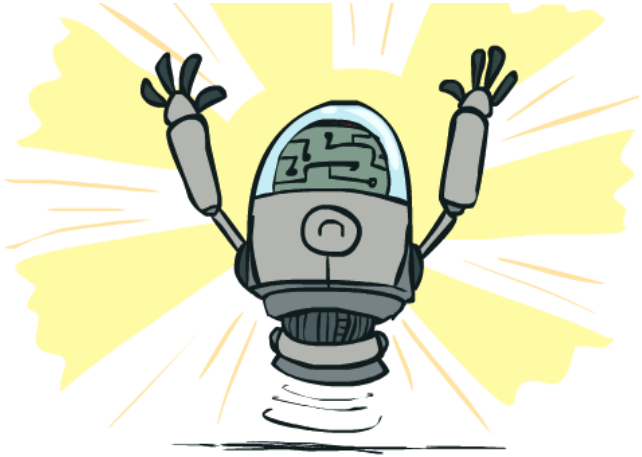
- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's “Computing Machinery and Intelligence”
- 1950—70: Excitement: Look, Ma, no hands!
  - 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry 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—2012: Statistical approaches
  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems… “AI Spring”?
- 2012— present: Excitement: Look, Ma, no hands!
  - Big Data, big compute, neural networks
  - Some re-unification of subfields
  - AI is being used in industry.



What Can AI Do?

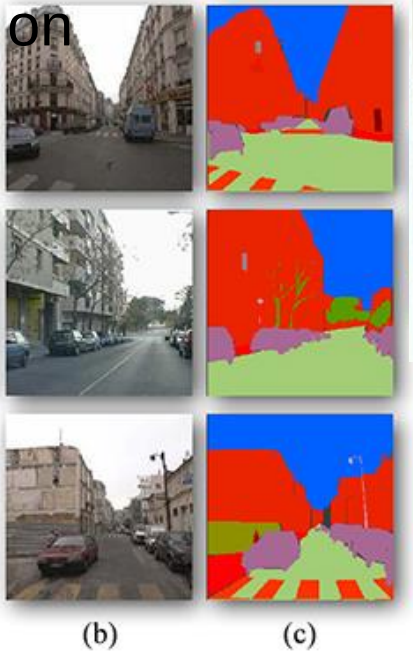
Quiz: Which of the following can be done at present?

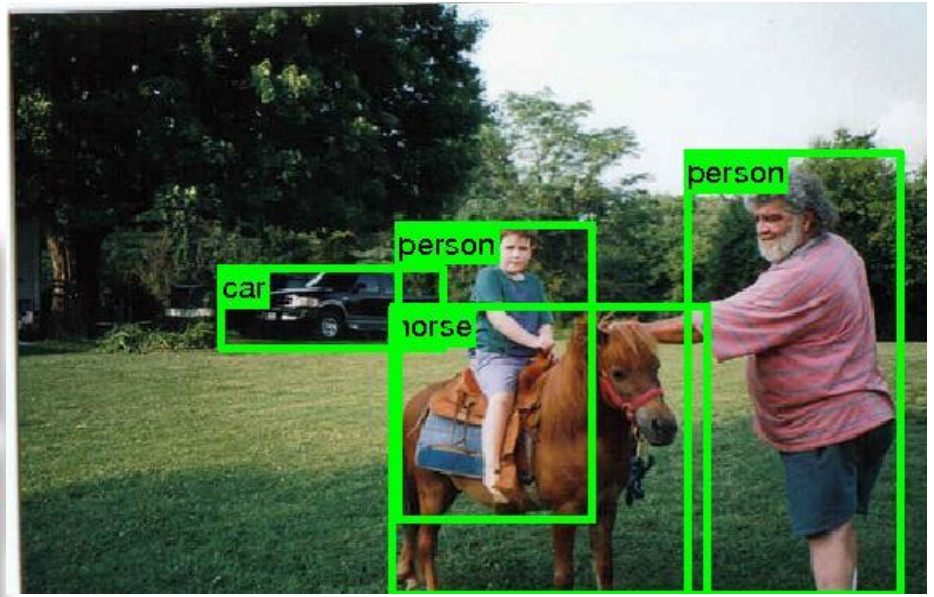
- ✓ Play a decent game of Jeopardy?
- ✓ Win against any human at chess?
- ✓ Win against the best humans at Go?
- ✓ Play a decent game of tennis?
- ✓ Grab a particular cup and put it on a shelf?
- ✗ Unload any dishwasher in any home?
- ? Drive safely along the highway?
- ✗ Drive safely along University 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?
- ✗ Perform a surgical operation?
- ✗ Unload a known dishwasher in collaboration with a person?
- ✓ Translate spoken Chinese into spoken English in real time?
- ✓ Write an intentionally funny story?



Computer Vision

Scene Segmentation





Object Recognition

https://pjreddie.com/darknet/yolo/

Image captioning: What begins to work

The flower was so vivid and attractive.

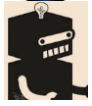
Blue flowers are running rampant in my garden.

We sometimes do well: 1 out of 4 times, machine captions were preferred over the original Flickr captions:

Spring in a white dress.

Blue flowers have no scent. Small white flowers have no idea what they are.

Scenes around the lake on my bike ride.



This horse walking along the road as we drove by.

- Text -> Images 2022

Stable diffusion, KerasCV implementation

First, we construct a model:

```
model = keras_cv.models.StableDiffusion(img_width=512, img_height=512)
```

Next, we give it a prompt:

```
images = model.text_to_image("photograph of an astronaut riding a horse", batch_size=3)


def plot_images(images):
    plt.figure(figsize=(20, 20))
    for i in range(len(images)):
        ax = plt.subplot(1, len(images), i + 1)
        plt.imshow(images[i])
        plt.axis("off")


plot_images(images)
```

```
25/25 [==============================] - 19s 317ms/step
```

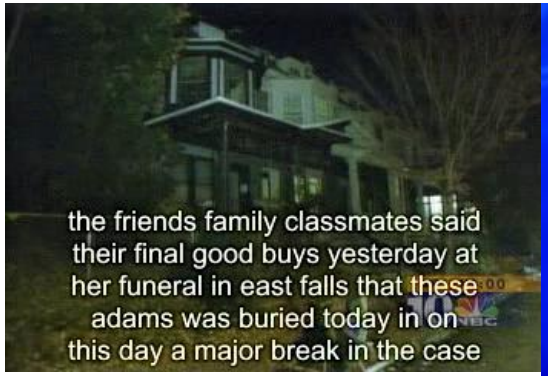


- Text -> Images
  2022

- Falcon Knight

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…

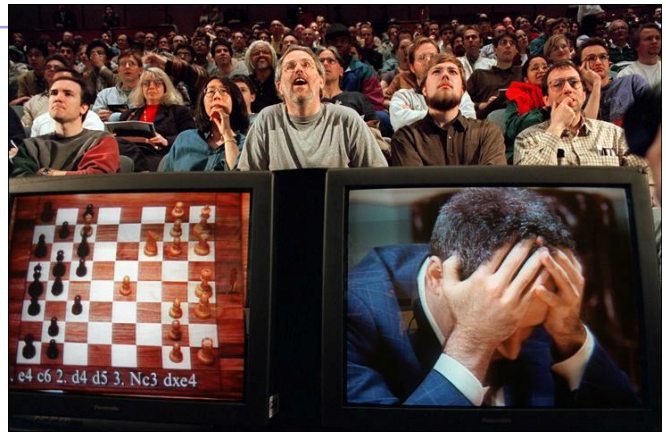
Jeopardy - 2011

GPT3 by OpenAI

Title: United Methodists Agree to Historic Split
Subtitle: Those who oppose gay marriage will form their own denomination
Article: After two days of intense debate, the United Methodist Church has agreed to a historic split - one that is expected to end in the creation of a new denomination, one that will be "theologically and socially conservative," according to The Washington Post. The majority of delegates attending the church's annual General Conference in May voted to strengthen a ban on the ordination of LGBTQ clergy and to write new rules that will "discipline" clergy who officiate at same-sex weddings. But those who opposed these measures have a new plan: They say they will form a separate denomination by 2020, calling their church the Christian Methodist denomination.
The Post notes that the denomination, which claims 12.5 million members, was in the early 20th century the "largest Protestant denomination in the U.S.," but that it has been shrinking in recent decades. The new split will be the second in the church's history. The first occurred in 1968, when roughly 10 percent of the denomination left to form the Evangelical United Brethren Church. The Post notes that the proposed split "comes at a critical time for the church, which has been losing members for years," which has been "pushed toward the brink of a schism over the role of LGBTQ people in the church." Gay marriage is not the only issue that has divided the church. In 2016, the denomination was split over ordination of transgender clergy, with the North Pacific regional conference voting to ban them from serving as clergy, and the South Pacific regional conference voting to allow them.

Figure 3.14: The GPT-3 generated news article that humans had the greatest difficulty distinguishing from a human written article (accuracy: 12%).

Game Agents



- 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

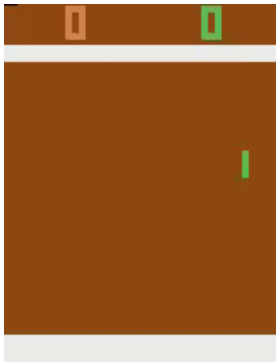
- 1996: Kasparov Beats Deep Blue
  “I could feel --- I could smell --- a new kind of intelligence across the table.”

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

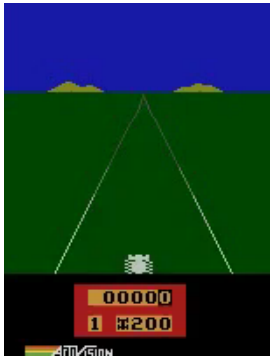
Text from Bart Selman, image from IBM’s Deep Blue pages

Game Agents

- Reinforcement learning

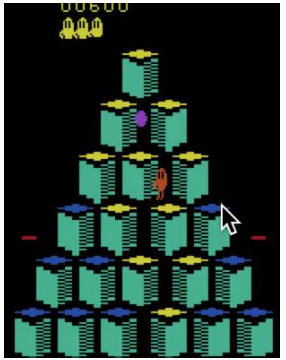


Pong



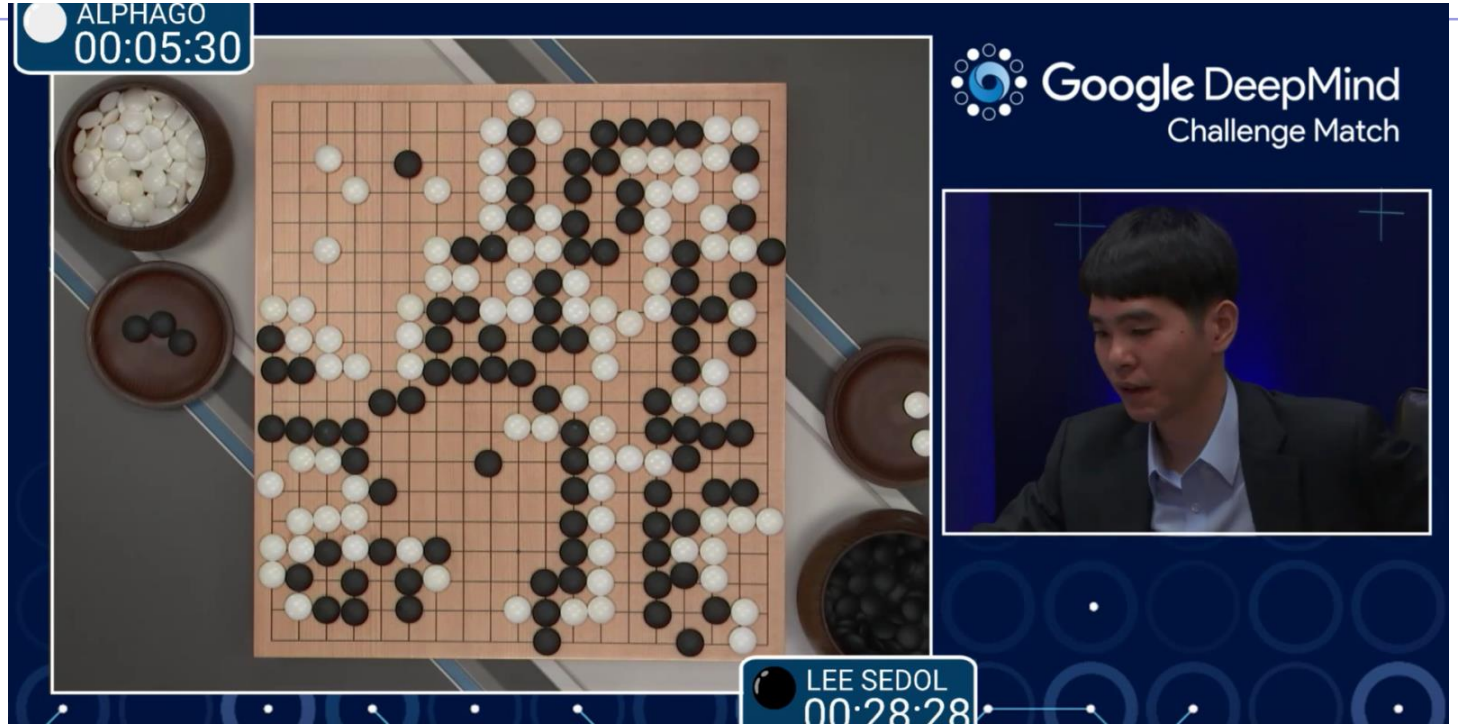
Enduro

Beamrider



Q*bert

2016



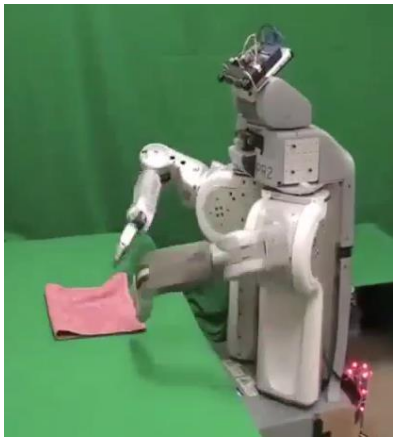
AlphaGo deep RL defeats Lee Sedol (4-1)

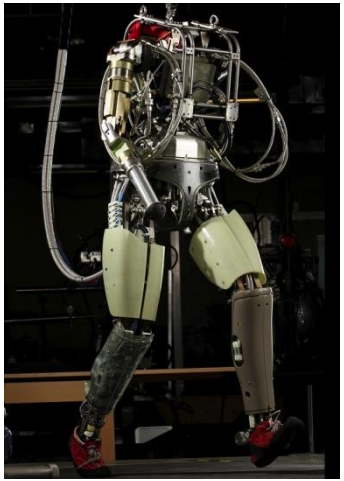
Dota2 - 2019

- OpenAI wins OG world champions team of 5 pros
- AI controlled 5 bots using different layers of same network
  - Trained with RL and self play
  - Equivalent to 45000 years (over 10 months)

Robotics

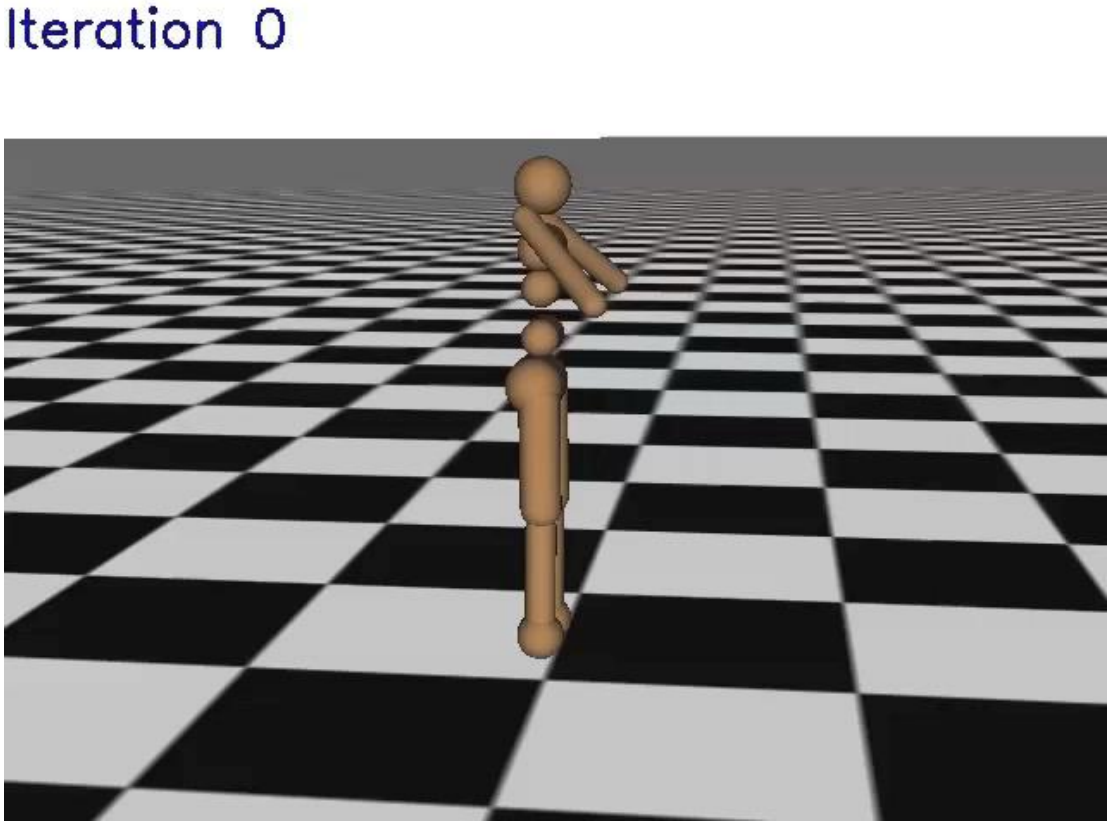
- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!
- Technologies
  - Vehicles
  - Rescue
  - Help in the home
  - Lots of automation…
- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control





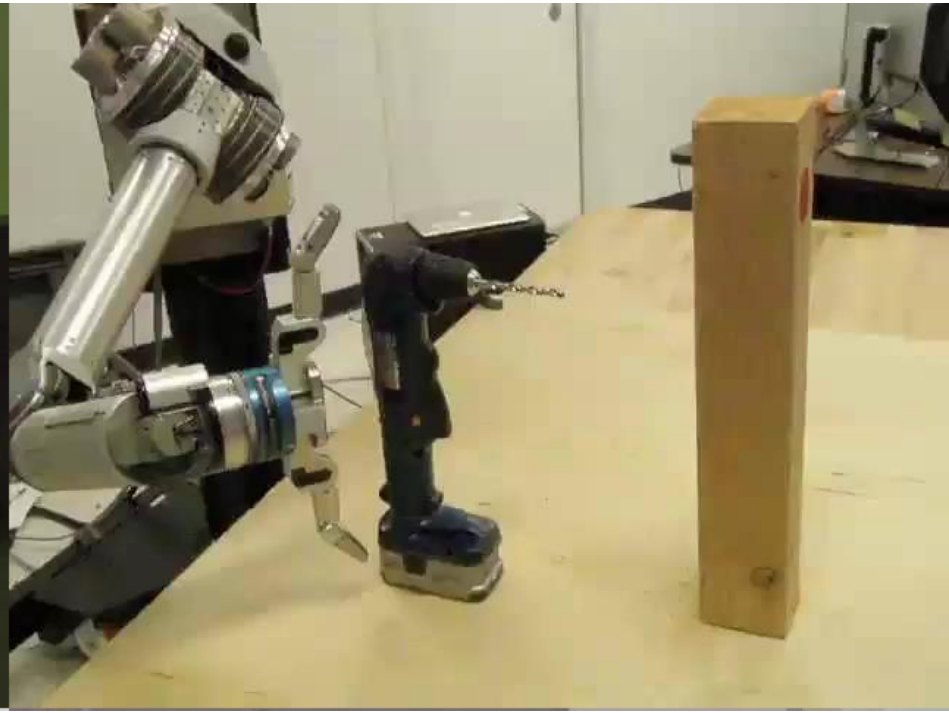
Images from UC Berkeley, Boston Dynamics, RoboCup, Google

Simulated Agents

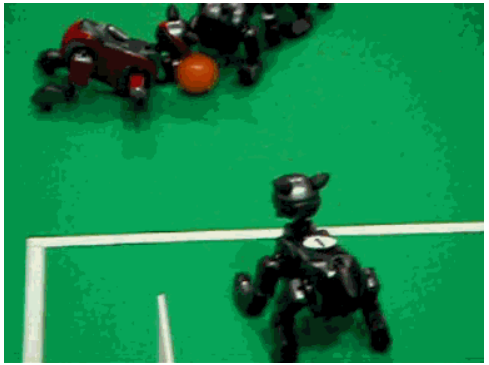


[Schulman, Moritz, Levine, Jordan, Abbeel, ICLR 2016]

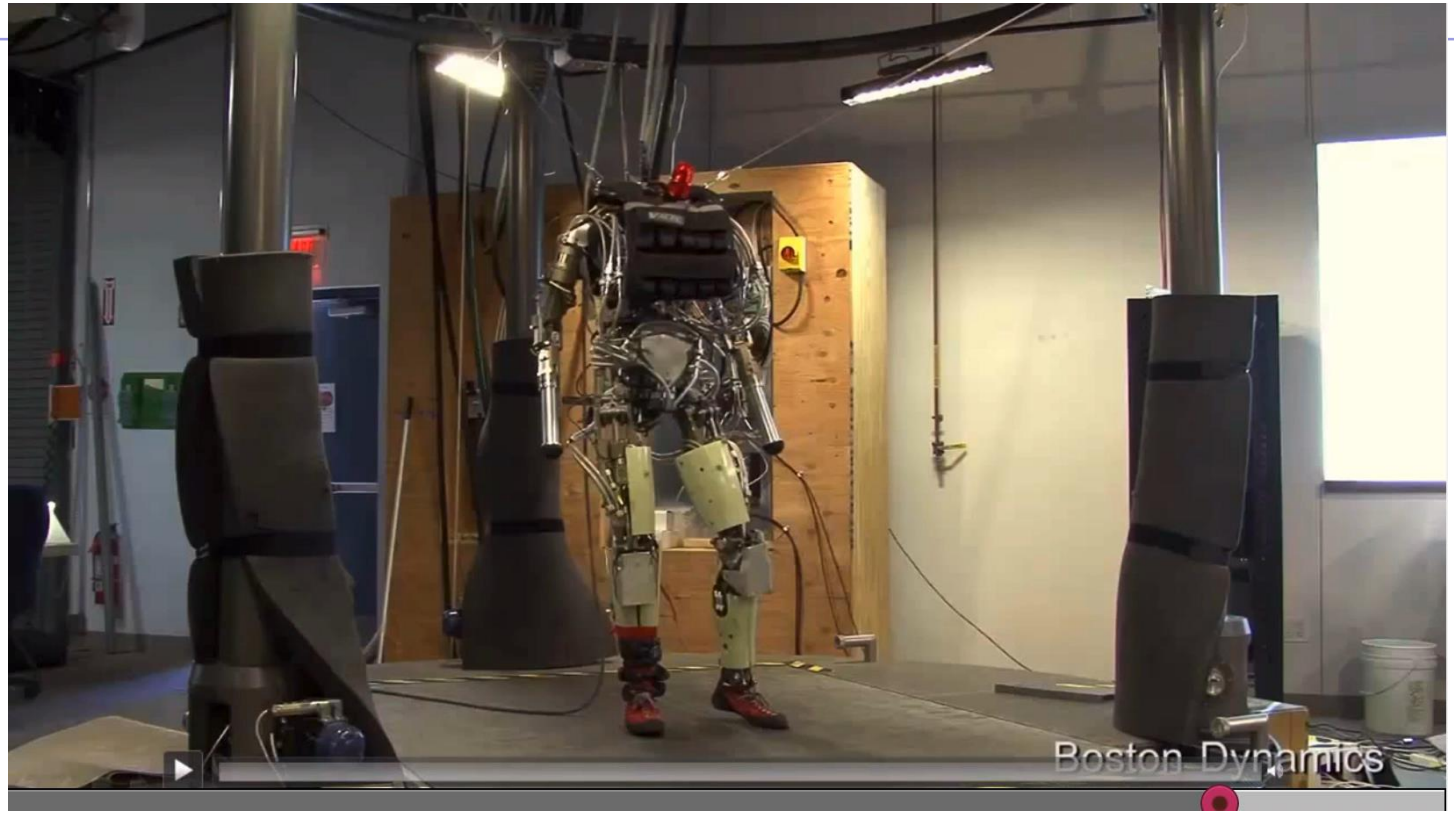
Robots



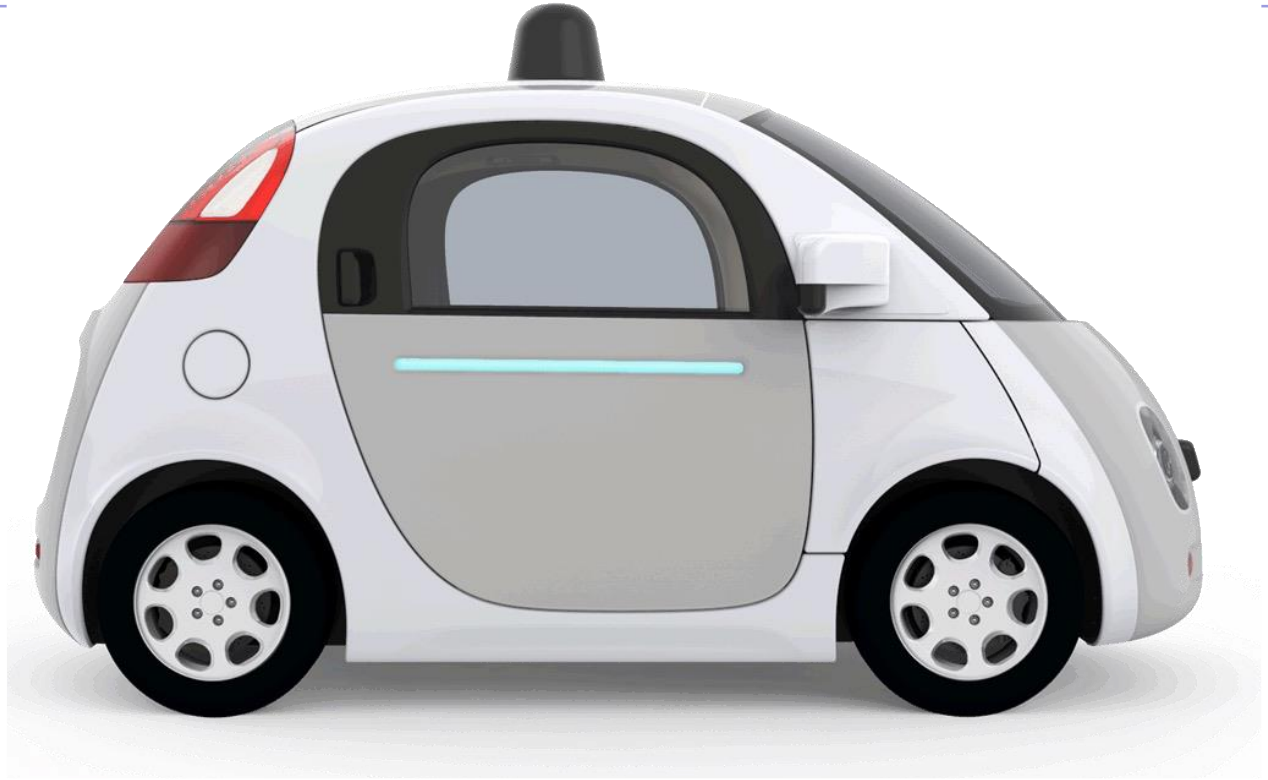
Robocup



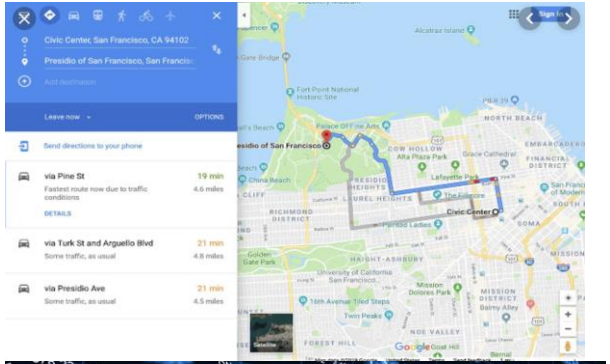
https://www.youtube.com/watch?v=_PC-V5GJP6Q

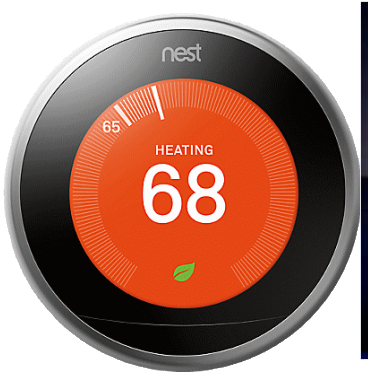

Boston Dynamics

Waymo Self-Driving Car 2019



Tools for Predictions & Decisions





Decision Making

- Applied AI in many kinds of automation:
  - Scheduling, airline routing
  - Route planning
  - Medical diagnosis
  - Web search
  - Spam classification
  - Automated help desks
  - Smarter devices, like cameras
  - Fraud detection
  - Product recommendation
  - … Lots more!

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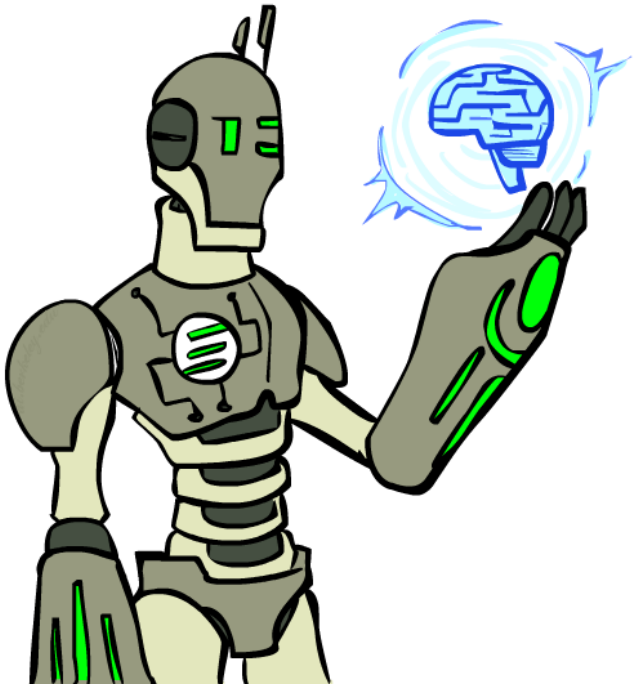

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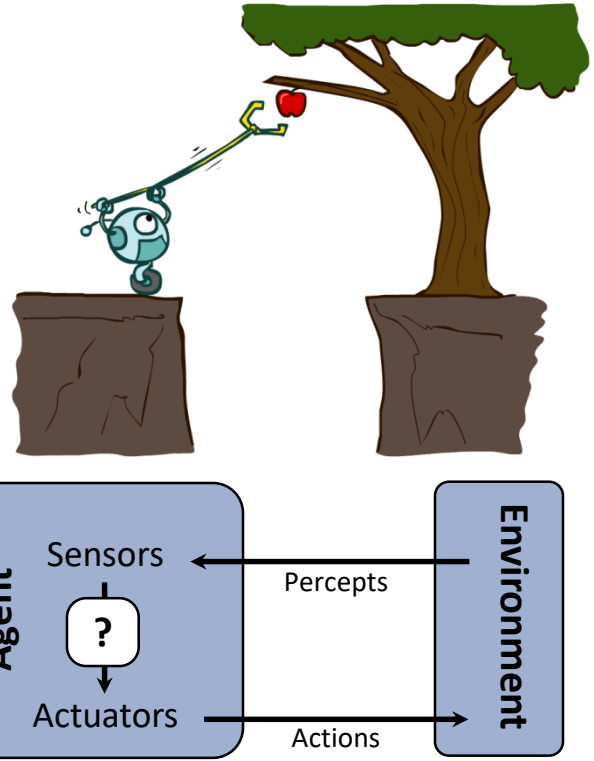
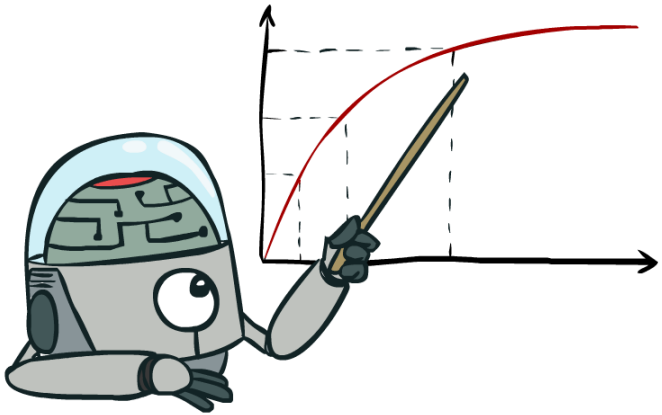
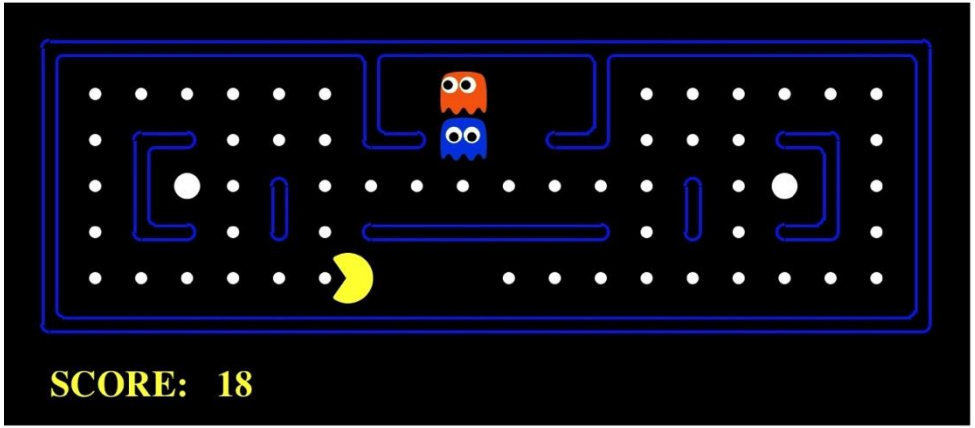
- **This course** is about:
  - General AI techniques for a variety of problem types
  - Learning to recognize when and how a new problem can be solved with an existing technique

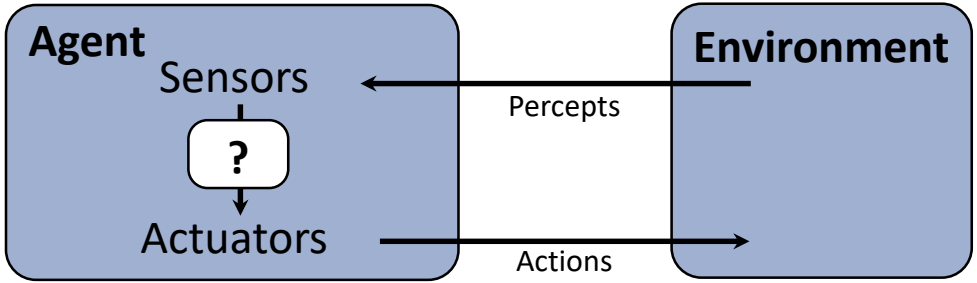


Maximize Your Expected Utility

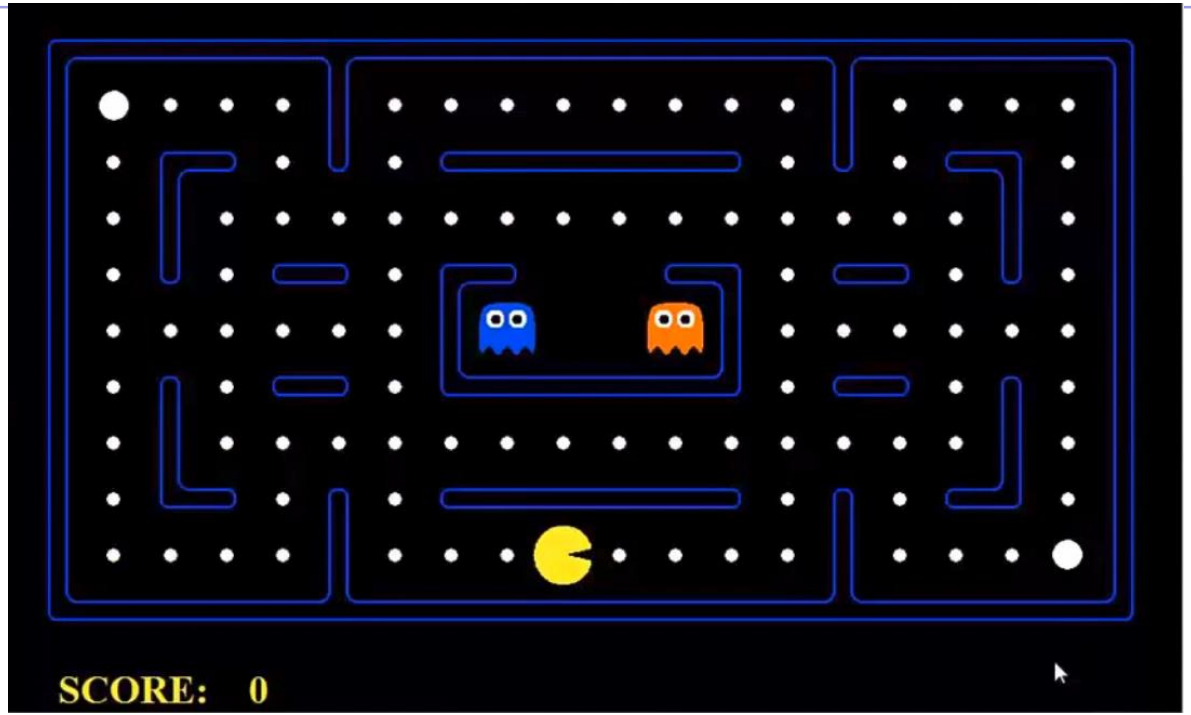


Pac-Man as an Agent





Assignments: Pac-man



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

Important This Week

- Important this week:
  - **Check out** canvas--- our main resource for assignments and grades
  - **Check out** website – for schedule and slides
  - **Check out** Ed – for discussions; we have added everyone to Ed
  - **Check out** Gradescope -- for written assignments
  - **P0: Python tutorial** is out