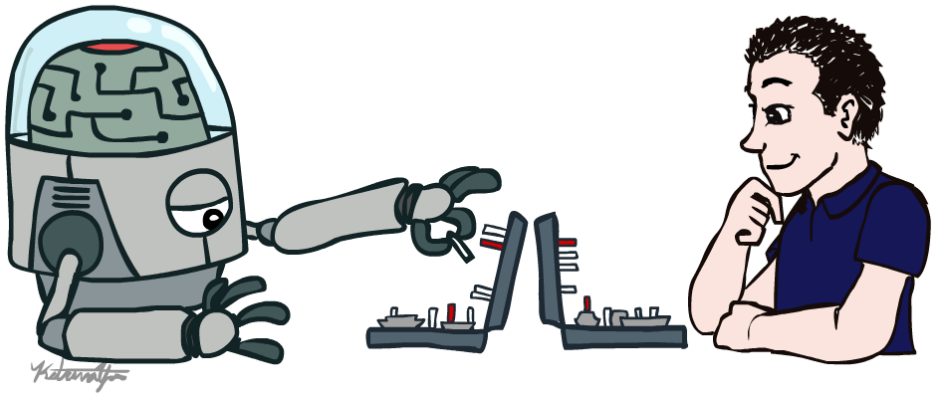
CS 4300/6300: Artificial Intelligence

Introduction



Instructor: Daniel Brown

University of Utah

[Adapted from those created by Dan Klein and Pieter Abbeel for CS188 Intro to AI at UC Berkeley. http://ai.berkeley.edu.]

Course Staff

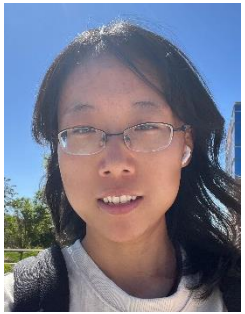
Professor

Daniel Brown

TAs

Atharv Belsare

Soumil Datta



Yile Li

Gabriella Goodman

Hannah Marumoto

Course Information

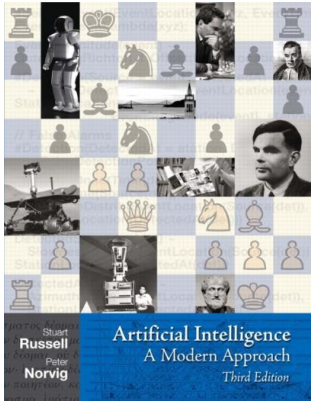
- Communication:
  - Announcements on Canvas
  - Questions? Discussion on piazza
- Course format:
  - Homeworks and programming assignments turned in via Gradescope.
  - In class midterm and final.
- Class Website:
  - https://www.cs.utah.edu/~dsbrown/classes/cs6300/

Course Information

- There will be a lot of math (and programming)
- Work and Grading:
  - 5 programming projects: Python,
    - 10% penalty for each day late.
  - ~10 homework assignments.
    - Hands on experience working through math.
  - Midterm (right before spring break) and Final (during finals week)
  - Class participation can help if your grade is on the margins

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.

Textbook

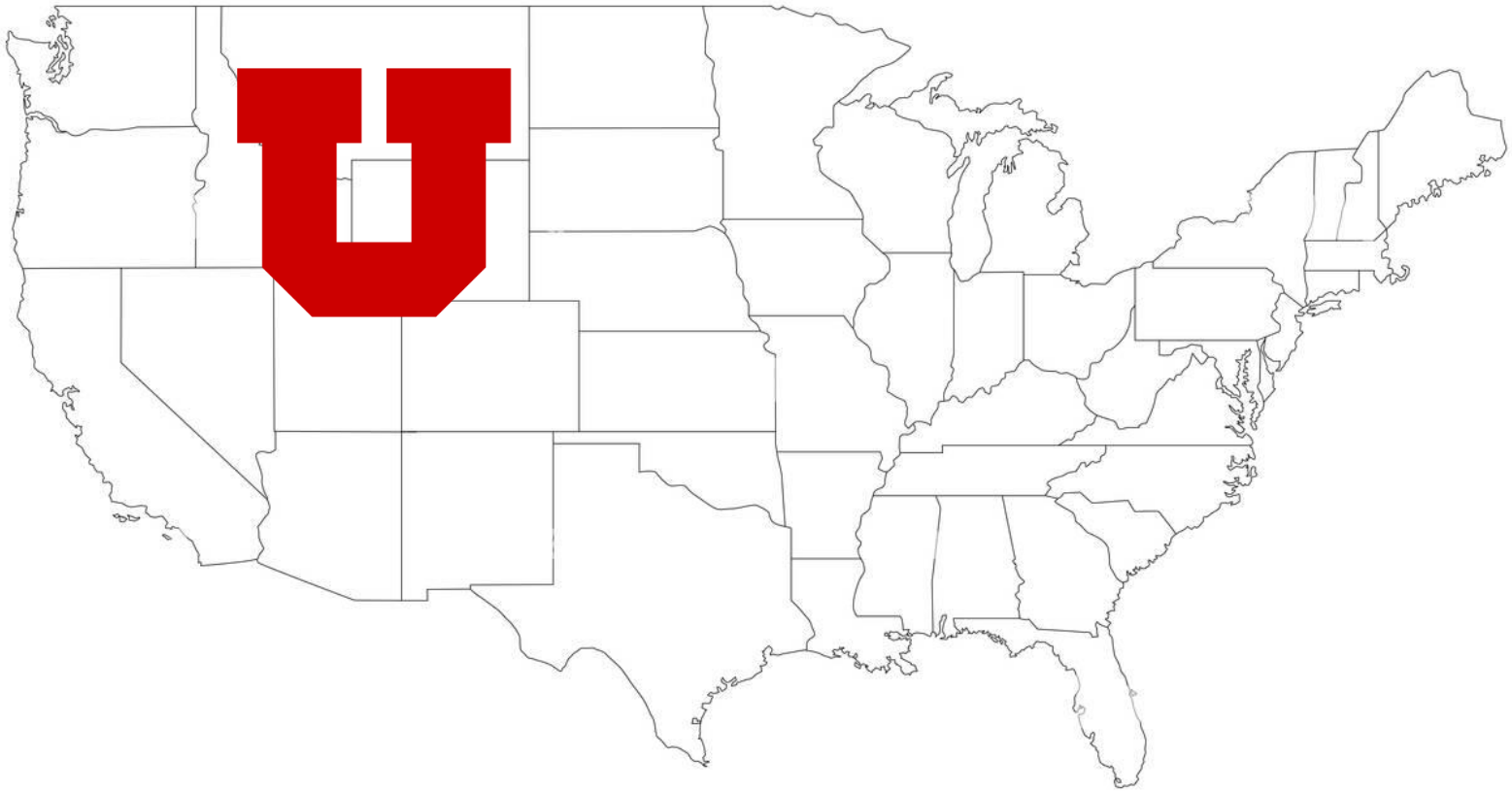
- Also not required, but for students who want to read more about Reinforcement Learning we recommend
  - Sutton and Barto “Reinforcement Learning: An Introduction”

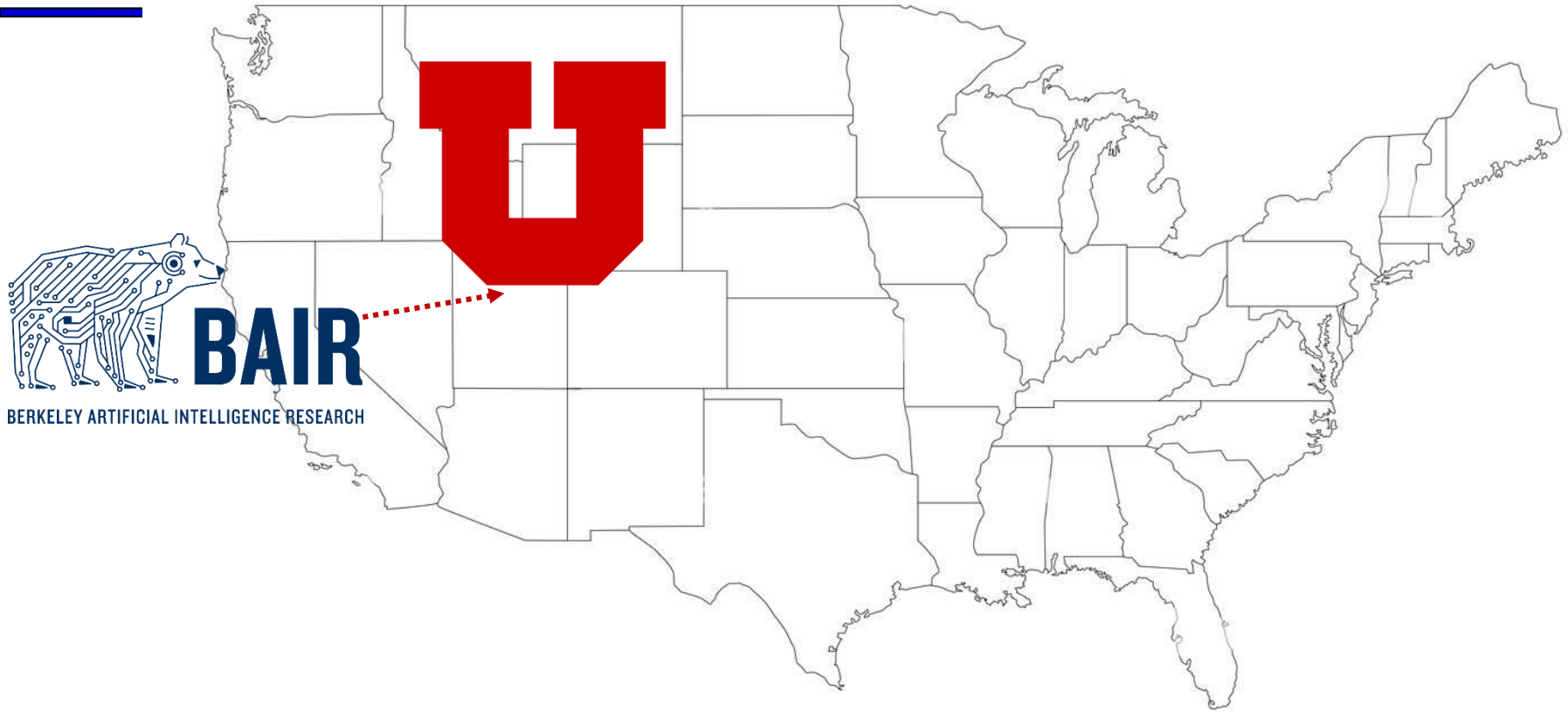
    http://incompleteideas.net/book/ebook/the-book.html
  - Some notation in our class will be closer to Sutton and Barto than Russell and Norvig
- We will also sometimes have readings from
  - Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaroun Courville. MIT Press, 2016.
  - Decision Making Under Uncertainty by Mykel J. Kochenderfer. MIT Press, 2015.

Important This Week

- Important this week:
  - **Register** for the class on piazza --- our main resource for discussion and communication
  - **P0: Python crash course/tutorial** is out (due on Friday 8/29 by 11:59pm)
- Also important:
  - **Office Hours TBD**
  - **We will try and provide good coverage across days and times.**

A little about me

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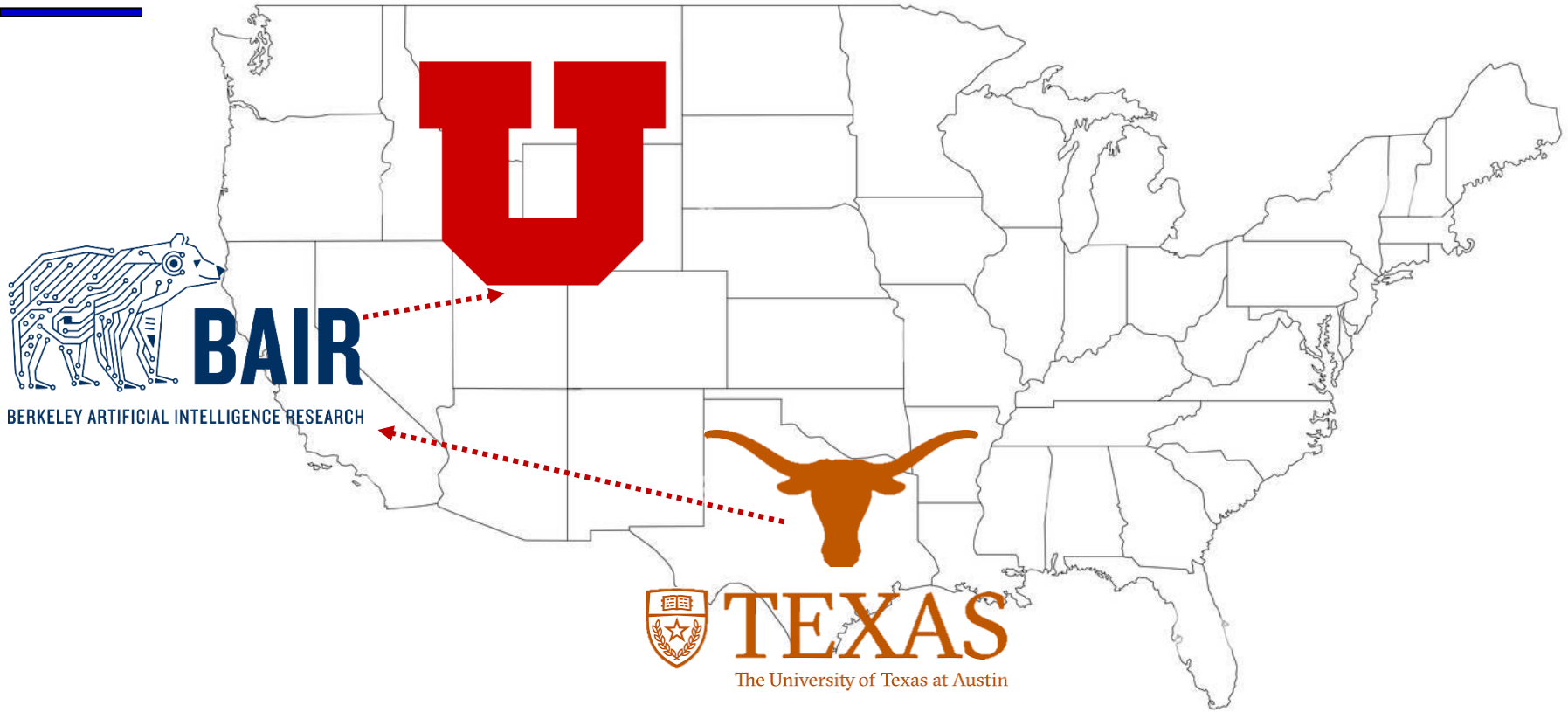
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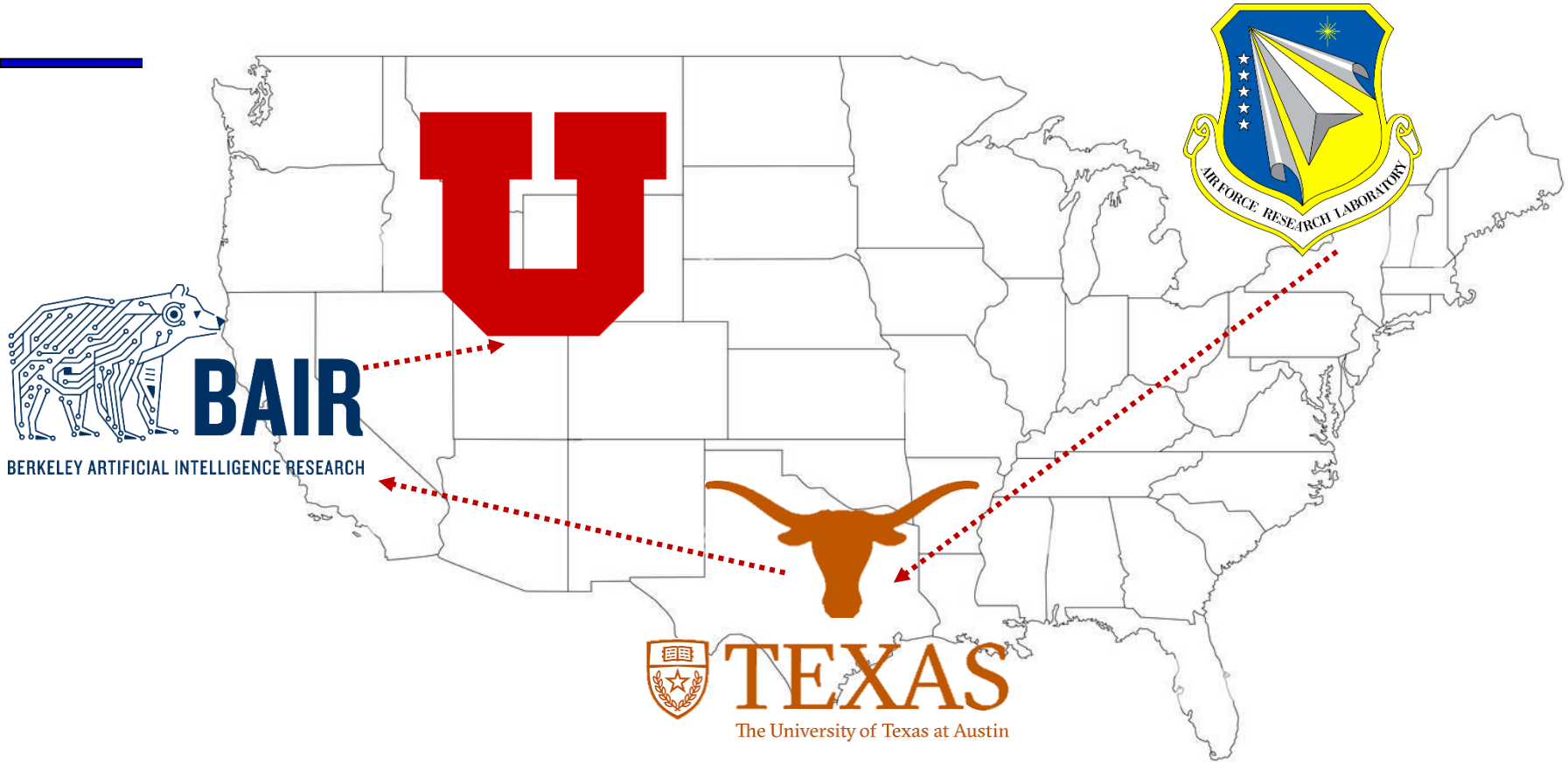
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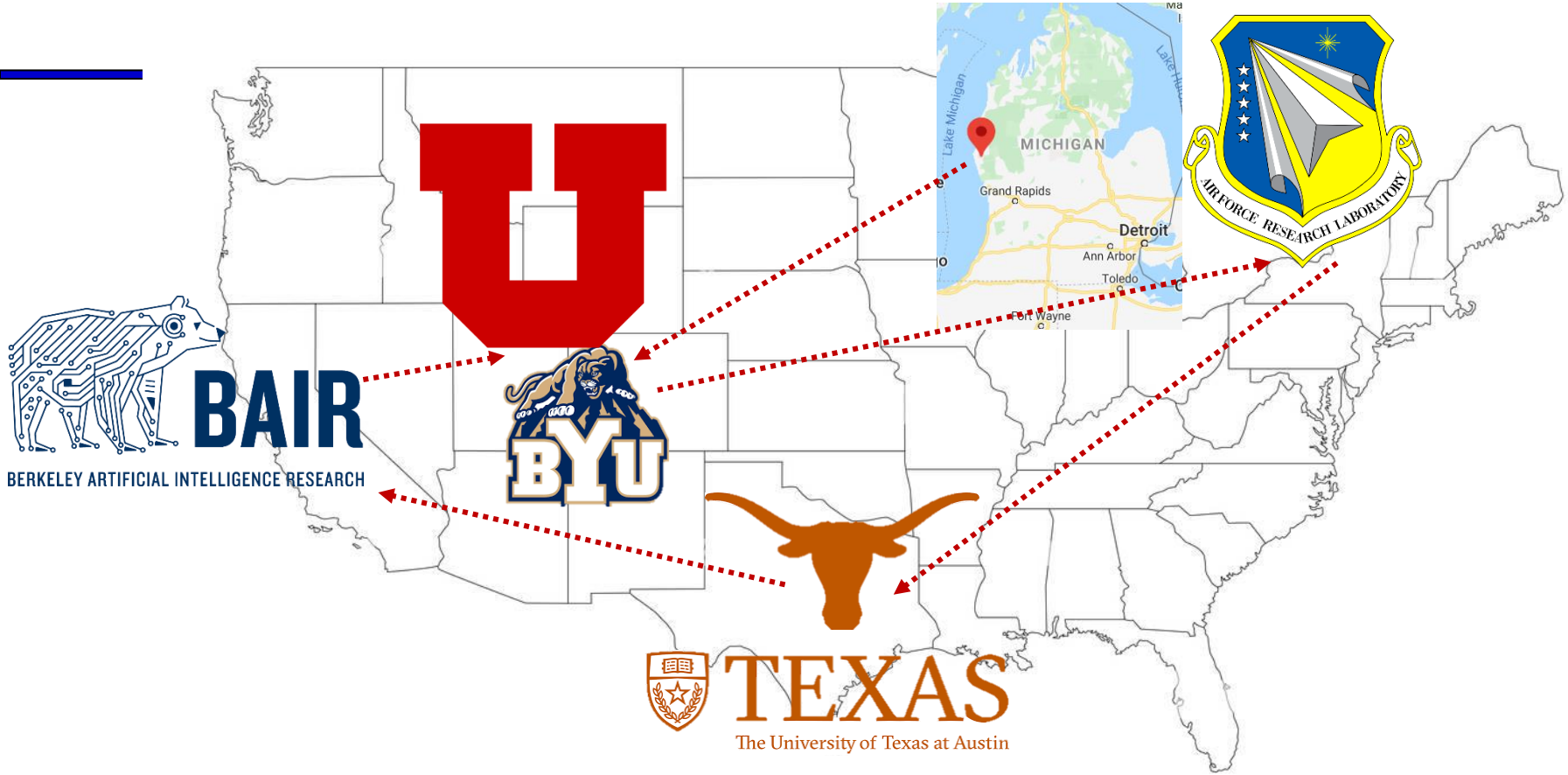
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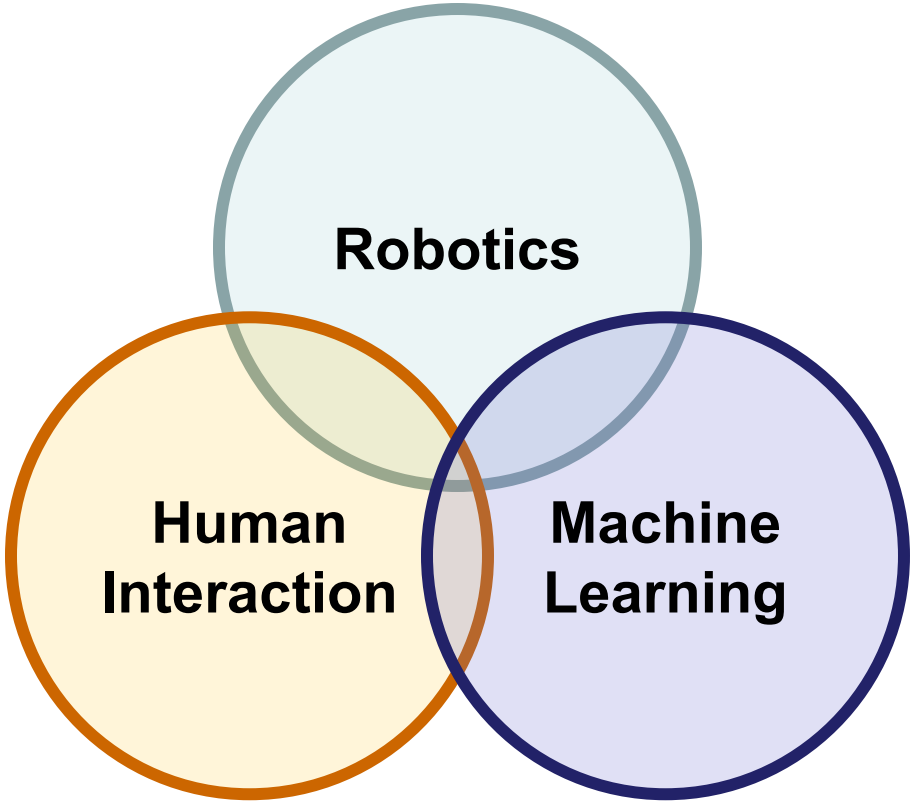
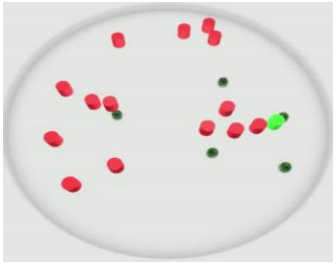
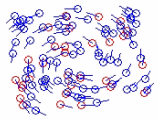
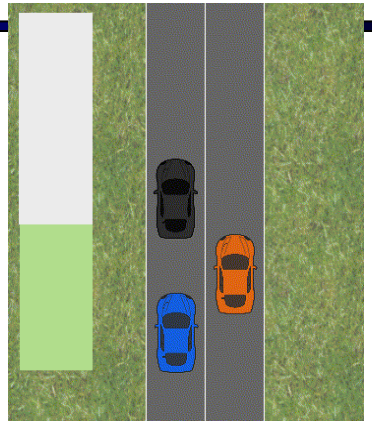

Robotics
Human Interaction
Machine Learning

Human-Robot Interaction

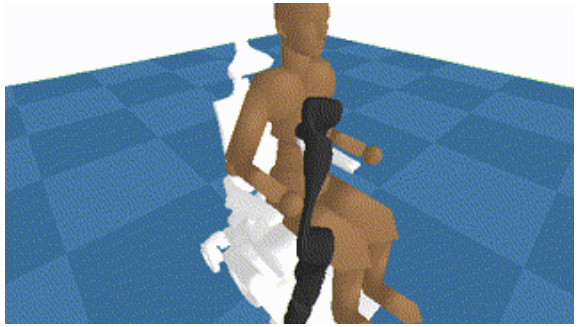




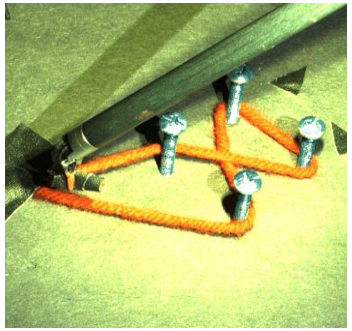
Human Swarm Interactions



Autonomous Driving

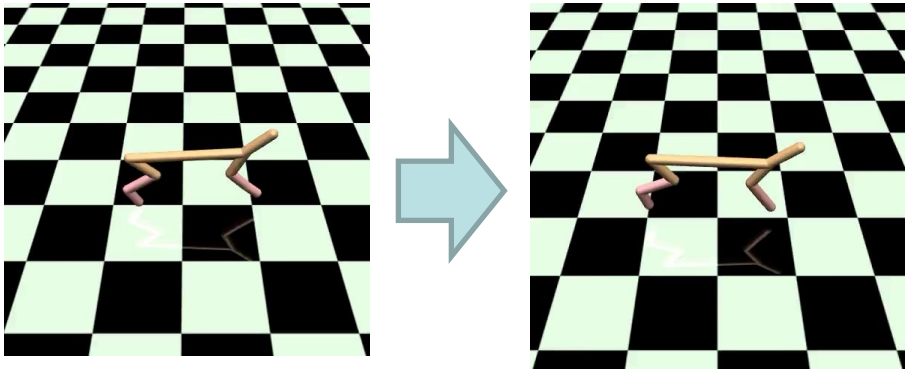


Shared Autonomy and Assistive

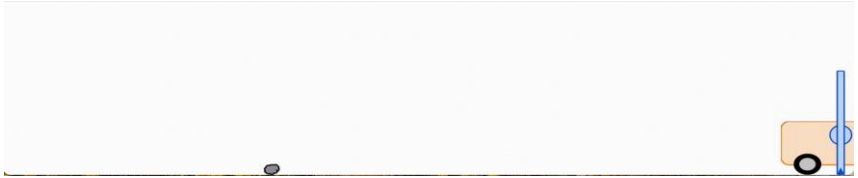


Human-in-the-Loop

Learning models of human preferences

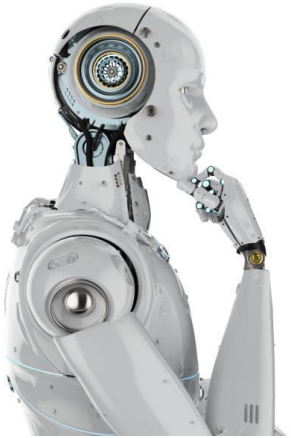


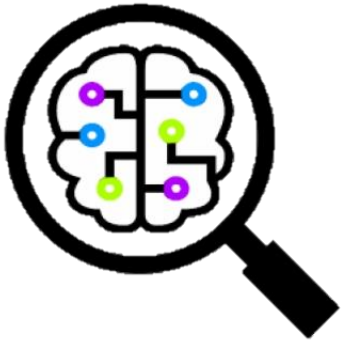
“Great weather today!”



“Didn’t get the job offer…”

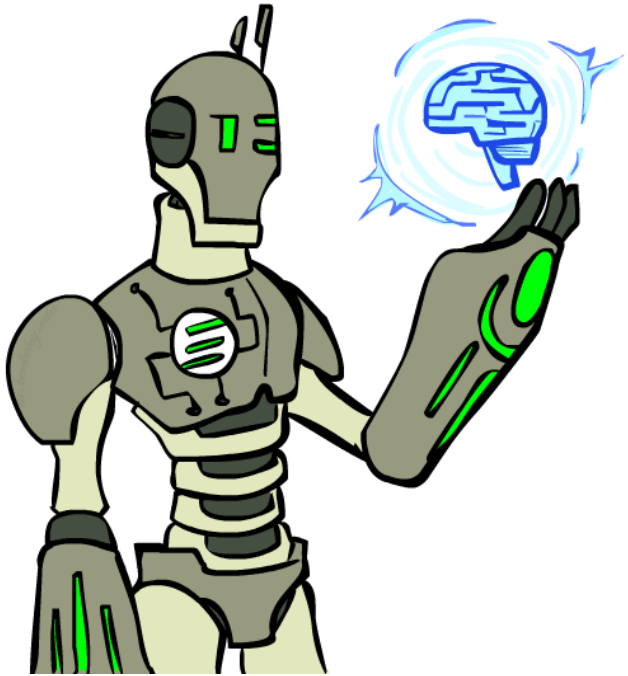
AI Safety and Robustness



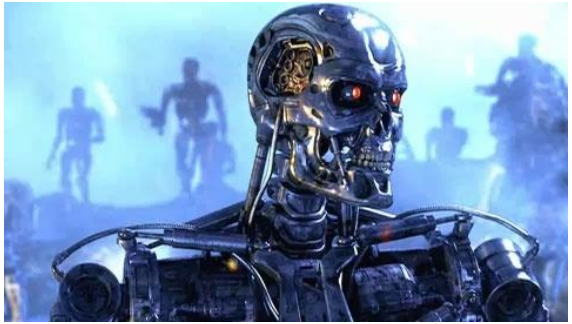


Today

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



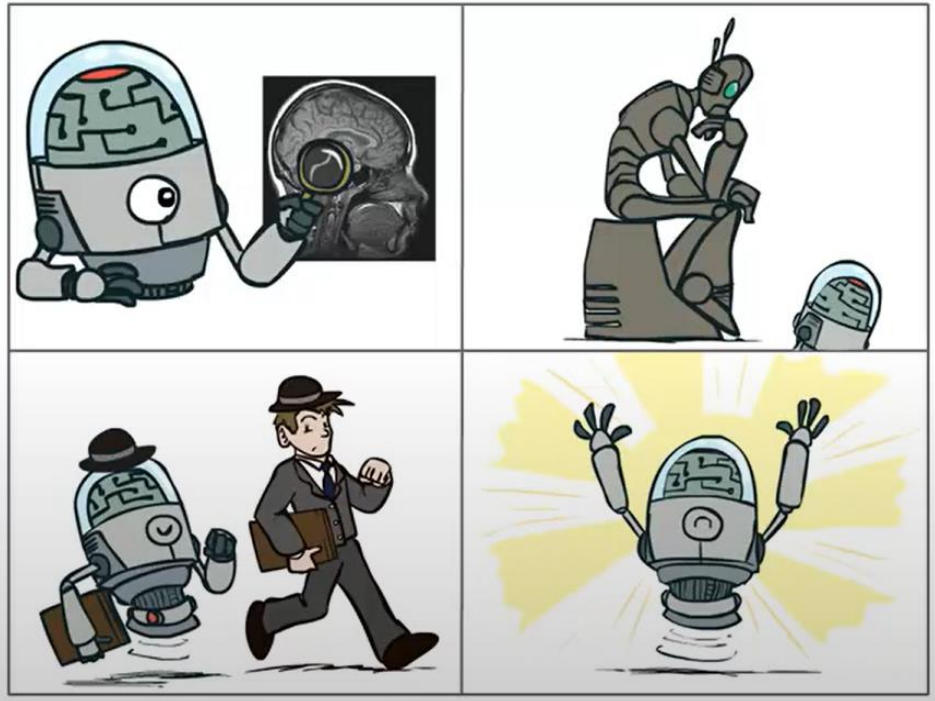
Sci-Fi AI?



What is AI?

The science of making machines that:

Think like people



Think rationally

Act like people

Act rationally

Rational Decisions

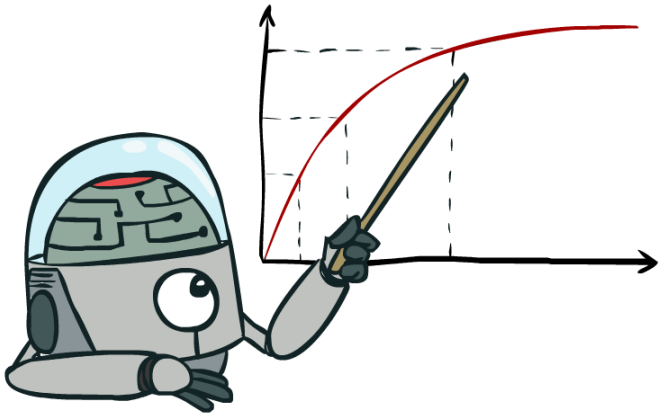
We'll use the term **rational** in a very specific, technical way:

- 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:

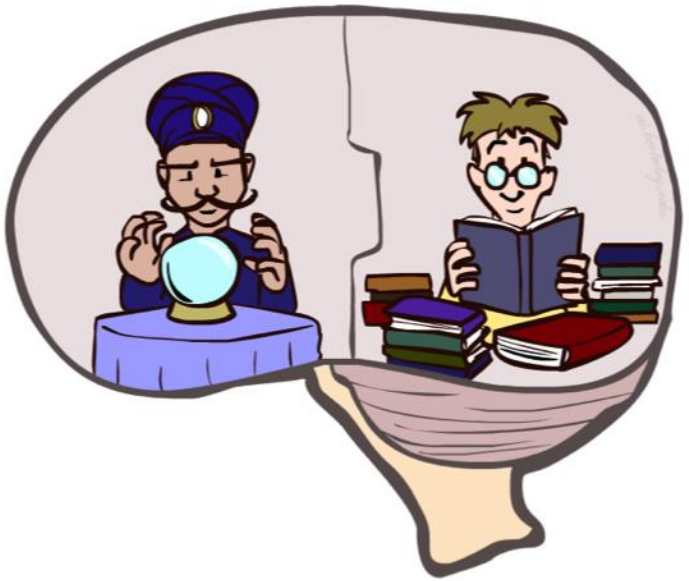
Computational Rationality

Maximize Your Expected Utility

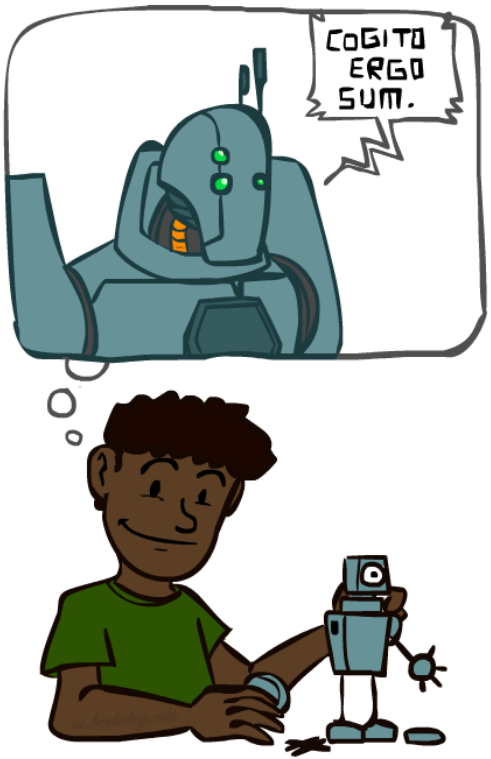


What About the Brain?

- 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



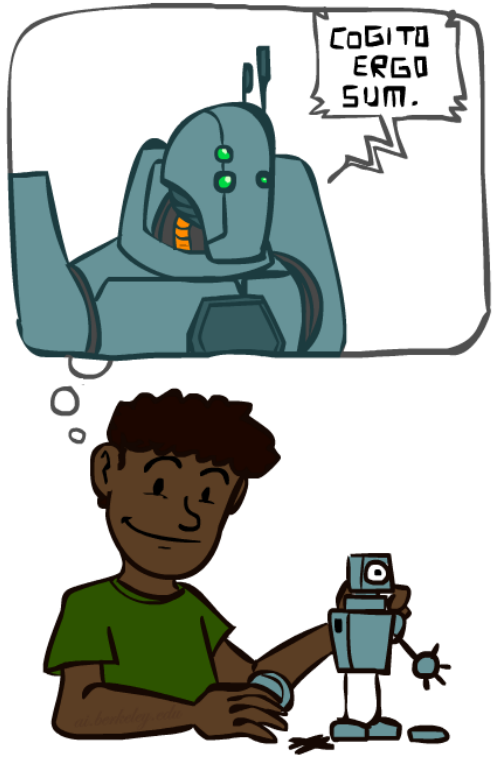
A (Short) History of AI



Demo: HISTORY – MT1950.wmv

A (Short) History of AI

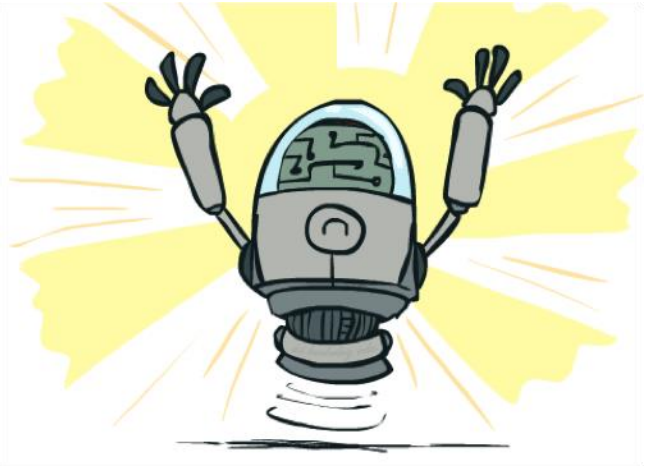
- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's “Computing Machinery and Intelligence”
- 1950—70: Excitement: Look, Ma, no hands!
  - 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry 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—: Statistical approaches
  - Resurgence of probability and statistics, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems… “AI Spring”?
- 2014—: Deep Learning and Scaling Things Up
  - Big data
  - Powerful compute (e.g. GPUs)
  - ChatGPT and other Large Language Models (LLMs)



What Can AI Do?

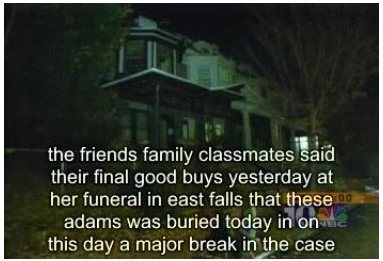
Quiz: Which of the following can be done at present?

- ✓ Play a decent game of table tennis?
- ✓ Play a decent game of Jeopardy?
- ✓ Drive safely along a curving mountain road?
- ✓ Buy a week's worth of groceries on the web?
- ✗ Buy a week's worth of groceries at Walmart?
- ? Discover and prove a new mathematical theorem?
- ? Converse successfully with another person for an hour?
- ? Perform a surgical operation?
- ✗ Come into your apartment and unload your dishwasher
- ✓ Translate spoken Chinese into spoken English in real time?
- ✓ Write decent poetry?
- ✓ Create aesthetically pleasing artwork
- ? Fold your laundry?

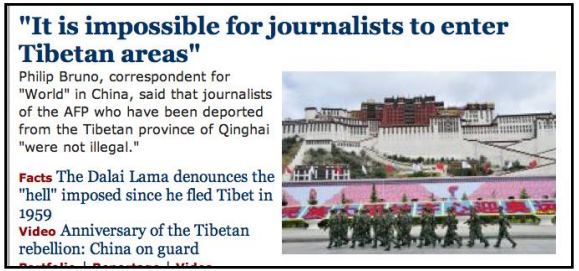


Natural Language

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

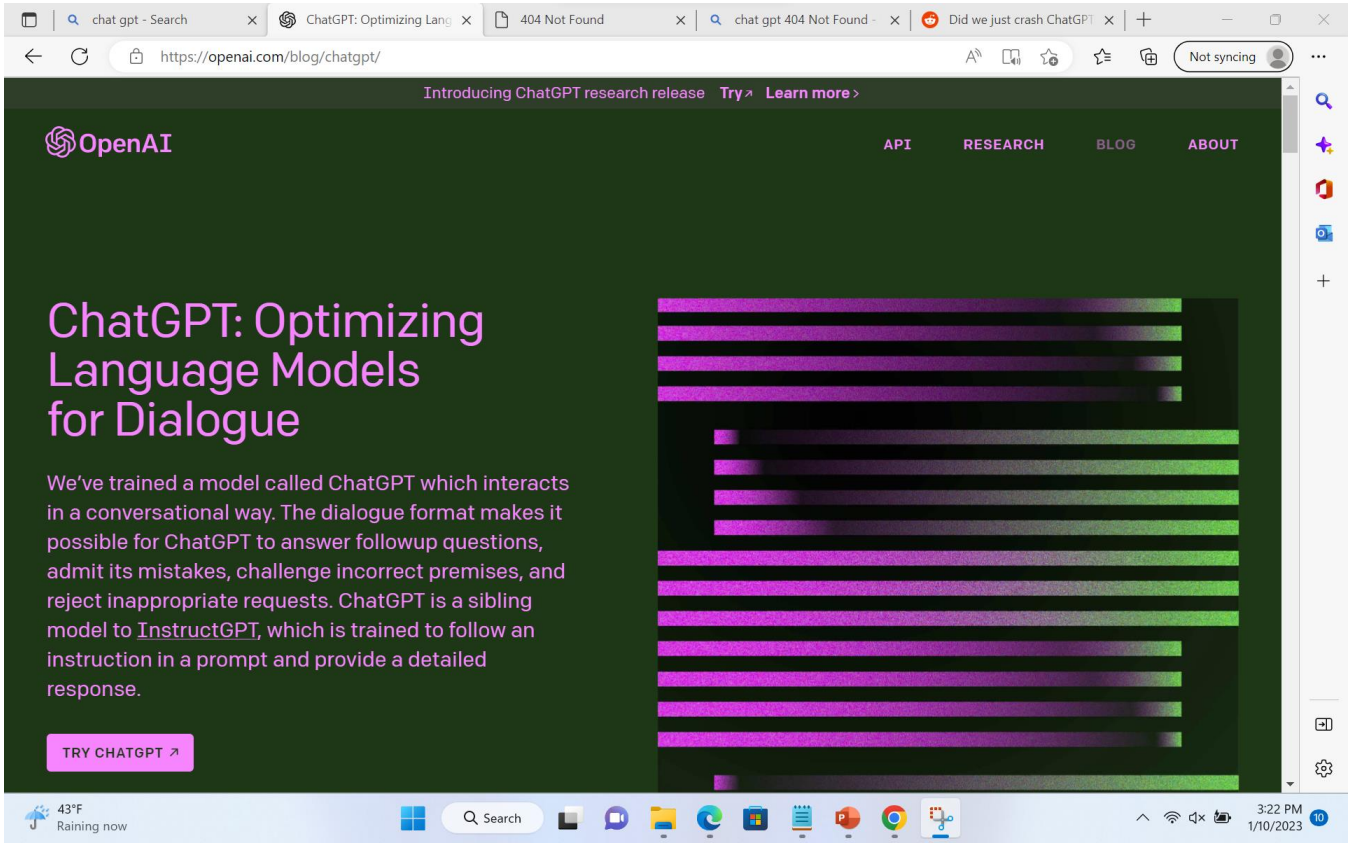


- Language processing technologies
  - Question answering
  - Machine translation



  - Web search
  - Text classification, spam filtering, etc…

Chat GPT


chat gpt - Search
ChatGPT: Optimizing Lang
404 Not Found
chat gpt 404 Not Found -
Did we just crash ChatGPT
https://openai.com/blog/chatgpt/
Not syncing
Introducing ChatGPT research release Try ↗ Learn more ›
OpenAI
API
RESEARCH
BLOG
ABOUT
ChatGPT: Optimizing Language Models for Dialogue
We've trained a model called ChatGPT which interacts in a conversational way. The dialogue format makes it possible for ChatGPT to answer followup questions, admit its mistakes, challenge incorrect premises, and reject inappropriate requests. ChatGPT is a sibling model to InstructGPT, which is trained to follow an instruction in a prompt and provide a detailed response.
TRY CHATGPT ↗
43°F
Raining now
Search
3:22 PM
1/10/2023


Gemini


OpenAI


deepseek


Llama 3
From Meta


Grok

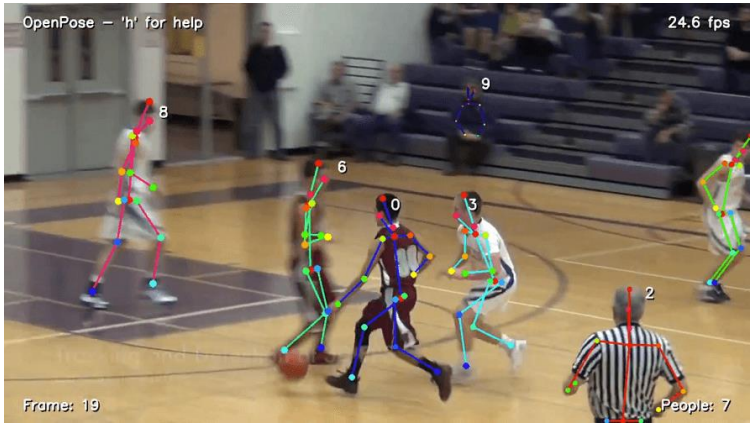
Text to Images (DALL-E)

- “An astronaut riding a horse in a photo-realistic way”

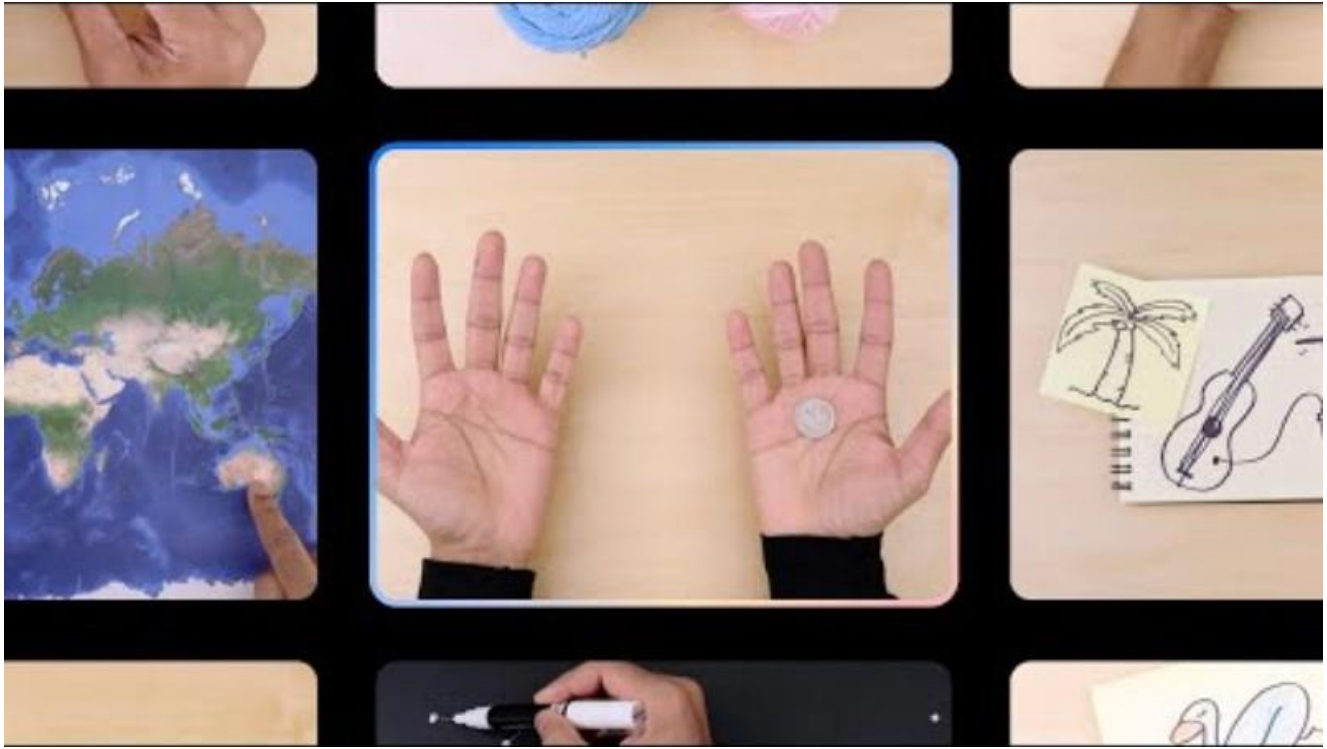
- “An armchair in the shape of an avocado.”

Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification

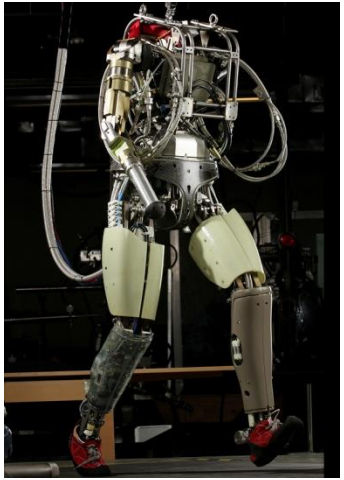


Multi-Modal Models



Robotics

- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!
- Technologies
  - Autonomous Vehicles
  - Rescue
  - Soccer!
  - Lots of automation…
  - But increasing amounts of learning…
- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control



Images from UC Berkeley, Boston Dynamics, RoboCup, Google

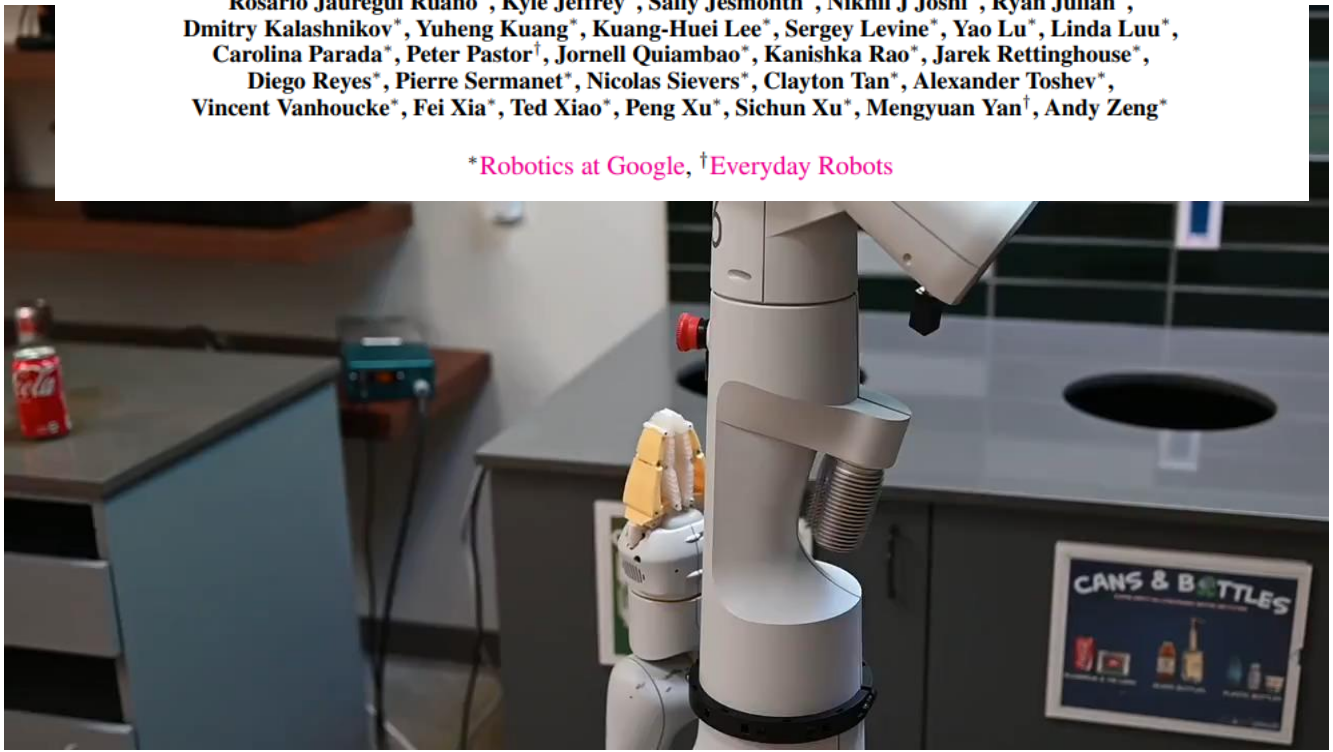
Boston Dynamics Atlas

https://vision-locomotion.github.io/

Do As I Can, Not As I Say: Grounding Language in Robotic Affordances

[1] Michael Ahn*, Anthony Brohan*, Noah Brown*, Yevgen Chebotar*, Omar Cortes*, Byron David*, Chelsea Finn*, Chuyuan Fu†, Keerthana Gopalakrishnan*, Karol Hausman*, Alex Herzog†, Daniel Ho†, Jasmine Hsu*, Julian Ibarz*, Brian Ichter*, Alex Irpan*, Eric Jang*, Rosario Jauregui Ruano*, Kyle Jeffrey*, Sally Jesmonth*, Nikhil J Joshi*, Ryan Julian*, Dmitry Kalashnikov*, Yuheng Kuang*, Kuang-Huei Lee*, Sergey Levine*, Yao Lu*, Linda Luu*, Carolina Parada*, Peter Pastor†, Jornell Quiambao*, Kanishka Rao*, Jarek Rettinghouse*, Diego Reyes*, Pierre Sermanet*, Nicolas Sievers*, Clayton Tan*, Alexander Toshev*, Vincent Vanhoucke*, Fei Xia*, Ted Xiao*, Peng Xu*, Sichun Xu*, Mengyuan Yan†, Andy Zeng*

*Robotics at Google, †Everyday Robots




autonomous, 1x speed
π

Logic

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

Article

Discovering faster matrix multiplication algorithms with reinforcement learning

https://doi.org/10.1038/s41586-022-05172-4

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Published online: 5 October 2022

Open access

Check for updates

Alhussein Fawzi[1,2]✉, Matej Balog[1,2], Aja Huang[1,2], Thomas Hubert[1,2], Bernardino Romera-Paredes[1,2], Mohammadamin Barekatain[1], Alexander Novikov[1], Francisco J. R. Ruiz[1], Julian Schrittwieser[1], Grzegorz Swirszcz[1], David Silver[1], Demis Hassabis[1] & Pushmeet Kohli[1]

Improving the efficiency of algorithms for fundamental computations can have a widespread impact, as it can affect the overall speed of a large amount of computations. Matrix multiplication is one such primitive task, occurring in many systems—from neural networks to scientific computing routines. The automatic discovery of algorithms using machine learning offers the prospect of reaching beyond human intuition and outperforming the current best human-designed algorithms. However, automating the algorithm discovery procedure is intricate, as the space of possible algorithms is enormous. Here we report a deep reinforcement learning approach based on AlphaZero[1] for discovering efficient and provably correct algorithms for the multiplication of arbitrary matrices. Our agent, AlphaTensor, is trained to play a single-player game where the objective is finding tensor decompositions within a finite factor space. AlphaTensor discovered algorithms that outperform the state-

SCIENCE

AlphaGeometry: An Olympiad-level AI system for geometry

17 JANUARY 2024

Trieu Trinh and Thang Luong

RESEARCH

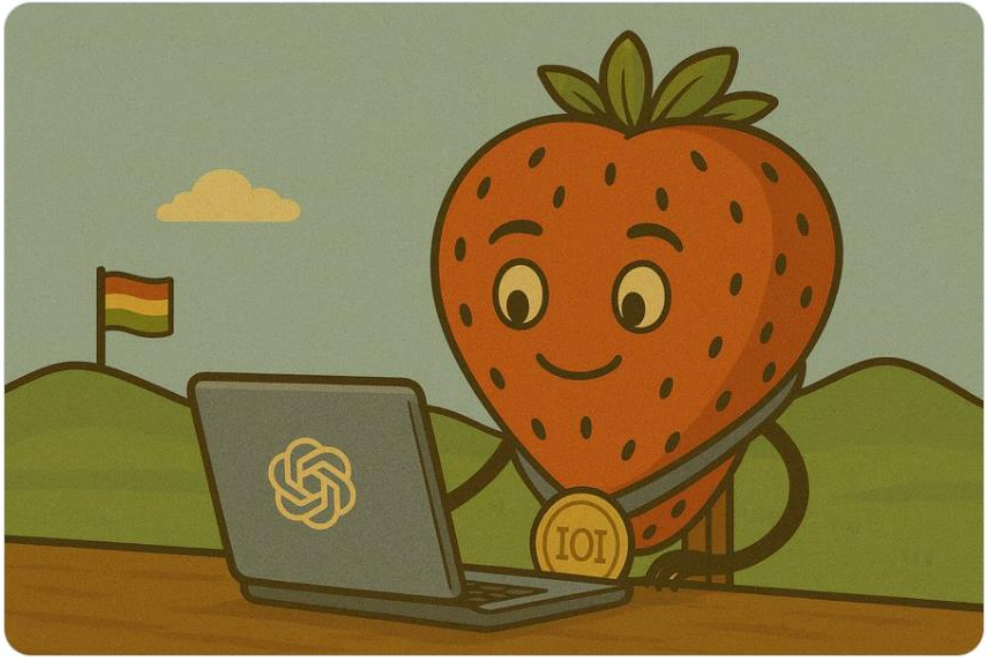
Advanced version of Gemini with Deep Think officially achieves gold-medal standard at the International Mathematical Olympiad

21 JULY 2025

Thang Luong and Edward Lockhart

Sheryl Hsu
@SherylHsu02

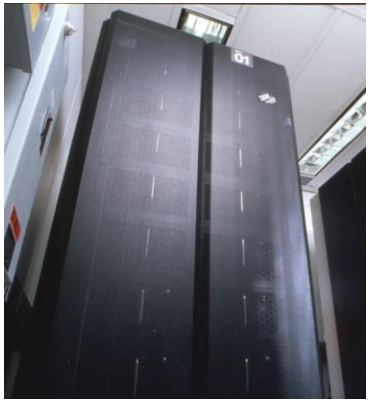
1/n I'm thrilled to share that our @OpenAI reasoning system scored high enough to achieve gold 🥇🥇 in one of the world's top programming competitions - the 2025 International Olympiad in Informatics (IOI) - placing first among AI participants! 👨‍💻👨‍💻



12:00 PM · Aug 11, 2025 · **2.2M** Views

Game Playing

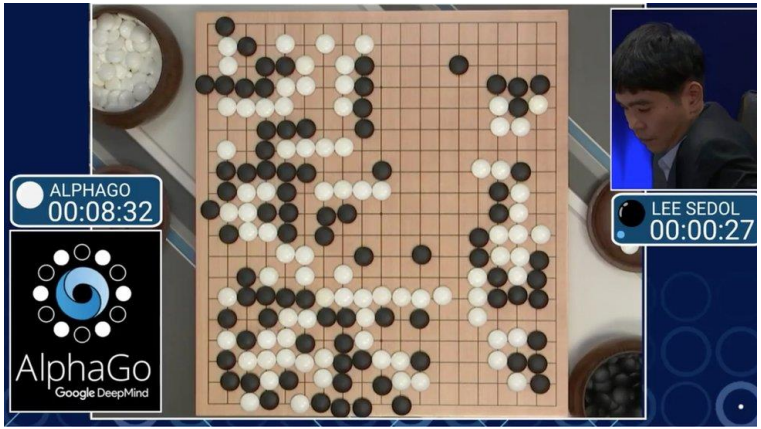
- Classic Moment: May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - “Intelligent creative” play
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - Can do about the same now with a PC cluster



- 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!

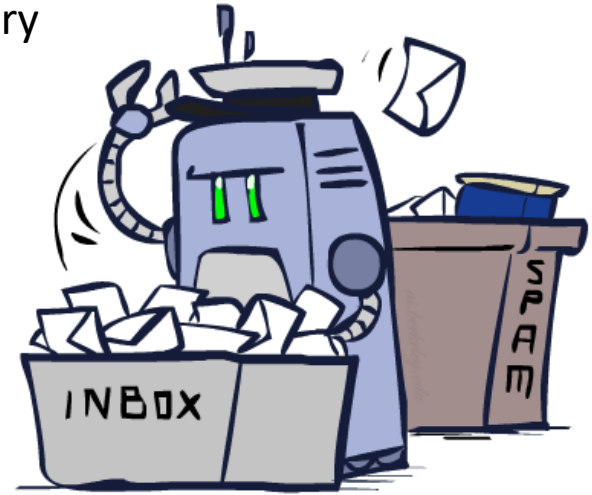
Text from Bart Selman, image from IBM’s Deep Blue pages

Winning at Games



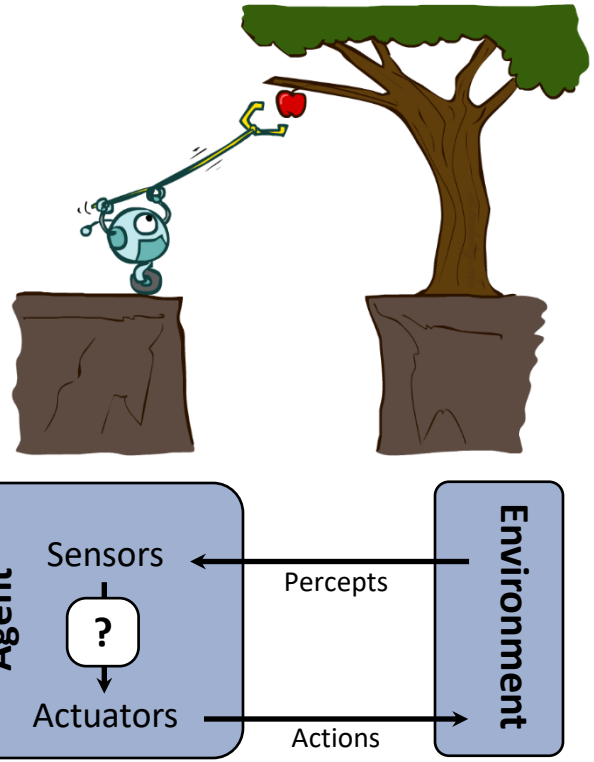
Decision Making

- 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!

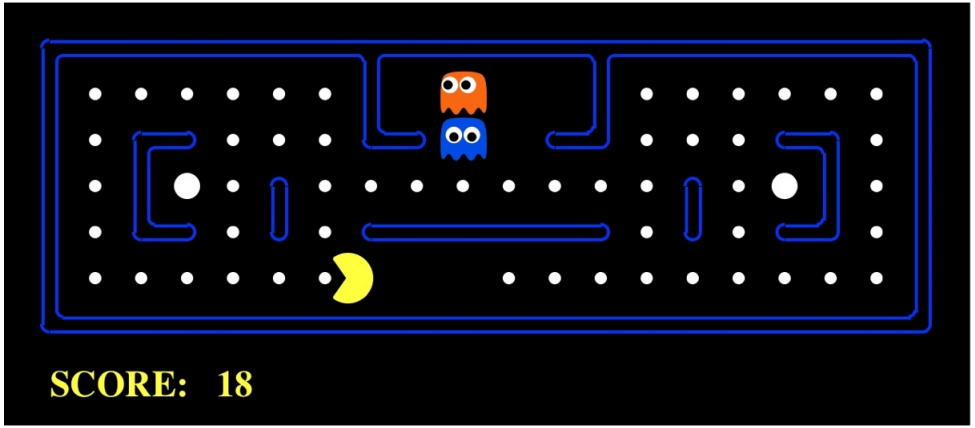


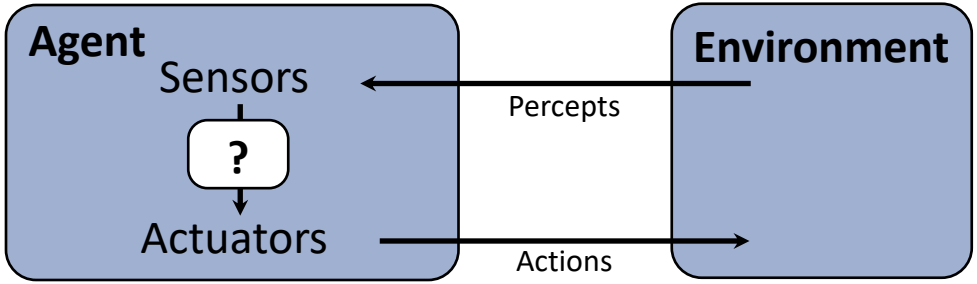
Designing Rational Agents

- 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





Pacman

- Google: “play pacman doodle”

Course Topics

- Part I: Making Decisions
  - Fast search
  - Adversarial and uncertain search
- Part II: Markov Decision Process (MDP) Basics
  - Planning
  - Reinforcement learning
- Part III: Reasoning Under Uncertainty
  - Bayes Nets
  - Hidden Markov Models (HMMs)
  - Imitation Learning
  - Reinforcement Learning from Human Feedback