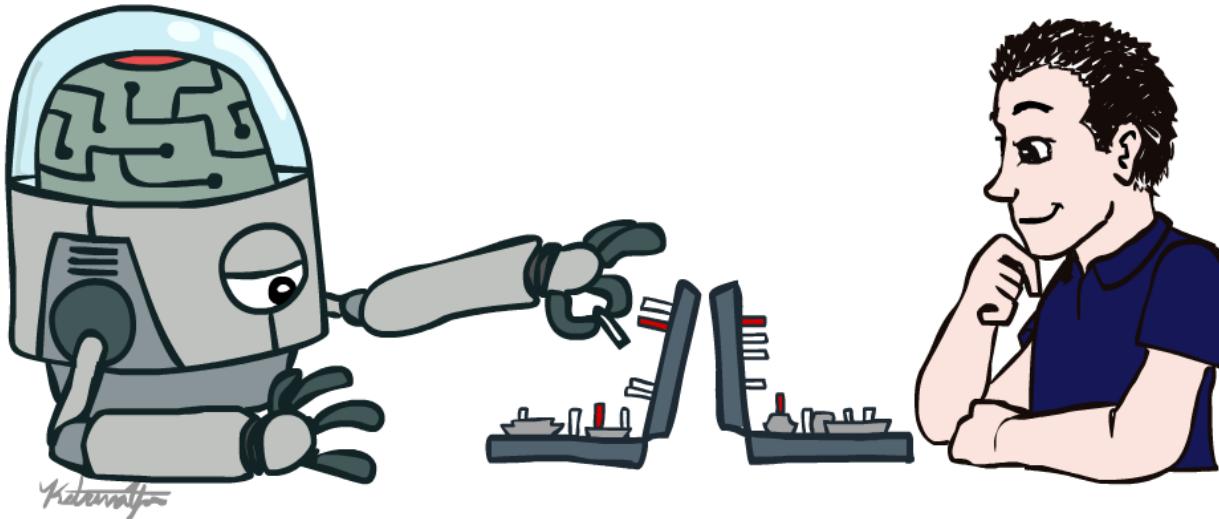


# CS 188: Artificial Intelligence

## Introduction



Fall 2024

Pieter Abbeel & Igor Mordatch

University of California, Berkeley

[Many of these slides were originated by Dan Klein and Pieter Abbeel]

# First Half of Today: Intros and Logistics

---

- Staff introductions: Pieter, Igor and course staff
- Course logistics
  - Lectures, discussions, office hours, and exams
  - Resources and communication platforms
  - Collaboration and academic honesty
  - DSP and extenuating circumstances
  - Stress management and mental health

# Staff Introductions: Pieter Abbeel

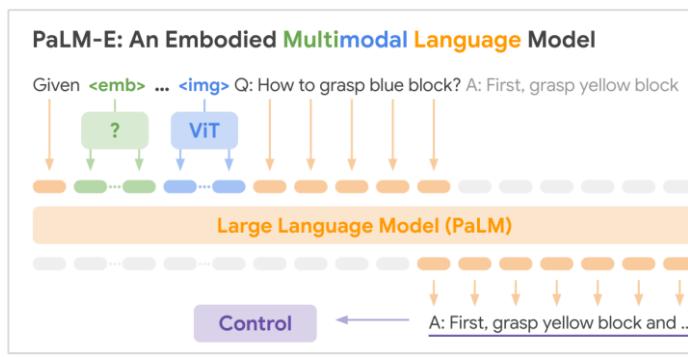
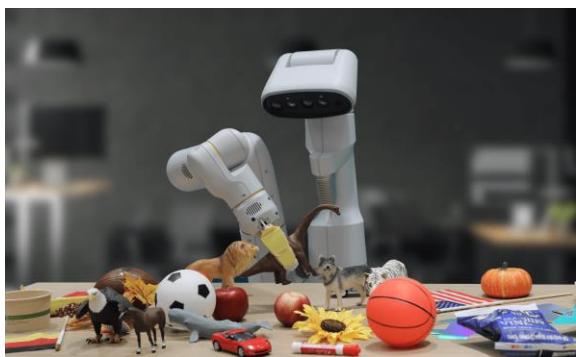
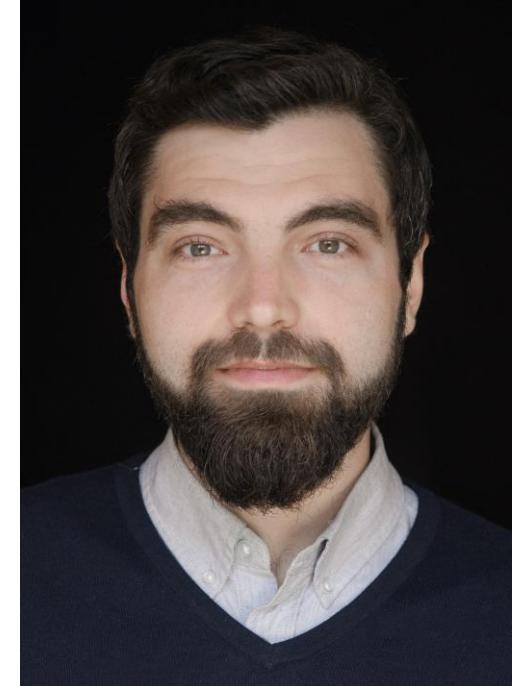
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- Currently:
  - Professor at UC Berkeley (2008 -- )
  - Co-founder / Chief Scientist at Covariant (2017 -- )
  - AI start-up investor and advisor (AIX, Perplexity, Ideogram, Genmo, Skilld, Reflection, ...)
- Previously:
  - Co-founder Gradescope
  - Early research scientist at OpenAI (2015-2017)
- Teaching:
  - 188 Intro to AI
  - 287 Advanced Robotics
  - 294-158 Generative AI / Deep Unsupervised Learning
- Research:
  - generative models
  - reinforcement learning
  - robotics

# Staff Introductions: Igor Mordatch

- Currently: Lecturer and Researcher at Google DeepMind
- Previously: OpenAI, UC Berkeley, Pixar
- Research focus: robotics, large models, multi-agent AI



# Our talented course staff!

## TAs:



Matei Gardea  
Head TA



Pranav Muralikrishnan  
Head TA



Xavier Yin  
Head TA



Catherine Chu



Erin Tan



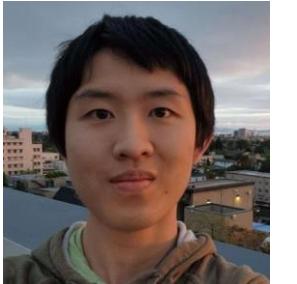
Fangchen Liu



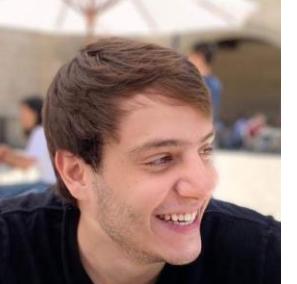
Jerry Sun



Joshua Liao



Kenny Wang



Kevin Zakka



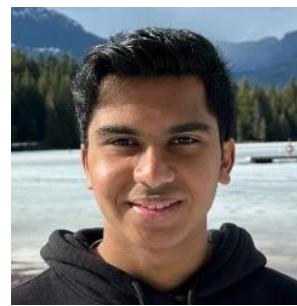
Michael Wu



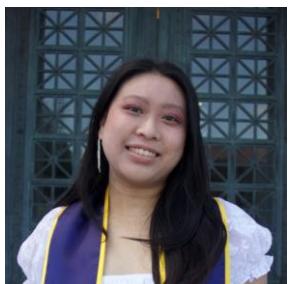
Mustafa Mirza



Mustafa Mirza



Mustafa Mirza



Samantha Huang



Wesley Zheng

## Readers:



Advika Bhike



Danial Toktarbayev



Faith Dennis



Tina Rong

# Course Information

<http://inst.cs.berkeley.edu/~cs188/fa24>

The screenshot shows the homepage of the CS 188 Fall 2024 website. The top navigation bar includes links for Dark Mode, Ed, OH Queue, Extensions Form, and Feedback Form. A sidebar on the left lists links for Calendar, Policies, Resources, Staff, and Projects. The main content area features a yellow "WARNING" box stating "This site is under construction. All dates and policies are tentative until this message goes away." Below this is the course title "CS 188 Fall 2024" and a "CS188" logo. There are sections for "Announcements" (with a "Past announcements" link) and "Calendar" (with a "Skip to current week" link). The central part of the page is a table showing the weekly schedule:

Wk.	Date	Lecture (pptx files)	Readings (AIMA, 4th ed.)	Discussion	Homework	Project
0	Thu Aug 29	1. Intro	Ch. 1-2	No Discussion	HW0 [optional] (due Tue, Sep 3 at 11:59 PM PT)	Project 0 [optional] (due Wed, Sep 4 at 5 PM PT)
1	Tue Sep 03	2. Uninformed Search	Ch. 3.1-3.4		HW1 (due Tue, Sep 10 at 11:59 PM PT)	Project 1 (due Fri, Sep 13 at 5 PM PT)
	Thu Sep 05	3. A* Search and Heuristics	Ch. 3.5-3.6		HW2 (due Tue, Sep 17 at 11:59 PM PT)	
2	Tue Sep 10	4. CSPs I	Ch. 6.1	1. Search	HW3 (due Tue, Sep 24 at 11:59 PM PT)	Project 2 (due Fri, Sep 27 at 5 PM PT)
	Thu Sep 12	5. CSPs II	Ch. 6.2-6.5		HW4 (due Tue, Sep 30 at 11:59 PM PT)	
	Tue Sep 17	6. Game Trees: Minimax	Ch. 5.2-5.5	2. CSPs	HW5 (due Tue, Oct 07 at 11:59 PM PT)	
Thu Sep 19	7. Game Trees: Expectimax, Utilities, Multiplayer	Ch. 5.2-5.5, 16.1-16.3	HW6 (due Tue, Oct 14 at 11:59 PM PT)			
	Tue	R Model	Ch. 17.1-17.2			

## ■ Communication:

- Announcements on Ed
- Questions?
  - Materials: public post on Ed
  - Confidential: private post on Ed
- If not suitable for Ed:
  - cs188-fa24-staff@lists.berkeley.edu
  - Or individual staff/instructors as needed

## ■ Course technology:

- Website
- Ed
- Gradescope
- This course is webcast

# Course Information

---

- Prerequisites:
  - (CS 61A or CS 61B) and (CS 70 or Math 55)
    - Recommended: CS 61A and CS 61B and CS 70
  - There will be math and programming
- Work and Grading:
  - 5 programming projects: Python, groups of 1 or 2
    - 5 late days budget for semester, maximum 2 per project
  - 10 homework assignments:
    - Electronic component: Online, interactive, solve alone/together, submit alone
    - Written component: On paper, solve alone/together, submit alone, self-asses
    - Drop lowest
  - One midterms, One final
  - Fixed scale
  - Participation can help on margins
  - Academic integrity policy

# Course Structure: Exams

---

- Save the dates!
  - Midterm: Thursday, October 17, 7–9pm PT
  - Final exam: Friday, December 20, 7-10pm PT
- If you can't make it:
  - If, and only if, you have a hard conflict with these times, contact us no later than Wednesday 9/4 to see if you qualify for alternate exam slot (midterm 9-11pm same day; final 9-noon next day). [cs188-fa24-staff@lists.berkeley.edu](mailto:cs188-fa24-staff@lists.berkeley.edu)
- More logistics closer to the exam

# Course Structure: Office Hours

---

- Join in-person or remotely to talk to staff about content, ask questions on assignments, or raise any concerns you have
- Schedule and queue available on website
  - Office hours start next week (September 3)

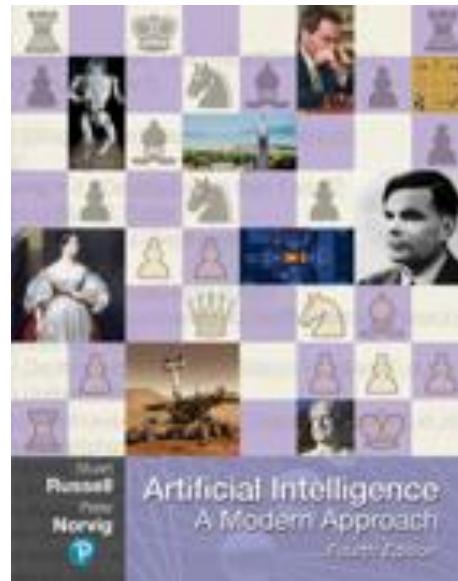
# Discussion Section

---

- 3 Types:
  - Review / warm-up exercises
  - Exam prep exercises
  - 2hr review session
- You are welcome to attend any section of your preference
- From past semesters' experience we know sections will be (over)crowded the first two weeks of section, but then onwards things will sort themselves out
- We will do our best to provide a webcast of section
- Discussion Sections are highly encouraged (but optional)
- Sections will start the week of Sep 9 (i.e. no discussion section this week / next week)

# Textbook

- Not required, but for students who want to read more we recommend
  - Russell & Norvig, AI: A Modern Approach, 4<sup>th</sup> Ed.



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

# Laptops in Lecture

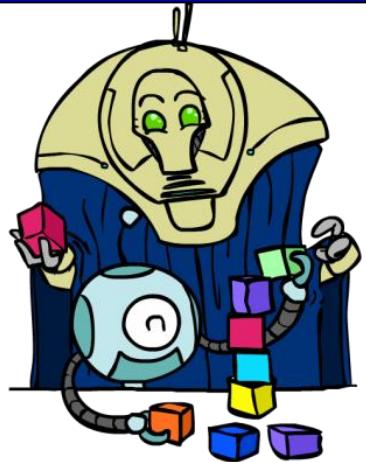
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- Laptops can easily distract students behind you

Please consider sitting towards the back if using your laptop in lecture

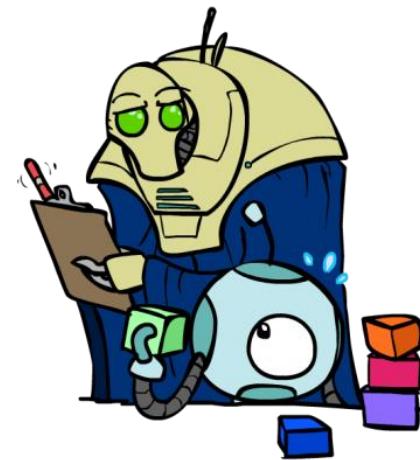
# Instruction vs. Assessment

---



Instruction

Grow knowledge, collaborate,  
work until success



Assessment

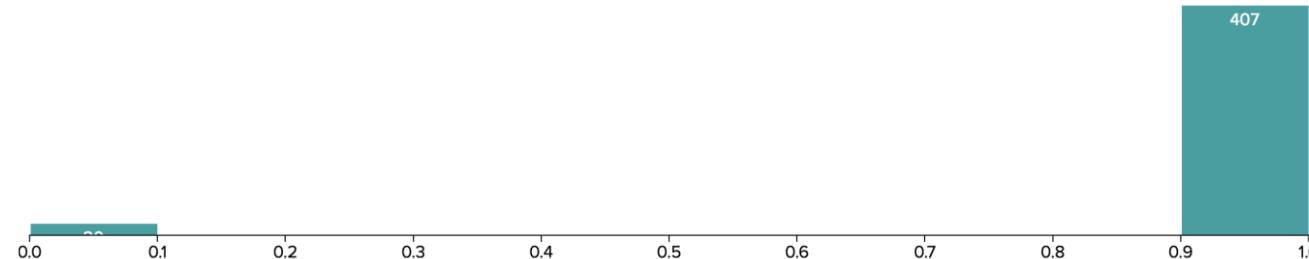
Measure knowledge, each student  
on their own, stopped before success

## Our experience: these two goals don't mix

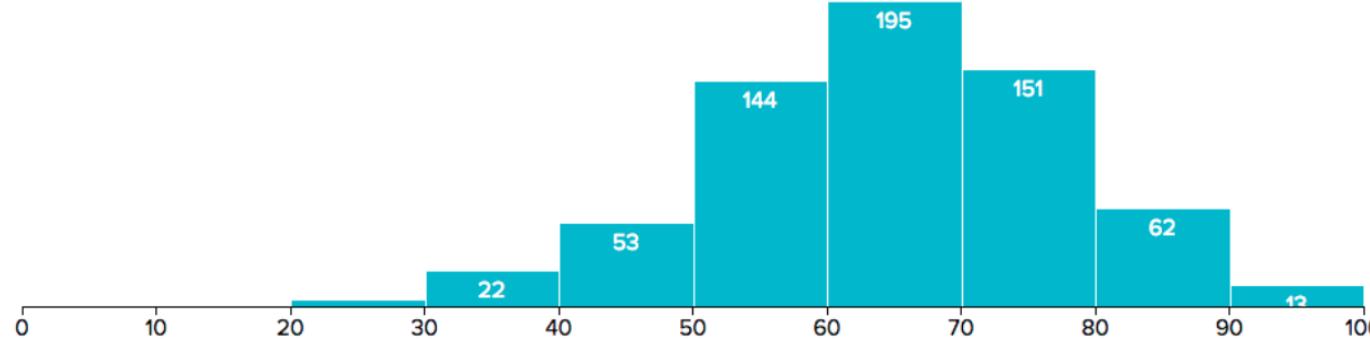
- Lecture / Section / OH / Ed / Homework / Projects are instruction
  - collaborative, work until success (but please no spoilers)
- Exams are assessment
  - on your own

# Some Historical Statistics

- Homework and projects: work alone/together, iterate/learn till you nailed it



- Exams: assessment



- Written component to homework = old exam questions
- Suggestion: assess yourself by first spending some time working alone

# Inclusion

- We believe in the crucial importance of creating a learning environment that is welcoming and respectful to students of all backgrounds. The following are specific steps that will help us in achieving this goal:
  - If you feel your academic performance has been impacted negatively due to a lack of inclusion, or due to experiences outside of class such as current events or family matters, please reach out to the instructors and staff. Our job is not only to teach but to support you in every way we can.
  - If something happens in the course that runs counter to the goal of making every student feel safe, respected, and welcome, please contact the head TA or the instructors; if you don't feel comfortable contacting course staff, you can fill out [this form](#) to anonymously let the department know.
  - You may also consult a departmental [Faculty Equity Advisor](#), or fill out the [anonymous feedback form](#) for the College of Engineering for equity and inclusion related feedback.
  - If you have a preferred name or set of pronouns that differ from your legal name, you may designate a preferred name for the classroom by following these [steps](#).
  - As a member of the CS 188 community, realize that you have an important duty to help other students feel respected in helping create an inclusive learning environment.

You can also find these links on the Policies tab on the class webpage

# Grading Structure

- Projects (25%)
  - Python programming assignments, autograded
  - You can optionally work with a partner
  - Reduced credit for submitting late, unless you have an extension
- Homework (20%)
  - Electronic homework: Autograded on Gradescope
  - Written homework: One question per week, graded by TAs on correctness
  - Submit individually (but feel free to discuss with others)
  - No late submissions, unless you have an extension
- Midterm (20%), Final Exam (35%)

Overall	Grade
[85, 100]	A
[80, 85)	A-
[75, 80)	B+
[70, 75)	B
[65, 70)	B-
[60, 65)	C+
[55, 60)	C
[50, 55)	C-
[45, 50)	D+
[40, 45)	D
[35, 40)	D-
[0 , 35)	F

# Extensions and Accommodations

---

- We'll drop your lowest homework score
- You have 5 slip days to use across the projects (max 2 for each)
  - See course policies page for details on how they work
- In case of extenuating circumstances, you can request an extension
  - Extension form will be linked on the website
  - We will consider each request seriously, but note that extensions are \*not\* automatically granted just because you submitted a request.

# DSP

---

- **Disabled Students' Program (DSP)**
  - There's a variety of accommodations UC Berkeley can help us set up for you in this class
  - <https://dsp.berkeley.edu/>
- **Are you facing barriers in school due to a disability?**
  - Apply to DSP!
  - We maintain proper access controls on this information: Only instructors, course managers, head TAs, and logistics TAs can access any DSP-related info
- Our goal is to teach you the material in our course. The more accessible we can make it, the better.

# Collaboration and Academic Dishonesty

---

- We're here to help! There are plenty of staff and resources available for you
  - You can always talk to a staff member if you're feeling stressed or tempted to cheat
  - Collaboration on homework is okay, but please cite collaborators
  - Do not post solutions online or share with others!
- Academic dishonesty policies
  - Reported to Center of Student Conduct
  - Negative points on assignments, and/or F in the class

# Stress Management and Mental Health

---

- **Your health is more important than this course**
- If you feel overwhelmed, there are options
  - Academically: Ask on Ed, talk to staff in office hours, set up a meeting with staff to make a plan for your success this semester
  - Non-academic:
    - Counselling and Psychological Services (CAPS) has multiple free, confidential services
      - Casual consultations: <https://uhs.berkeley.edu/counseling/lets-talk>
      - Crisis management: <https://uhs.berkeley.edu/counseling/urgent>
    - Check out UHS's resources: <https://uhs.berkeley.edu/health-topics/mental-health>

# Announcements This Week

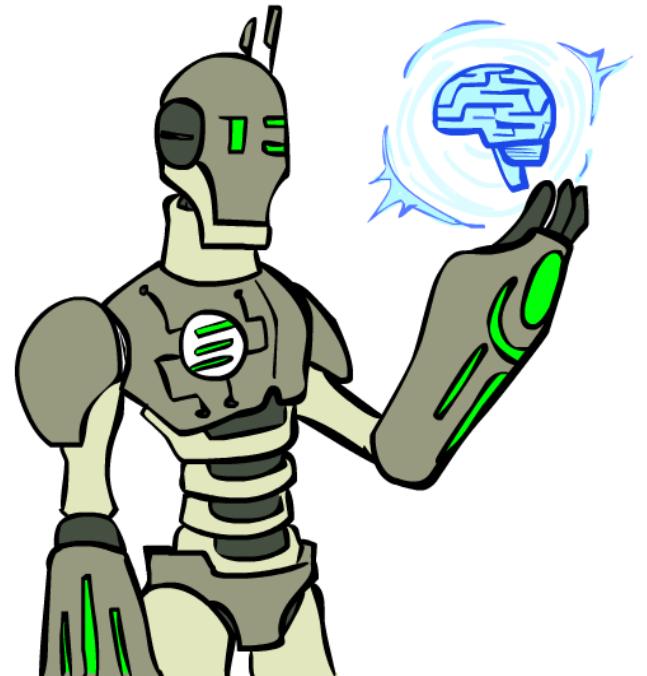
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- Important this week:
  - **Check out website:** <https://inst.eecs.berkeley.edu/~cs188/fa24>
  - **Make sure you are on Gradescope and Ed** (should be automatic, if not, contact staff)
  - **HW0: Math self-diagnostic** is online now (due on Tue Sep 3 at 11:59pm)
  - **P0: Python tutorial** is online now (due on Wed Sep 4 at 5pm)
  - **Inst accounts:** not needed, but if you want one, contact staff
- Also important:
  - We don't control enrollment.  
See <https://eecs.berkeley.edu/resources/undergrads/cs/degree-reqs/enrollment-policy> for information regarding enrollment into CS classes, including email contact for EECS staff if you have additional enrollment-related questions.

# Second Half of Today: What is AI?

---

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



# AI is having real-world impact

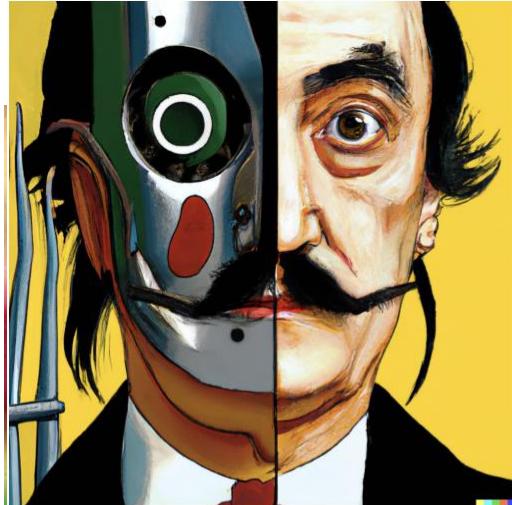
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- Public imagination
  - Text assistants



# AI is having real-world impact

- Public imagination
  - Text assistants
  - Image generation



vibrant portrait painting of Salvador Dalí with a robotic half face



a shiba inu wearing a beret and black turtleneck



a close up of a handpalm with leaves growing from it



an espresso machine that makes coffee from human souls, artstation



panda mad scientist mixing sparkling chemicals, artstation

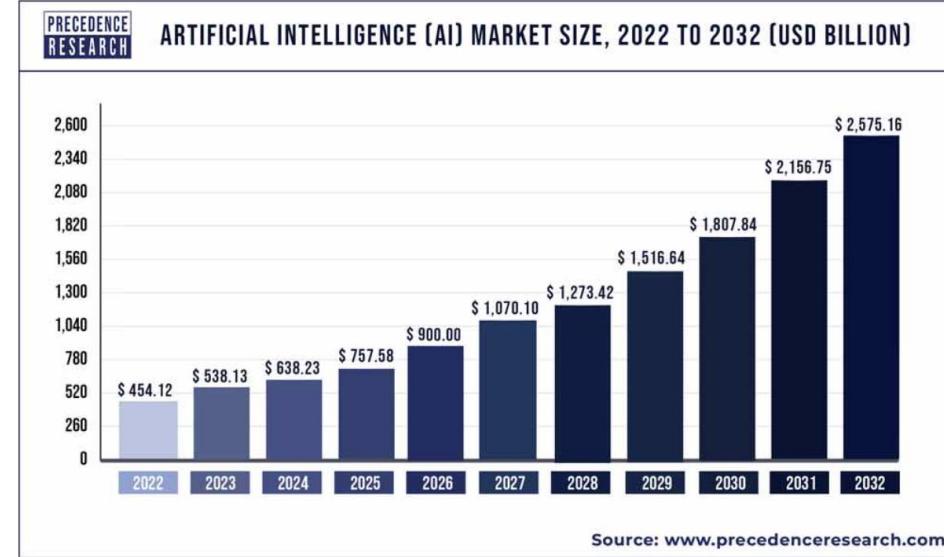


a corgi's head depicted as an explosion of a nebula

# AI is having real-world impact

- Public imagination
- Economy
  - 454 billion USD globally

The global artificial intelligence (AI) market size was valued at USD 454.12 billion in 2022 and is expected to hit around USD 2,575.16 billion by 2032, progressing with a CAGR of 19% from 2023 to 2032. The North America artificial intelligence market was valued at USD 167.30 billion in 2022.



<https://www.precedenceresearch.com/artificial-intelligence-market>

# AI is having real-world impact

- Public imagination
- Economy
- Politics



# AI is having real-world impact

---

- Public imagination
- Economy
- Politics



# AI is having real-world impact

---

- Public imagination
- Economy
- Politics



# AI is having real-world impact

---

- Public imagination
- Economy
- Politics



# AI is having real-world impact

- Public imagination
- Economy
- Politics
- Law

Aug. 18, 2023, 12:18 PM; Updated: Aug. 18, 2023, 12:48 PM

## AI-Generated Art Lacks Copyright Protection, D.C. Court Says (1)



**Riddhi Setty**  
Reporter



**Isaiah Poritz**  
Legal Reporter



Bloomberg Law, 2023

## *8 Daily Newspapers Sue OpenAI and Microsoft Over A.I.*

The suit, which accuses the tech companies of copyright infringement, adds to the fight over the online data used to power artificial intelligence.

New York Times, 2024

# AI is having real-world impact

- Public imagination
- Economy
- Politics
- Law
- Labor

Finance & economics | Free exchange

New research shows the robots are coming for jobs—but stealthily

Look beneath the aggregate economic numbers, and change is afoot

The Economist, 2021

## *The Optimist's Guide to Artificial Intelligence and Work*

The focus of much discussion is on how it will replace jobs, but nothing is inevitable.

New York Times, 2023

## **The human labor behind AI chatbots and other smart tools**

Data labeling is an important step in developing artificial intelligence but also exposes the people doing the work to harmful content.

MarketWatch, 2023

# AI is having real-world impact

- Public imagination
- Economy
- Politics
- Law
- Labor
- Sciences

nature  
BIOTECH

## AlphaFold Developers Win \$3-Million Breakthrough Prize in Life Sciences

DeepMind's system for predicting the 3D structure of proteins is among five recipients of science's most lucrative awards

By Zeeya Merali, Nature magazine on September 22, 2022

Nature, 2022

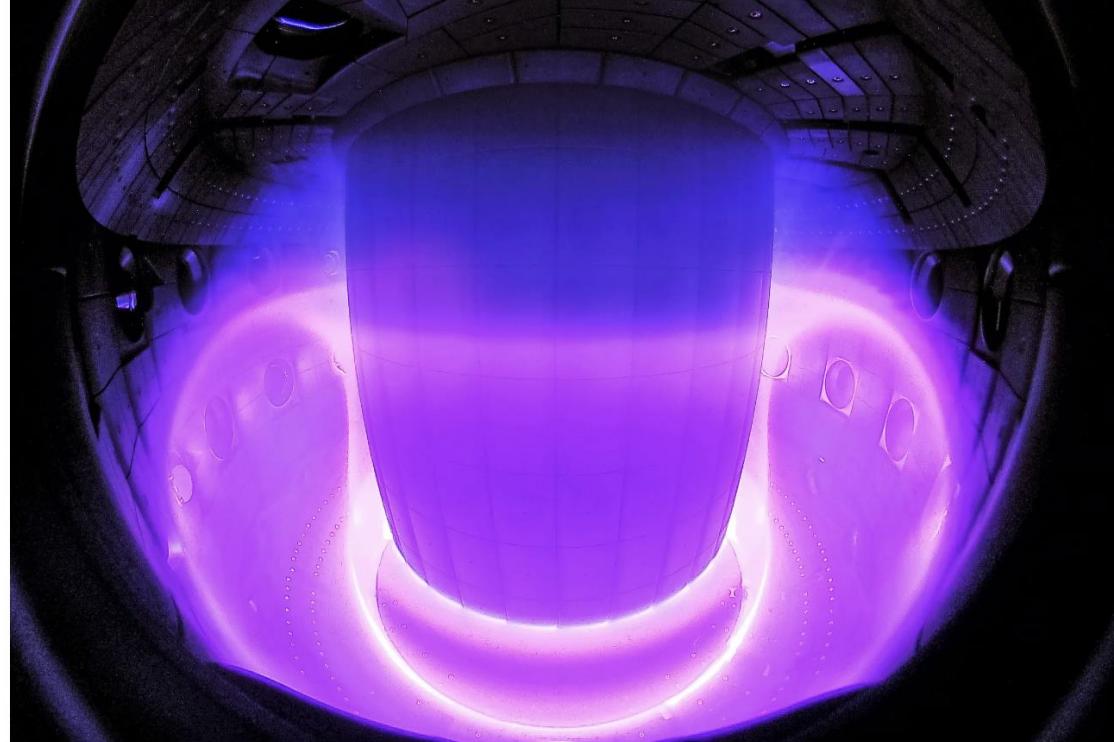
# AI is having real-world impact

- Public imagination
- Economy
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- Sciences

AMIT KATWALA SCIENCE FEB 16, 2022 11:00 AM

## DeepMind Has Trained an AI to Control Nuclear Fusion

The Google-backed firm taught a reinforcement learning algorithm to control the fiery plasma inside a tokamak nuclear fusion reactor.



PHOTOGRAPH: CURDIN WÜTHRICH, SPC/EPFL

Wired, 2022

# AI is having real-world impact

- Public imagination
- Economy
- Politics
- Law
- Labor
- Sciences
- Education

BREAKING

## ChatGPT In Schools: Here's Where It's Banned—And How It Could Potentially Help Students

Arianna Johnson Forbes Staff

*I cover the latest trends in science, tech and healthcare.*

Follow

2

Jan 18, 2023, 02:31pm EST

Forbes, 2023

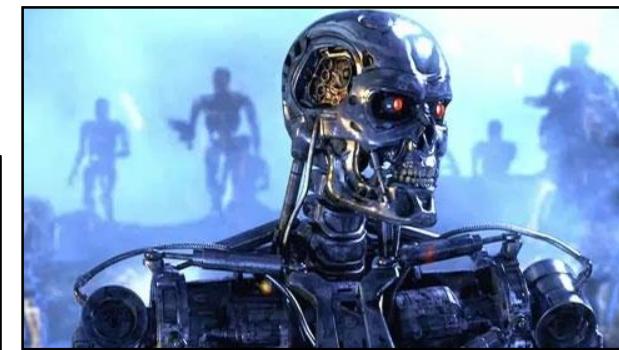
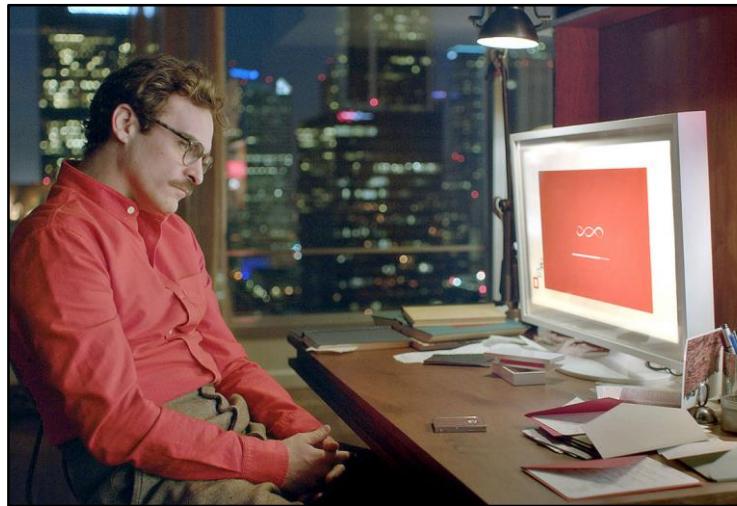
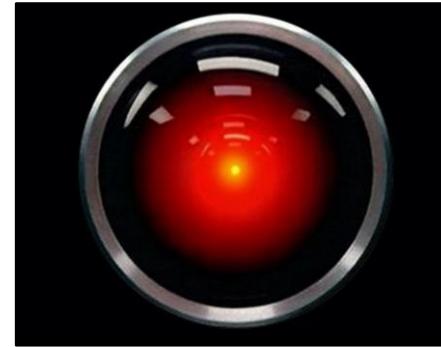
# AI is having real-world impact

---

- Public imagination
- Economy
- Politics
- Law
- Labor
- Sciences
- Education

Ok, but what does AI *do*???

# Science fiction AI?



# What is AI?

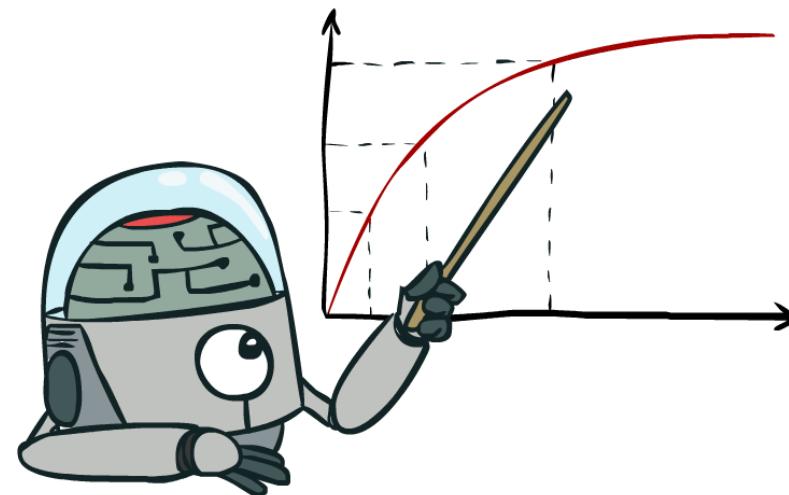
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The science of making machines that:

# Rational Decisions

---

- We'll use the term **rational** in a very specific, technical way:
  - Rational: *maximally achieving pre-defined goals*
  - Goals are expressed in terms of the **utility** of outcomes
  - World is uncertain, so we'll use **expected utility**
  - Being rational means acting to **maximize your expected utility**



# Rational Decisions

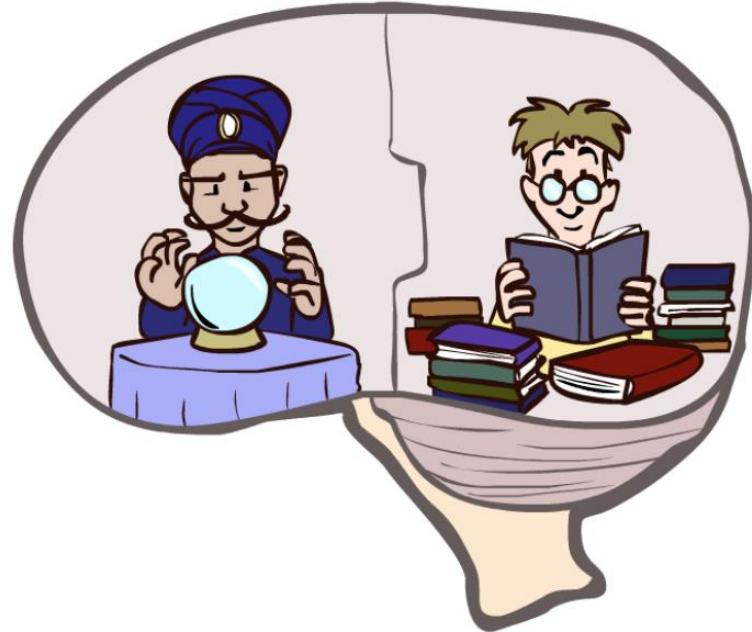
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A better title for this course would be:  
**Computational Rationality**

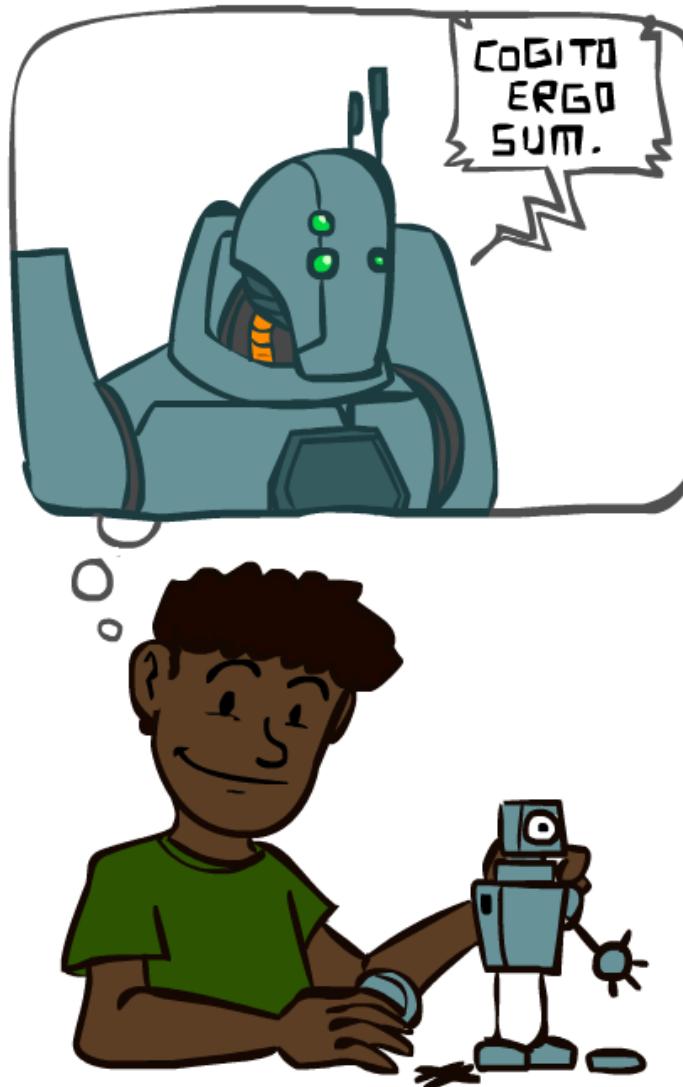
# What About the Brain?

- 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!
- AI may be better than brains at some tasks
- *"Brains are to intelligence as wings are to flight"*
- We can't yet build AI on the scale of the brain
  - ~100T synapses in the human brain vs ~500B weights in artificial neural networks
- Still, the brain can be a great inspiration for AI!



# A (Short) History of AI

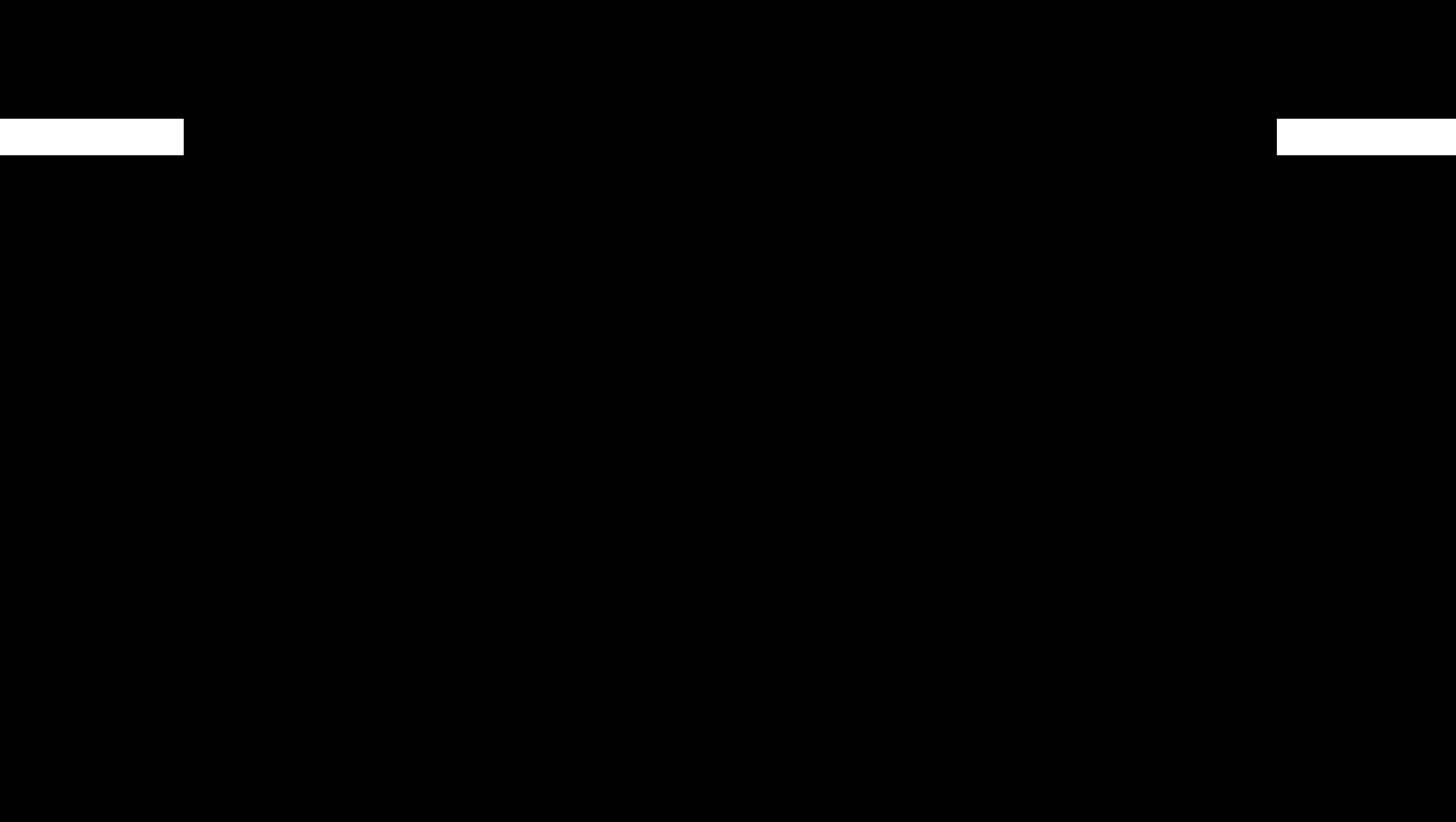
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# A (Short) History of AI

---

- 1940-1950: Early days: neural and computer science meet
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's "Computing Machinery and Intelligence"
- 1950—70: Excitement! Logic-driven
  - 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



# A (Short) History of AI

- 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”?
  - 1996: Kasparov defeats Deep Blue at chess
  - 1997: Deep Blue defeats Kasparov at chess



“I could feel --- I could smell ---  
a new kind of intelligence  
across the table.” ~Kasparov

# A (Short) History of AI

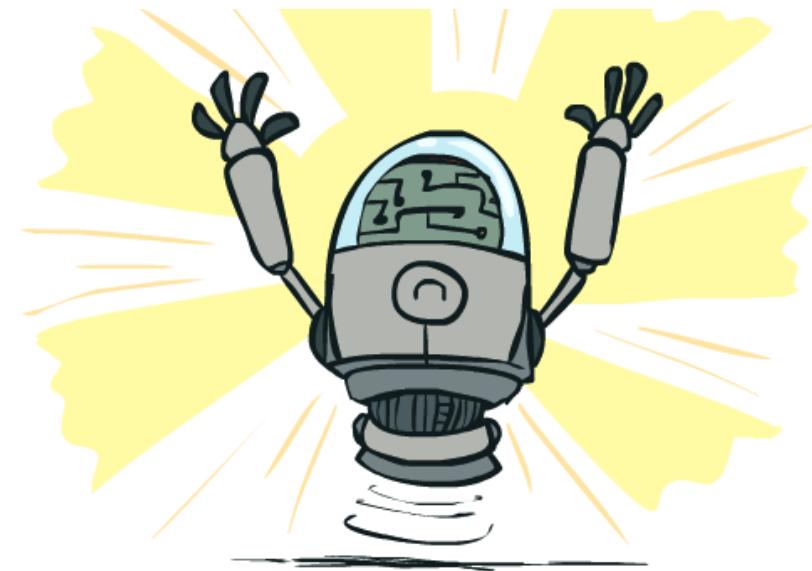
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- 2000—: Where are we now?
  - Big data, big compute, neural networks
  - Some re-unification of sub-fields
  - AI used in many industries
  - Chess engines running on ordinary laptops can defeat the world's best chess players
  - What can AI do now?

# What Can AI Do?

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

- ✓ Win against any human at chess?
- ✓ Win against the best humans at Go?
- Play a decent game of table tennis?
- Unload any dishwasher in any home?
- Drive safely along the highway?
- Drive safely along streets of San Francisco?
- Buy a week's worth of groceries on the web?
- Buy a week's worth of groceries at Berkeley Bowl?
- Discover and prove a new mathematical theorem?
- Perform a surgical operation?
- Translate spoken Chinese into spoken English in real time?
- Win an art competition?
- Write an intentionally funny story?
- Construct a building?



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Google's AlphaGo beats Lee Sedol at Go in 2016



But ... a plot twist in 2023!

DEEP BLUE WAS JUST THE START —

**Man beats machine at Go in human victory over AI**

Amateur exploited weakness in systems that have otherwise dominated grandmasters.

RICHARD WATERS, FINANCIAL TIMES - 2/19/2023, 4:51 AM

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## Google DeepMind trained a robot to beat humans at table tennis

It was able to draw on vast amounts of data to refine its playing style and adjust its tactics as matches progressed.

By Rhiannon Williams

August 9, 2024

# What Can AI Do?

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

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- ✗ Unload any dishwasher in any home?
- ✓ Drive safely along the highway?
- ✓ Drive safely along streets of San Francisco?
- Buy a week's worth of groceries on the web?
- Buy a week's worth of groceries at Berkeley Bowl?
- Discover and prove a new mathematical theorem?
- Perform a surgical operation?
- Translate spoken Chinese into spoken English in real time?
- Win an art competition?
- Write an intentionally funny story?
- Construct a building?



The Register®

**California DMV hits brakes on Cruise's SF driverless fleet after series of fender benders**

50% chop effective 'immediately' as department investigates traffic and safety issues

# What Can AI Do?

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

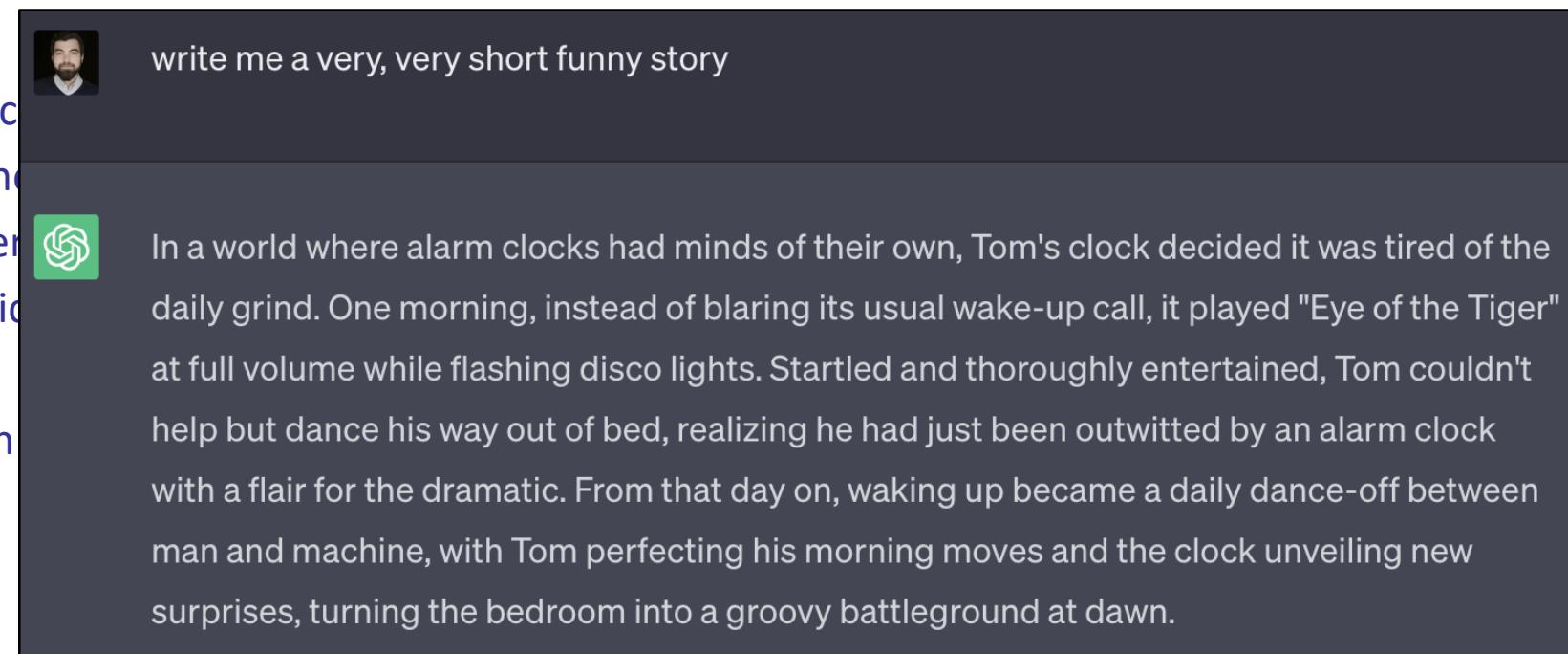
- ✓ Win against any human at chess?
- ✓ Win against the best humans at Go?
- ✓ Play a decent game of table tennis?
- ✗ Unload any dishwasher in any home?
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- ✗ Drive safely along streets of San Francisco?
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- ✗ Buy a week's worth of groceries at Benihana?
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- Construct a building?



A screenshot of a conversational AI interface. On the left, there is a small profile picture of a man with a beard. Next to it, the user's message reads: "write me a very, very short funny story". On the right, the AI's response is displayed in a larger text block: "In a world where alarm clocks had minds of their own, Tom's clock decided it was tired of the daily grind. One morning, instead of blaring its usual wake-up call, it played "Eye of the Tiger" at full volume while flashing disco lights. Startled and thoroughly entertained, Tom couldn't help but dance his way out of bed, realizing he had just been outwitted by an alarm clock with a flair for the dramatic. From that day on, waking up became a daily dance-off between man and machine, with Tom perfecting his morning moves and the clock unveiling new surprises, turning the bedroom into a groovy battleground at dawn."

# What Can AI Do?

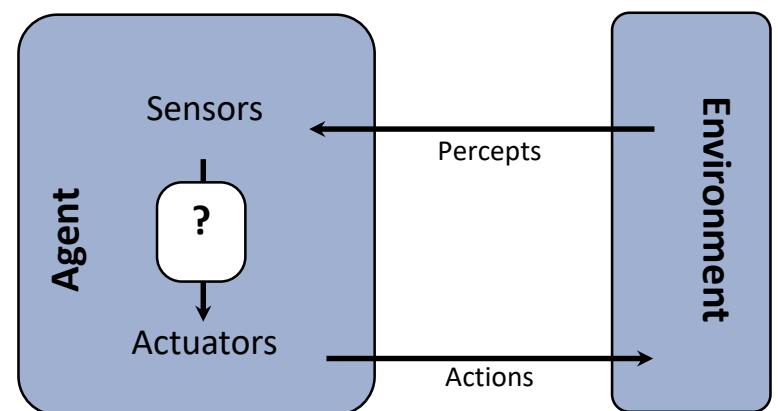
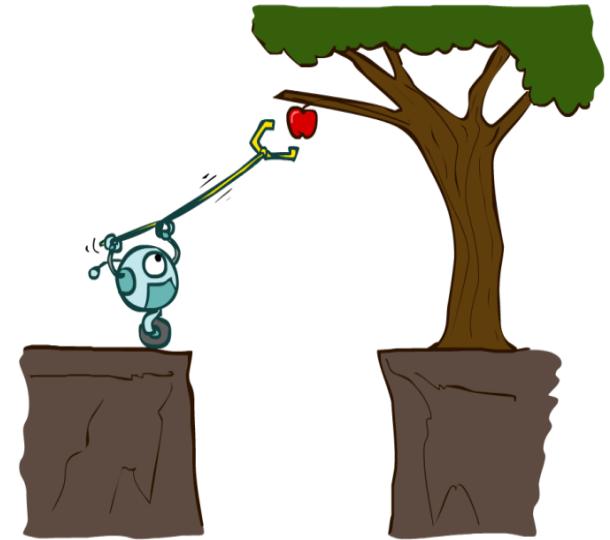
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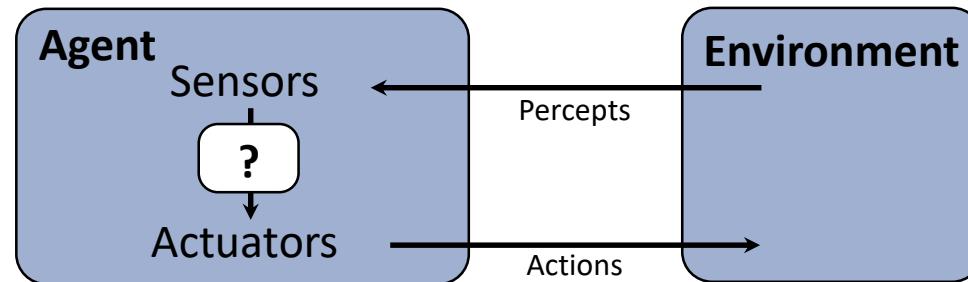
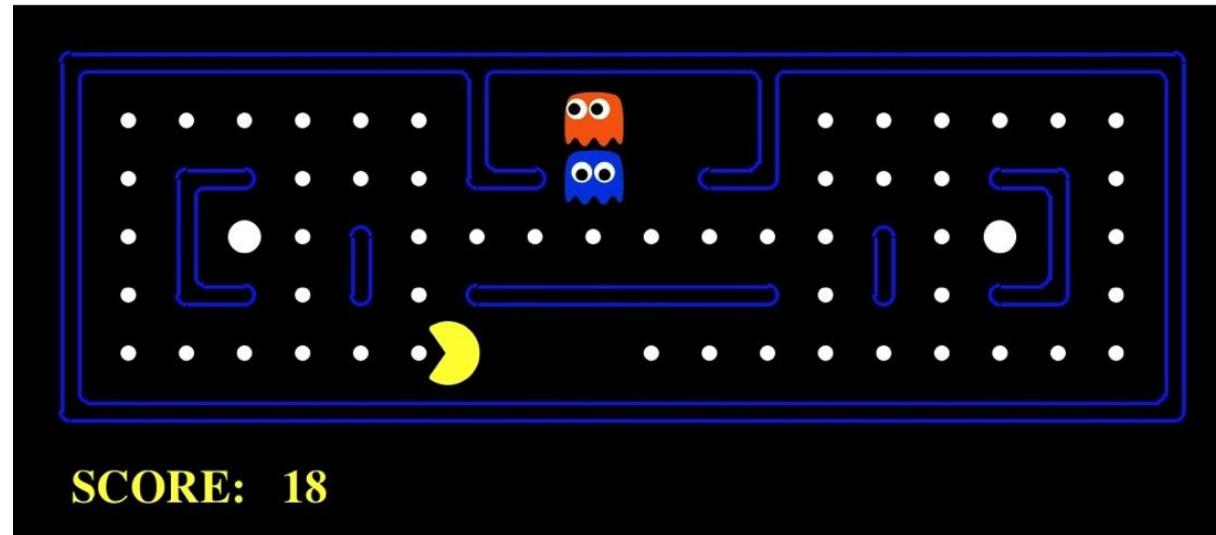


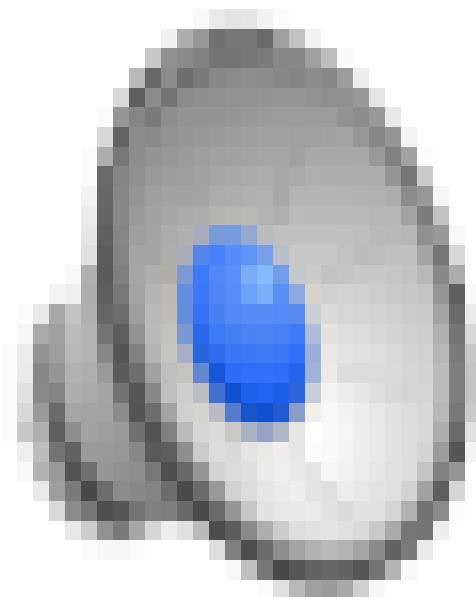
# This Course: Designing Rational Agents

- 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





# Course Topics

## Core Components of Rational Agents:

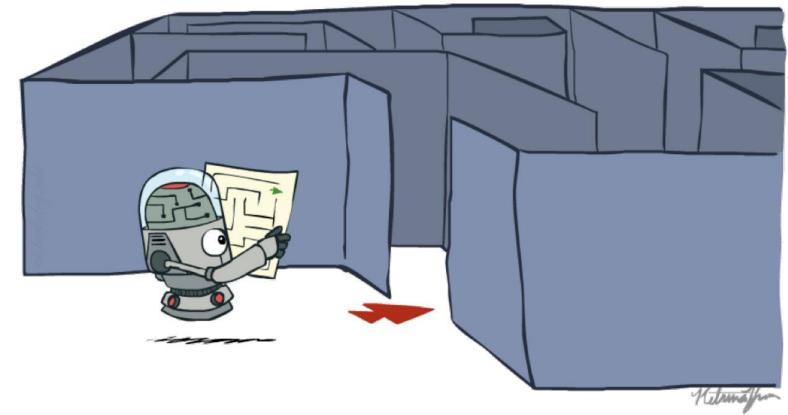
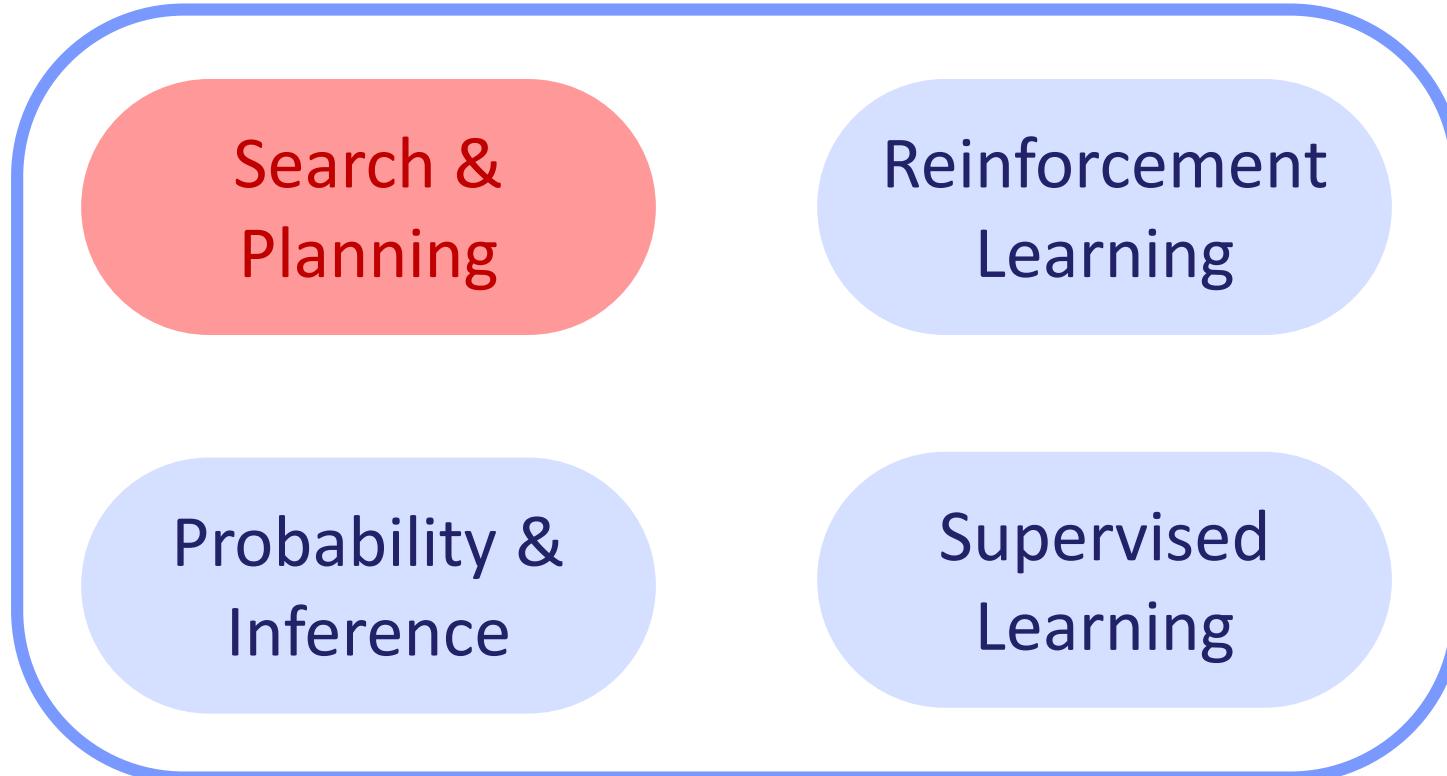
Search &  
Planning

Reinforcement  
Learning

Probability &  
Inference

Supervised  
Learning

# Course Topics



How to find the best *plan* for to solve a problem?

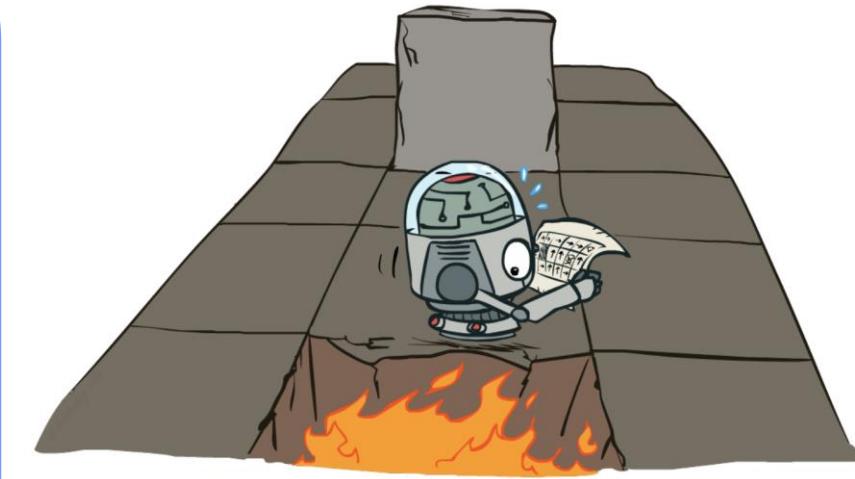
# Course Topics

Search &  
Planning

Reinforcement  
Learning

Probability &  
Inference

Supervised  
Learning



How to learn to best *act* in the world?

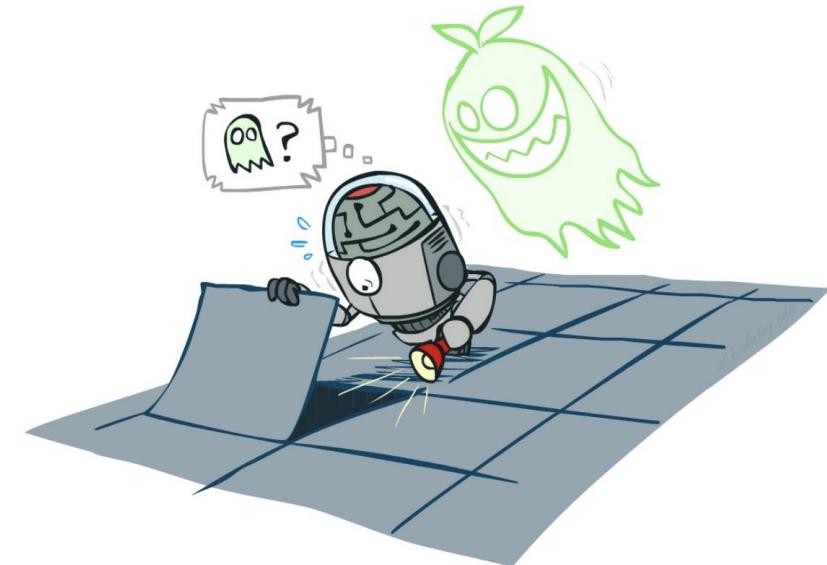
# Course Topics

Search &  
Planning

Reinforcement  
Learning

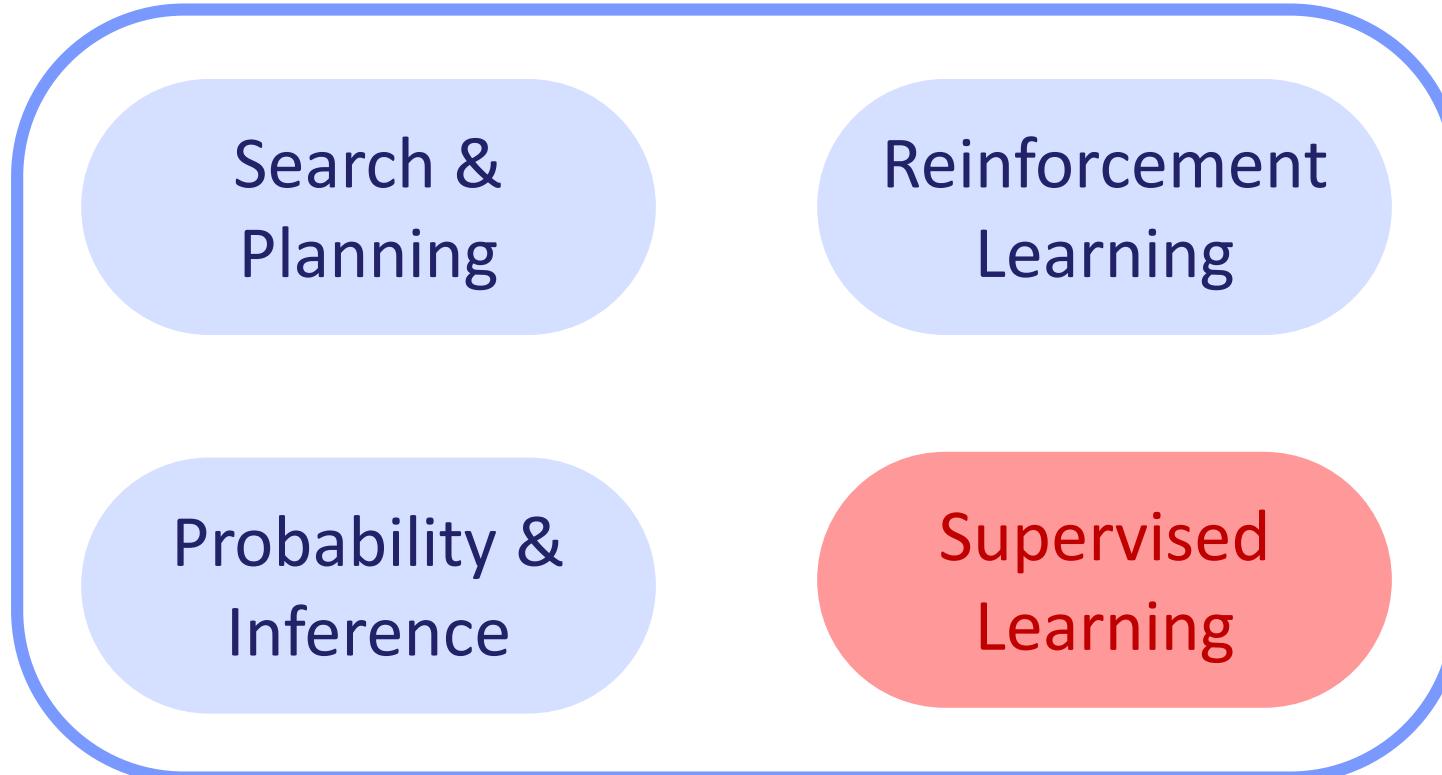
Probability &  
Inference

Supervised  
Learning



How to make sense of *uncertainty* in the world?

# Course Topics



How to learn a *model* of the world from *data*?

# Course Topics

Search &  
Planning

Reinforcement  
Learning

Probability &  
Inference

Supervised  
Learning

Applications

Impact on Sciences, Technology, Society

# Should I take CS 188?

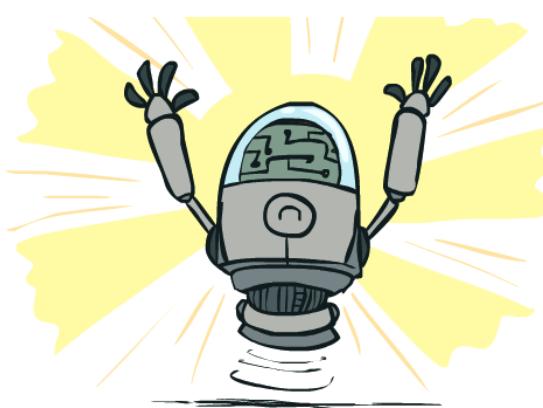
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- Yes, if you want to know how to design rational agents!
  - CS 188 gives you extra mathematical maturity
  - CS 188 gives you a survey of other non-CS fields that interact with AI (e.g. robotics, cognitive science, economics)
- Disclaimer: If you're interested in making yourself more competitive for AI jobs, CS 189 and CS 182 are better fits.
  - The last few CS 188 lectures (neural networks) are used by many modern state-of-the-art systems. CS 189 and CS 182 cover these in more depth

# By the end of this course you'll:

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- Build and understand math of rational, learning agents
- Select and apply the right AI methods for wide range of problems
- Recognize how these methods are used in modern AI systems
- Be prepared to make decisions on how AI is used in society



# Next Week: Search

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