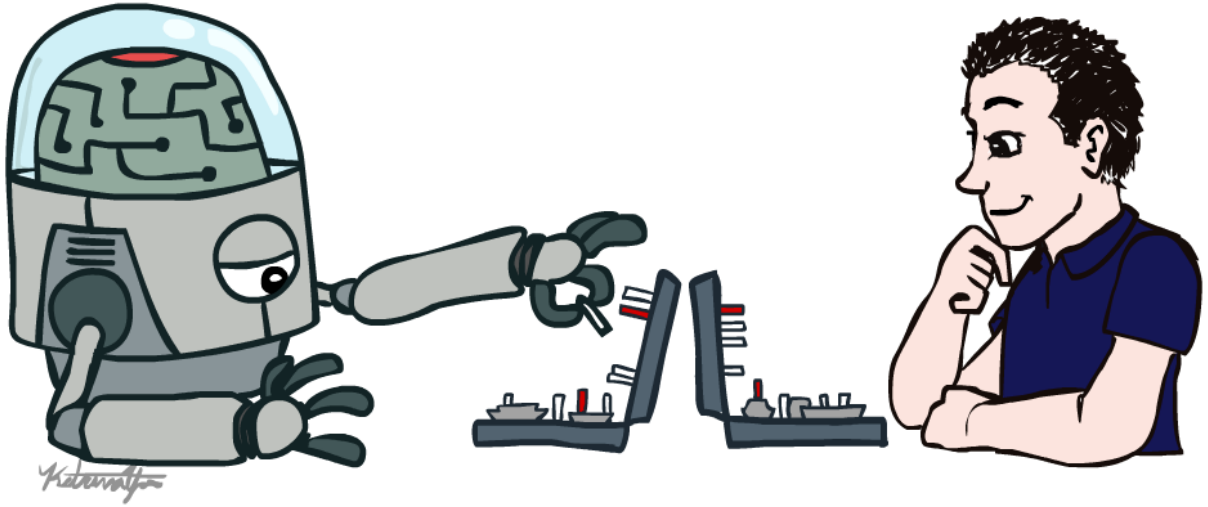
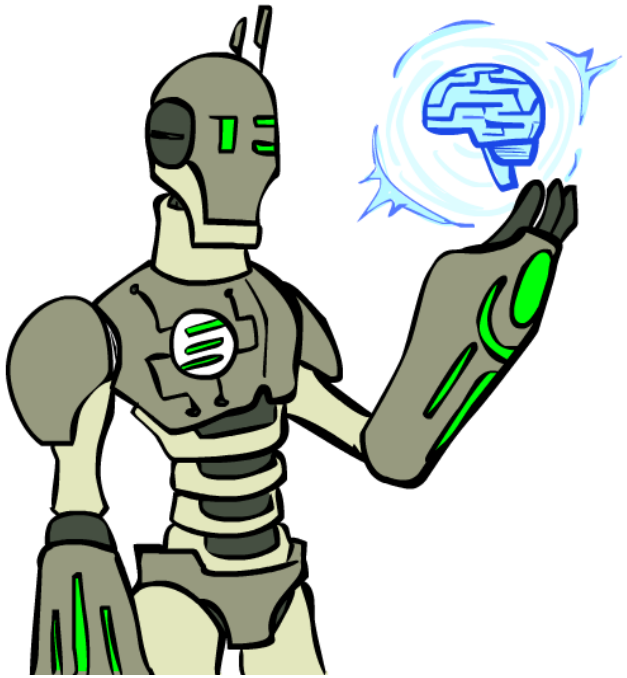
Artificial Intelligence

Introduction



(some material of this introduction © University of California, Berkeley)

What is AI?



Current AI hype is having real-world impact

- Public imagination
  - Text assistants

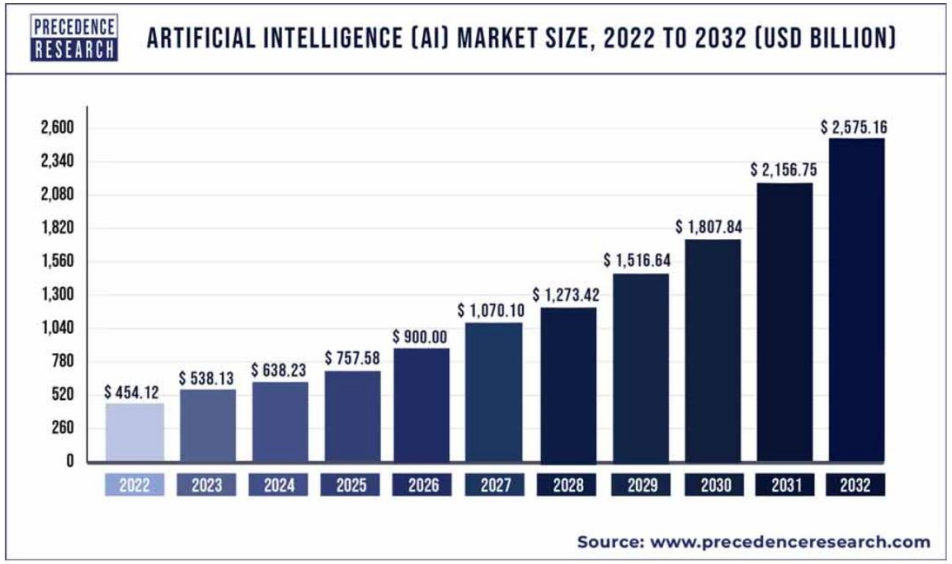
Current AI hype is having real-world impact

- Public imagination
  - Text assistants
  - Image generation

Current AI hype 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

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- Public imagination
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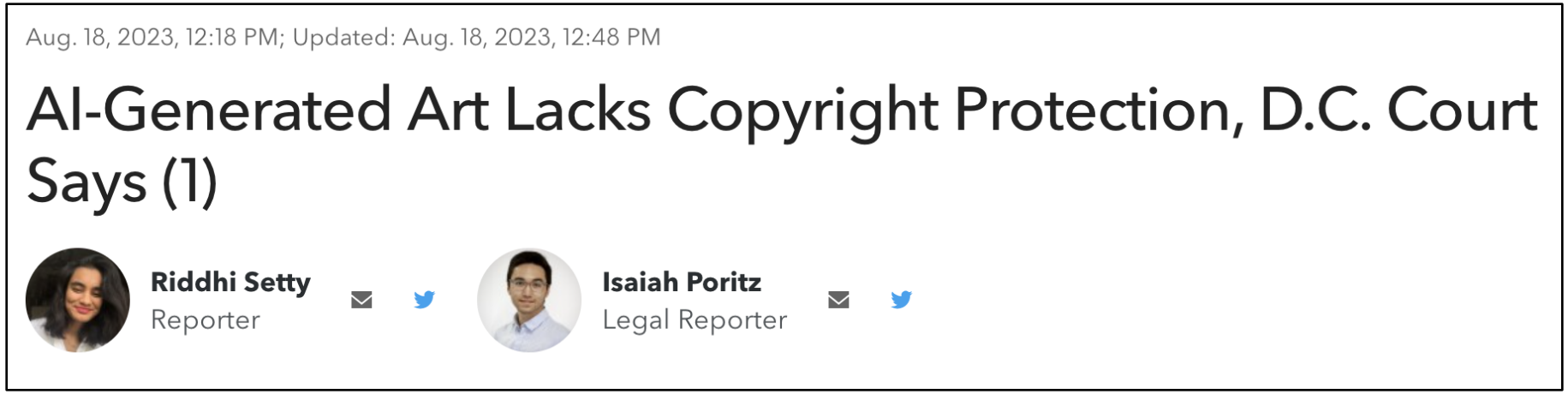
- Politics

Current AI hype 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

Current AI hype 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

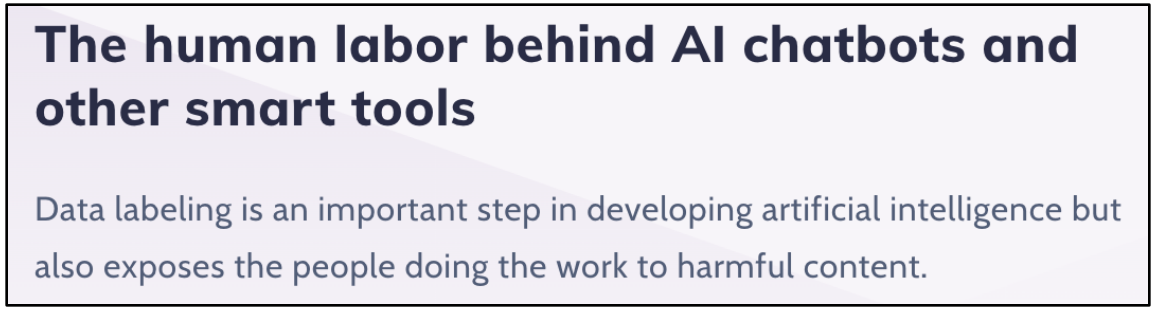
Look beneath the aggregate economic numbers, and change is afoot

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

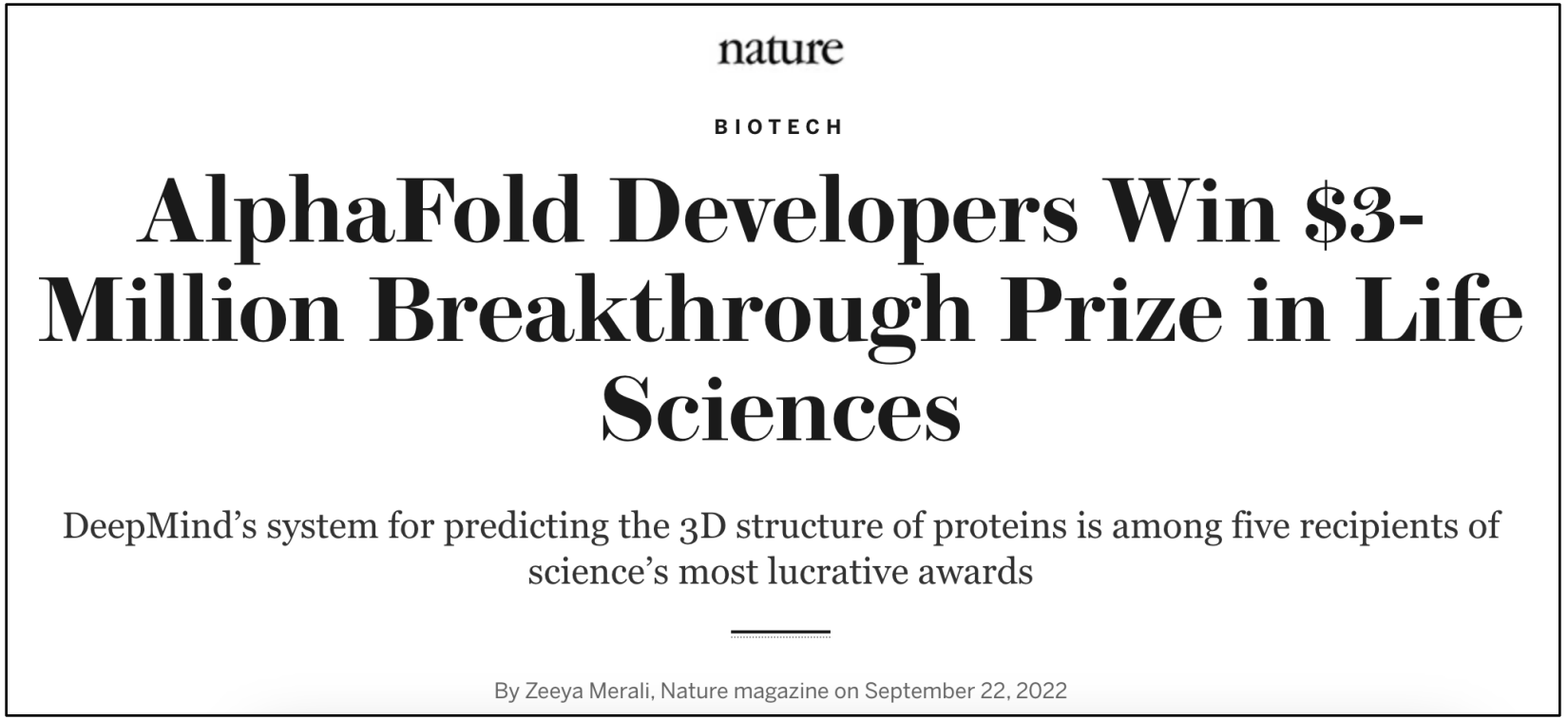

The human labor behind AI chatbots and other smart tools

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

MarketWatch, 2023

Current AI hype 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

Current AI hype is having real-world impact

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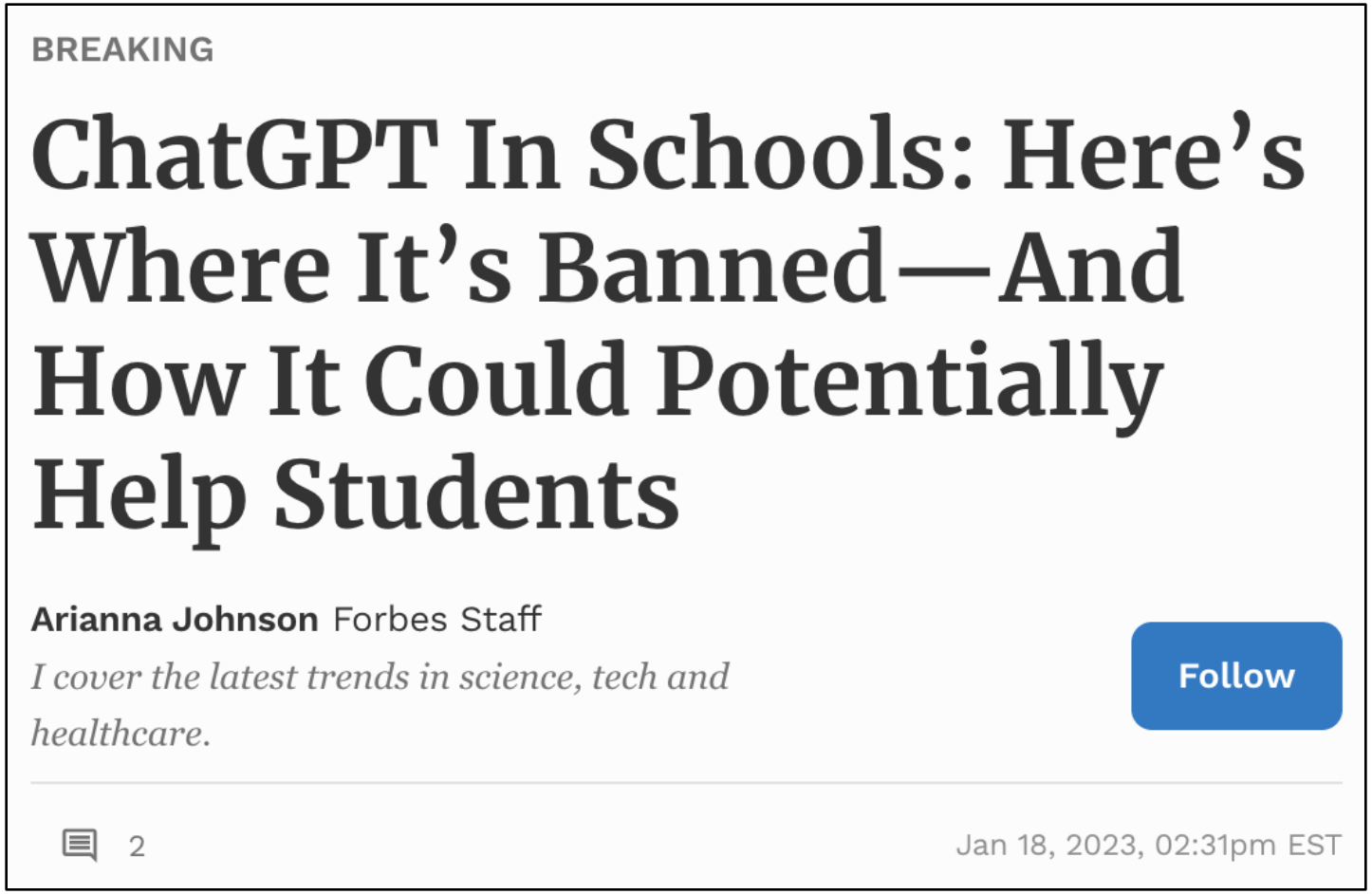
- Politics
- Law
- Labor
- Sciences
- Education



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.

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Jan 18, 2023, 02:31pm EST

Forbes, 2023

Current AI hype is having real-world impact

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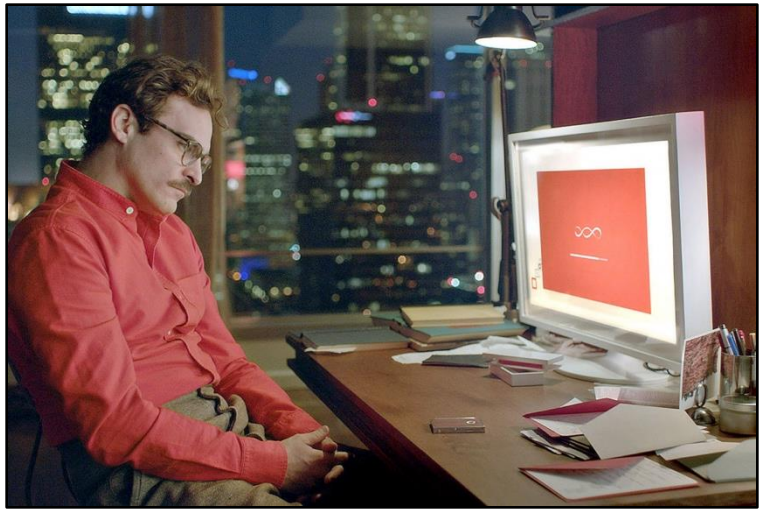
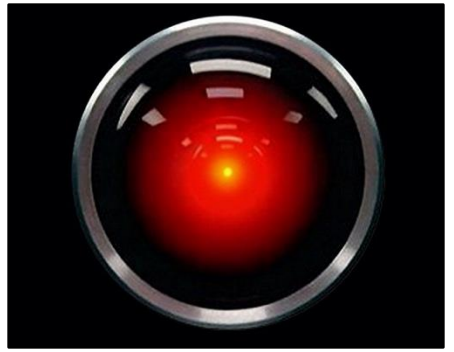
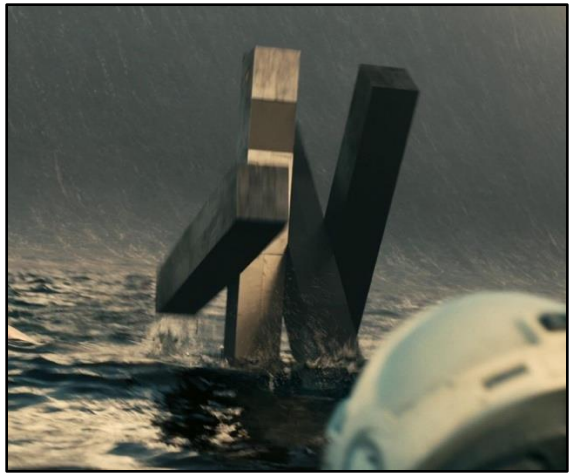
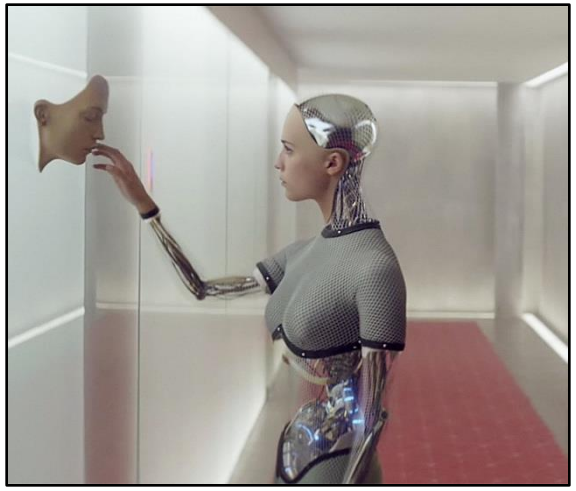
Ok, but what actually is AI???

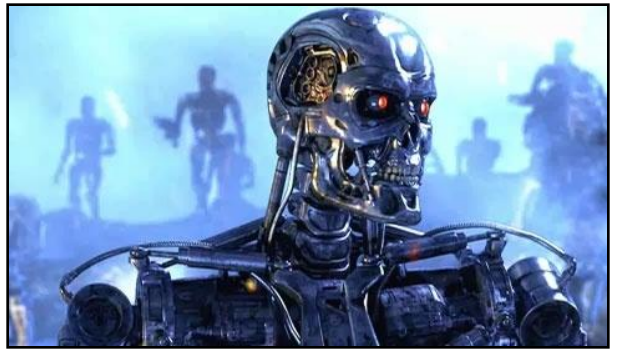
Science fiction AI?





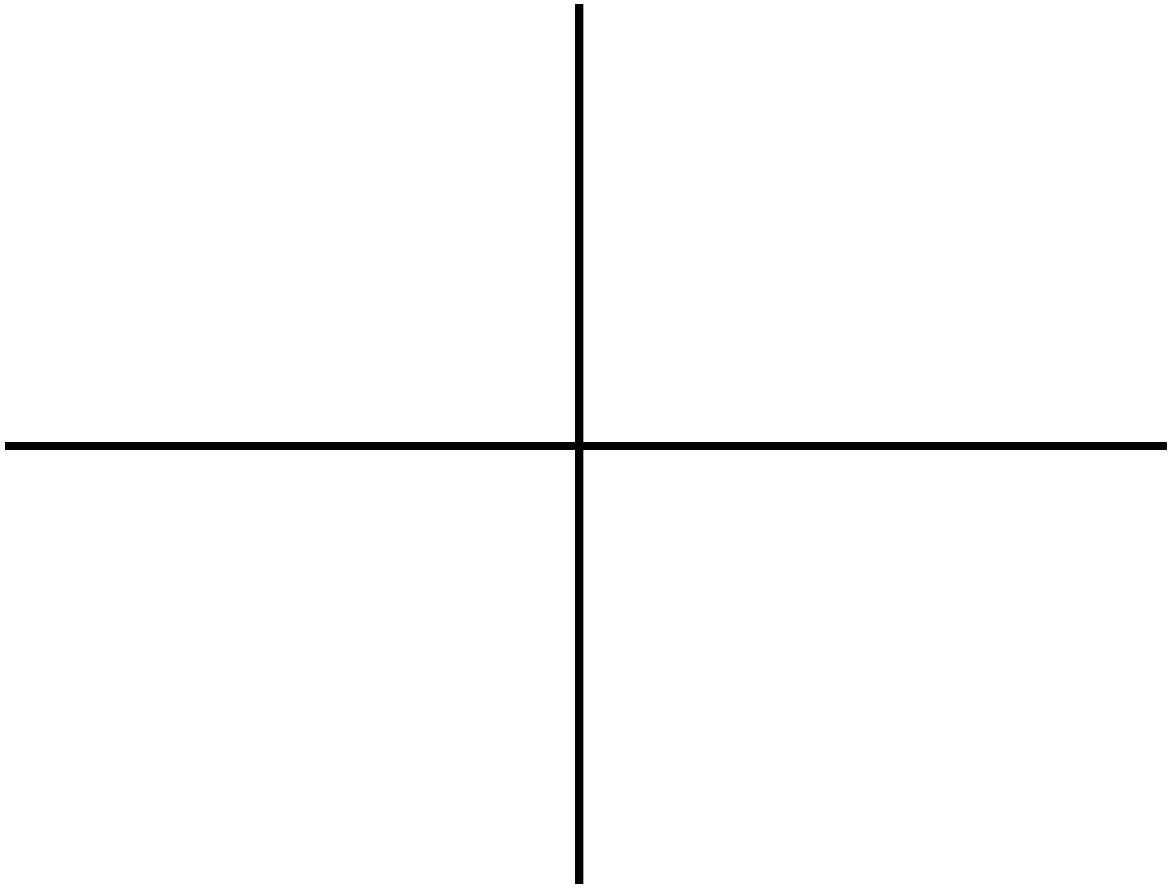






Goal: what should we build?

Should we make machines that…



What is Artificial Intelligence?

- Some definitions that have been proposed
  1. Systems that think like humans
  2. Systems that act like humans
  3. Systems that think rationally
  4. Systems that act rationally

Thinking Like Humans

Model the cognitive functions and behaviors of humans

- Human beings are our best example of intelligence
- We should use that example!

What is Artificial Intelligence?

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Acting Like Humans

- Turing test (1950)
  - operational definition of intelligent behavior
  - Can a human interrogator tell whether (written) responses to her (written) questions come from a human or a machine?
- Systems tend to cheat on these tests…
- Is acting like humans really what we want?
  - Humans often think/act in ways we don't consider intelligent
  - Why?

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Thinking Rationally

- Rationality: an abstract ideal of intelligence, rather than "whatever humans think/do"
  - Ancient Greeks invented syllogisms: argument structures that always yield correct conclusions given correct premises
  - This led to logic, and probabilistic reasoning
- Is rational thought enough?
  - A system that only thinks and doesn't do anything is quite useless
  - Any means of communication would already be an action
  - And it is hard to measure thought in the first place …

Acting Rationally

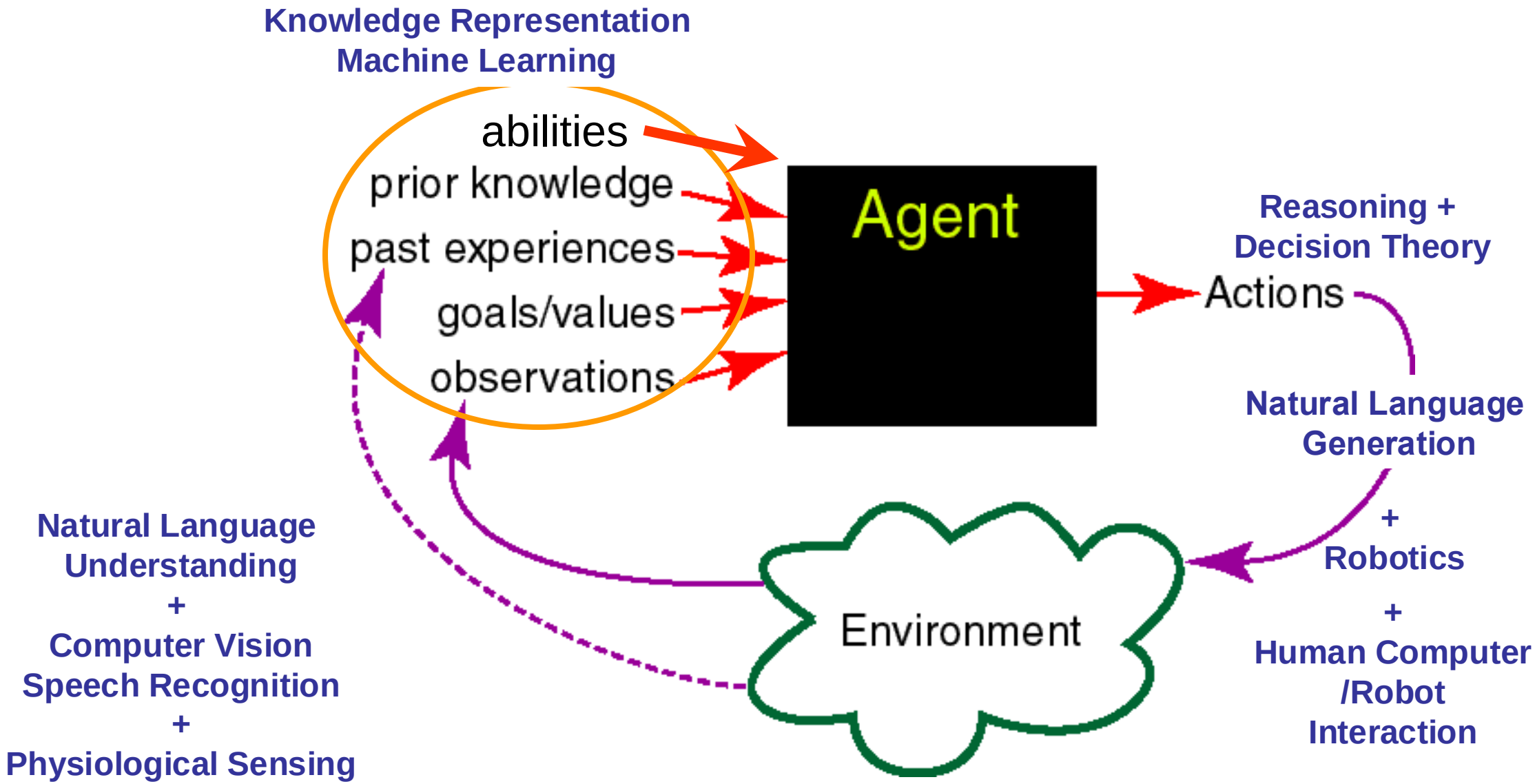
We will emphasize this view of AI

- Rationality is more cleanly defined than human behaviour, so
  - it's a better design objective
  - in cases where human behaviour is not rational, often we'd prefer rationality
    - Example: you wouldn't want a shopping agent to make impulsive purchases!
  - And once we have a rational agent, we can always tweak it to make it irrational!
- It's easier to define rational action than rational thought

AI as Study and Design of Intelligent Agents

- Intelligent agents: universal artifacts that **act** **rationally** in their environment
  - They are universal because their behaviour is characterized only by declarative knowledge
  - Their actions are appropriate for their goals and circumstances
  - There are flexible to changing environments and goals
  - They learn from experience
  - They make appropriate choices given perceptual limitations and limited resources
- This definition drops the constraint of *cognitive plausibility*
  - Same as building flying machines by understanding general principles of flying (aerodynamic) vs. by reproducing how birds fly

Intelligent Agents in the World



Computational Agents

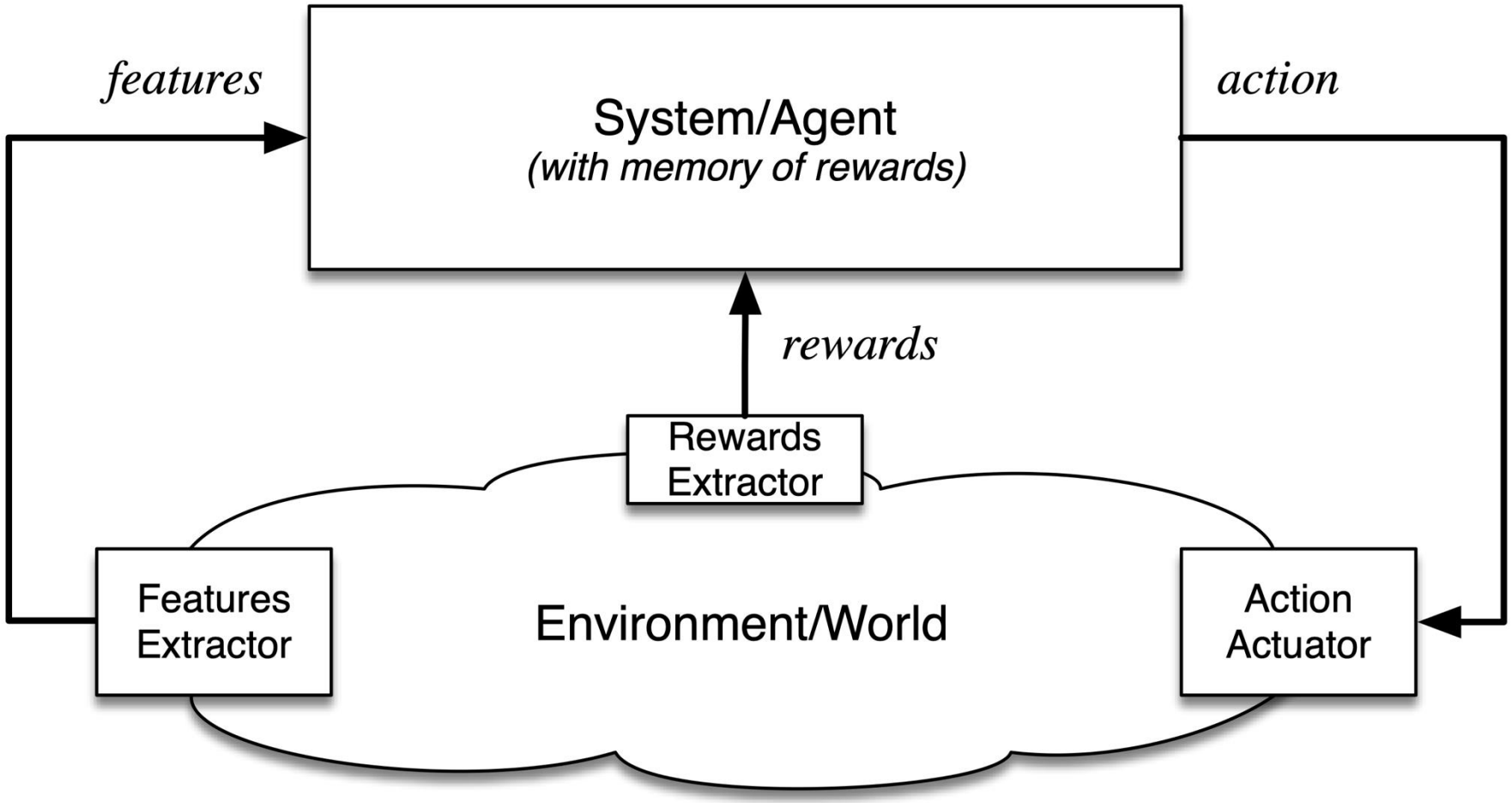
- A computational agent is an agent whose decisions about its actions can be explained in terms of computation.

- The decisions can be broken down into primitive operations that can be implemented in a physical device.

Robots vs. Other Intelligent Agents

- In AI, artificial agents that have a physical presence in the world are known as robots
  - Robotics is the field concerned with the implementation of the physical aspects of a robot
    - They are called *embodied agents*
    - I.e., perception of and action in the physical environment
    - Sensors and actuators
- Agents without a physical presence: software agents
  - E.g. desktop assistants, decision support systems, web crawlers, text-based translation systems, intelligent tutoring systems, etc
  - They also interact with an environment, but not the physical world
- Software agents and robots
  - differ in their interaction with the environment
  - share all other fundamental components of intelligent behavior

Reinforcement Learning

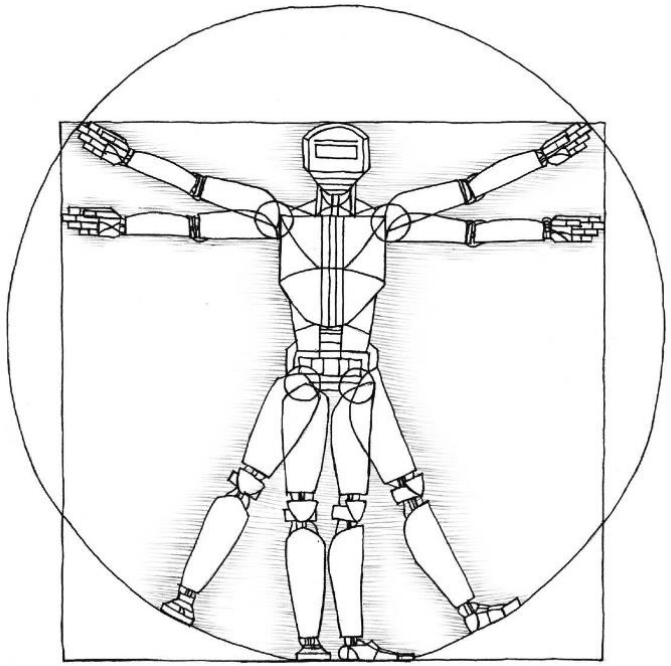


Other perspectives on Intelligence

- Skills-based perspective
- “A system is only intelligent if it can do [X].”
  - Play chess?
  - Learn from experience?
  - Use words properly?
  - Make mistakes?
  - Not make mistakes?

Other perspectives on Intelligence

- Embodiment perspective (Rodney Brooks)
- Ground-up hierarchy of behaviors, start with a body and build layers of complexity from there.

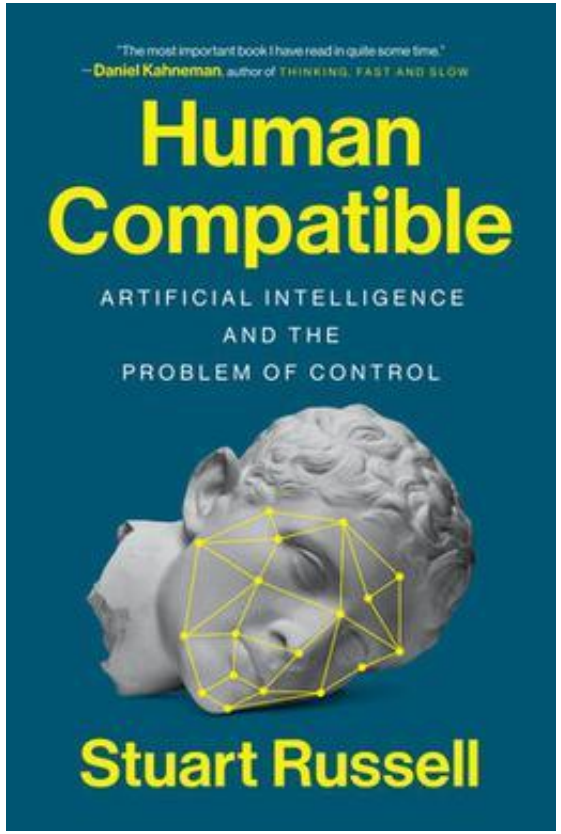


Other perspectives on Intelligence

- Psychometrics perspective (François Chollet)
- “Measuring abilities, not skills […] across a broad range of tasks, including tasks that were previously unknown to the ability-enabled system and its developers.”

Other perspectives on Intelligence

- Human-compatible perspective (Stuart Russell)



1. Machine's objective is to maximize human utility.
2. Initially uncertain about human preferences.
3. Must learn about preferences from human behavior.

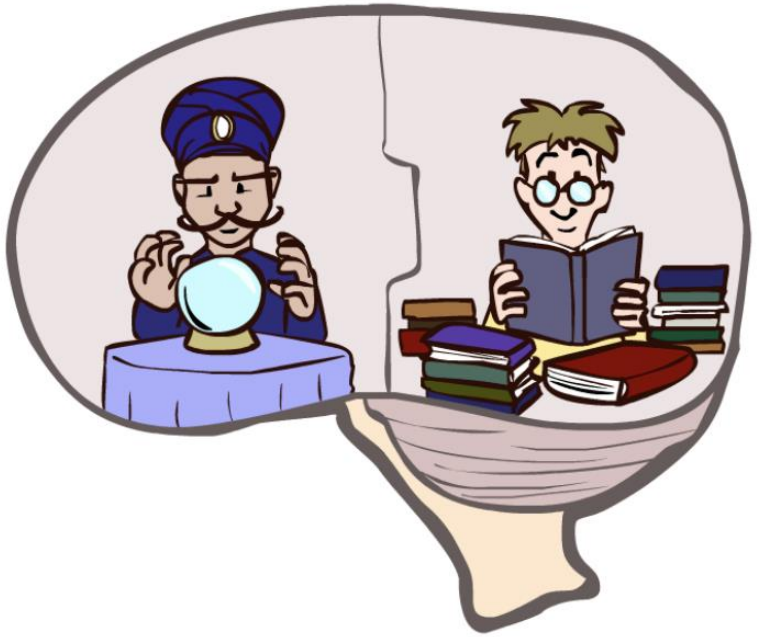
Other perspectives on Intelligence

A human being should be able to change a diaper, plan an invasion, butcher a hog, conn a ship, design a building, write a sonnet, balance accounts, build a wall, set a bone, comfort the dying, take orders, give orders, cooperate, act alone, solve equations, analyze a new problem, pitch manure, program a computer, cook a tasty meal, fight efficiently, die gallantly. Specialization is for insects.

—Robert A. Heinlein
American science fiction author

What About the Brain?

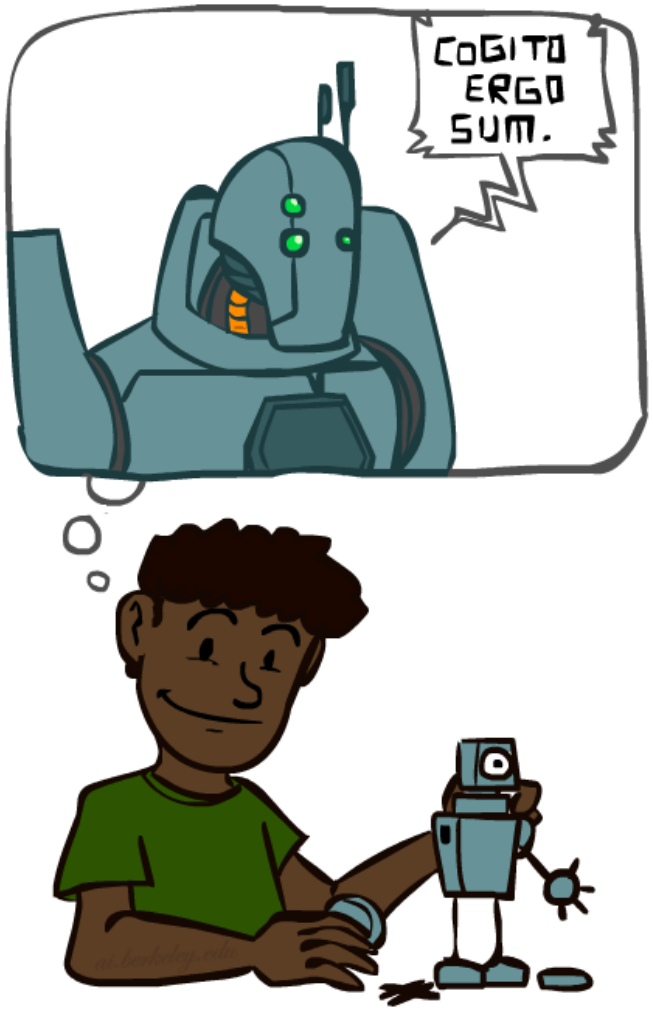
- Brains (human minds) are very good at making rational decisions, but not perfect
- Brains aren't as modular as software, so hard to reverse engineer!
- AI may be better than brains at some tasks
- *"Brains are to intelligence as wings are to flight"*
- We can't yet build AI on the scale of the brain
  - ~100T synapses in the human brain vs ~1.8T weights in GPT4
- Still, the brain can be a great inspiration for AI!



A (Short) History of AI

- 1940-1950: Early days: neural and computer science meet
  - 1943: McCulloch & Pitts: Perceptron–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

*"We propose that a **2-month, 10-man study of artificial intelligence** be carried out **during the summer of 1956** at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that **every aspect of learning** or **any other feature of intelligence** can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. **We think that a significant advance can be made** in one or more of these problems if a carefully selected group of scientists work on it together for a summer."*



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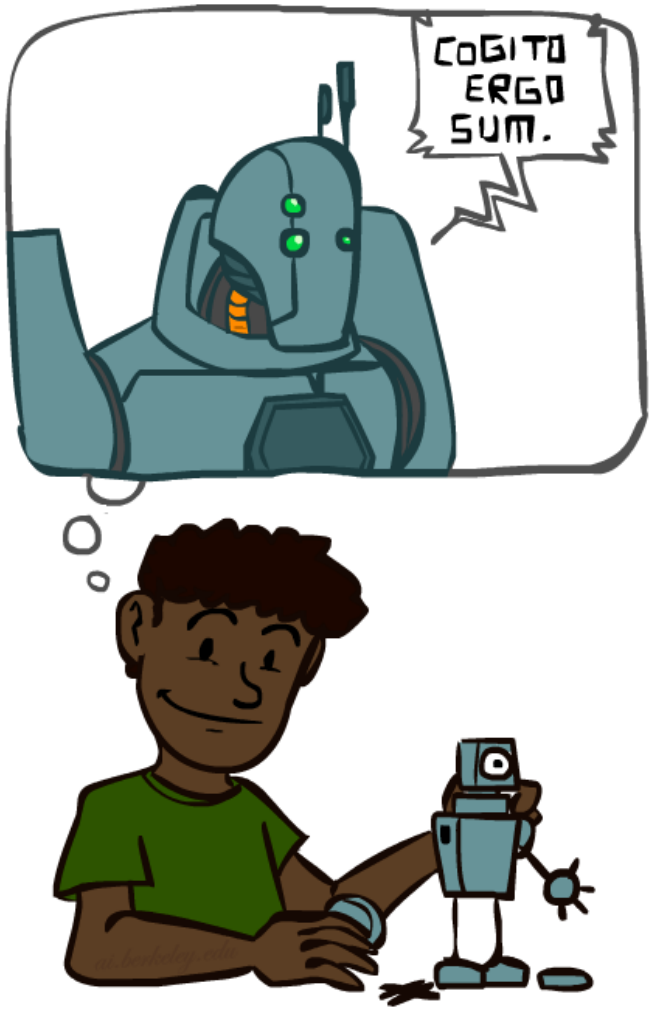
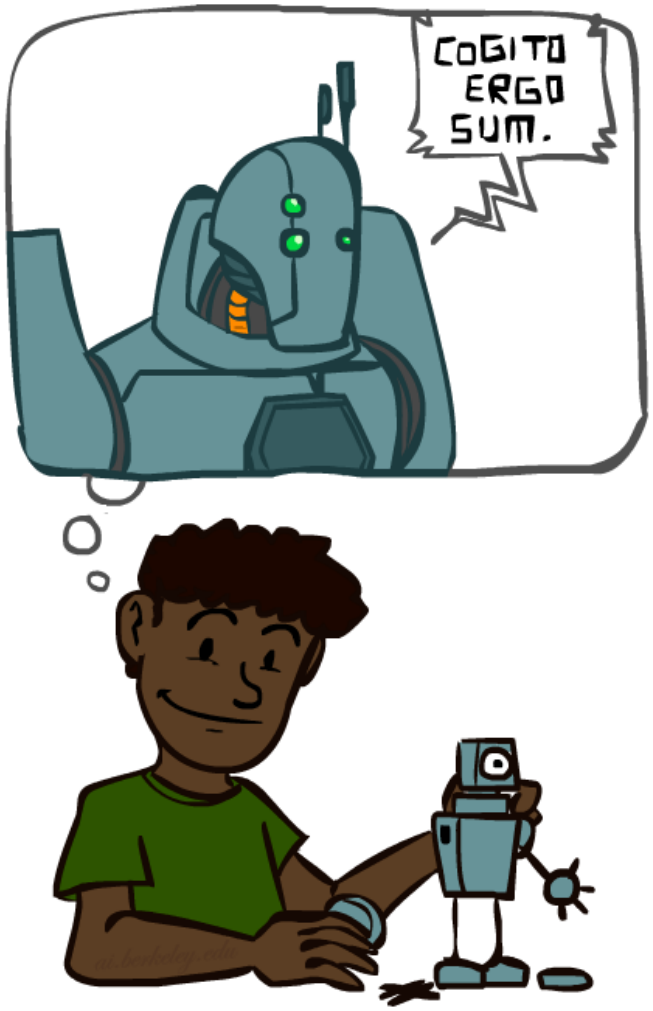
  - 1956: Dartmouth meeting: “Artificial Intelligence” adopted
  - 1969: Minsky & Papert: perceptrons can’t learn XOR/parity!
- 1970—90: Knowledge-based approaches
  - 1969—79: Early development of knowledge-based systems
  - 1980—88: Expert systems industry booms; backpropagation makes it feasible to train multi-layer neural networks
  - 1988—93: Expert systems industry busts: “AI Winter”
- 1990—2010: Statistical approaches, agents
  - Resurgence of probability, focus on uncertainty
  - Agents and learning systems… “AI Spring”?
  - 1992: TD-Gammon achieves human-level play at backgammon
  - 1997: Deep Blue defeats Gary Kasparov at chess
  - 2002: Embodied AI; Roomba vacuum invented



A (Short) History of AI

- 2010—2017: Big Data, GPUs, Deep Learning
  - 2011: Apple releases Siri
  - 2012: AlexNet wins ImageNet competition
  - 2015: DeepMind achieves “human-level” control in Atari games
  - 2016: DeepMind’s AlphaGo defeats Lee Sedol at Go
  - 2016: Google Translate migrates to neural networks
- 2017—: Scaling Up, Large Language Models
  - 2017: Google invents Transformer architecture
  - 2017: DeepStack/Libratus defeat humans at poker
  - 2018-2020: AlphaFold predicts protein structure from amino acids
  - 2021-2022: Modern text-to-image generation
  - 2022: OpenAI releases ChatGPT
  - 2023: Every other company also releases a chatbot



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?
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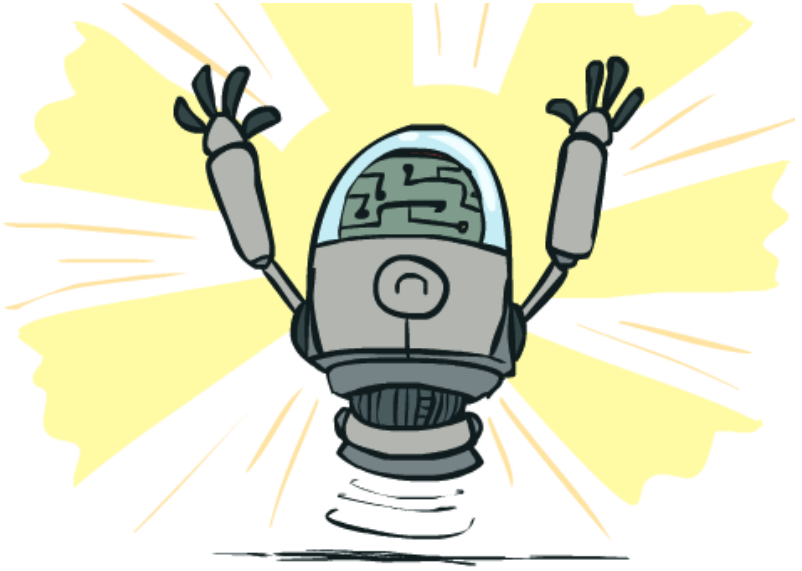
- Discover and prove a new mathematical theorem?
- Perform a surgical operation?
- Translate spoken Chinese into spoken English in real time?
- Win an art competition?
- Write an intentionally funny story?
- Construct a building?



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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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California just opened the floodgates for self-driving cars

After a state regulatory board ruling, San Francisco will have 24/7 robotaxis on its streets. A Washington Post analysis shows how it's a pivotal moment for the industry.

By Trisha Thadani and Jeremy B. Merrill

Updated August 10, 2023 at 10:06 p.m. EDT | Published August 10, 2023 at 9:15 p.m. EDT

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

Jude Karabus

Mon 21 Aug 2023 // 14:28 UTC

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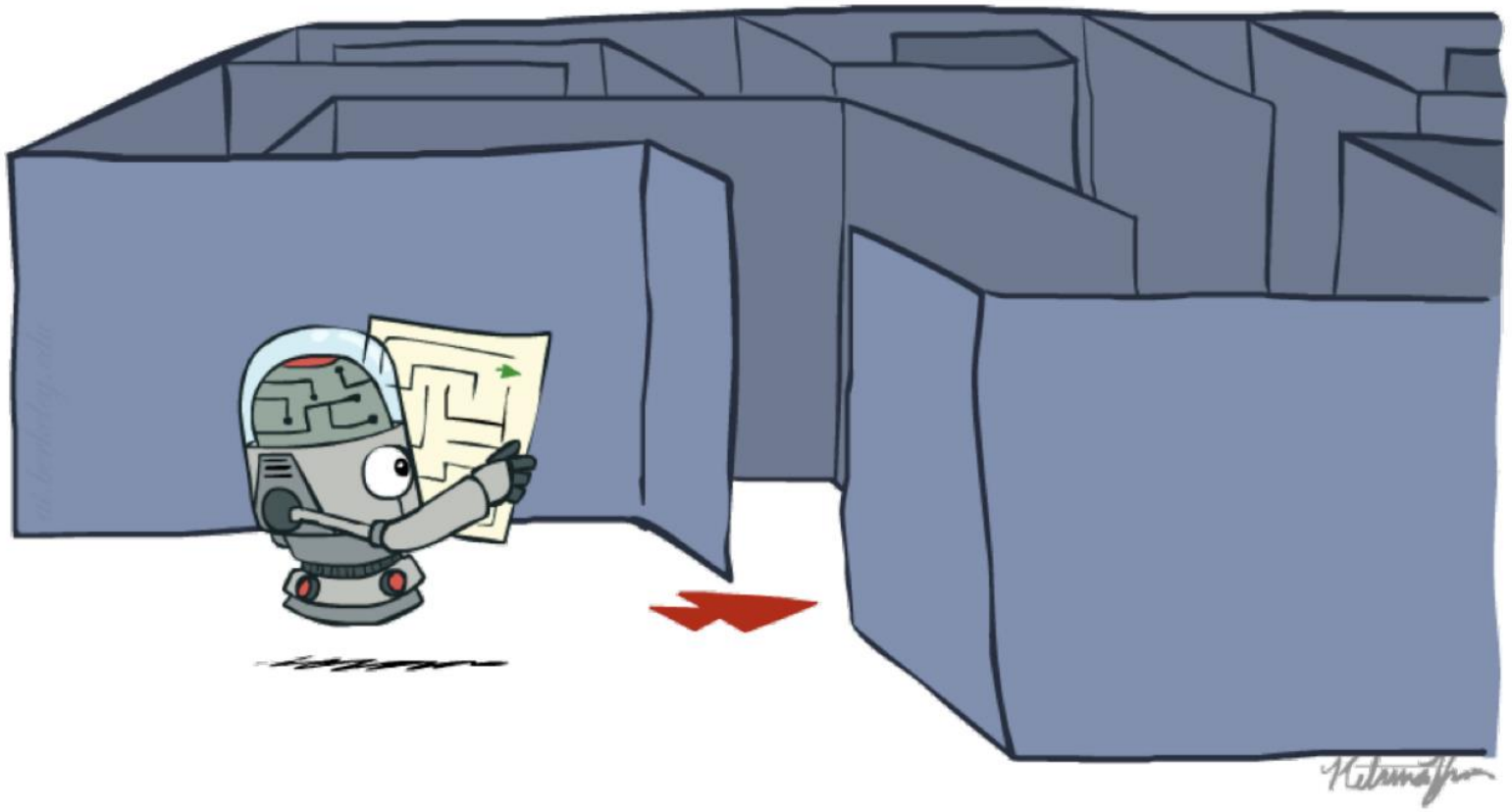
Classical Programming vs AI

- **Classical programming**:
  - Input + Program  Results
- **Artificial Intelligence**:
  - Data + Knowledge + Goal  Program

How do we implement all this: Search



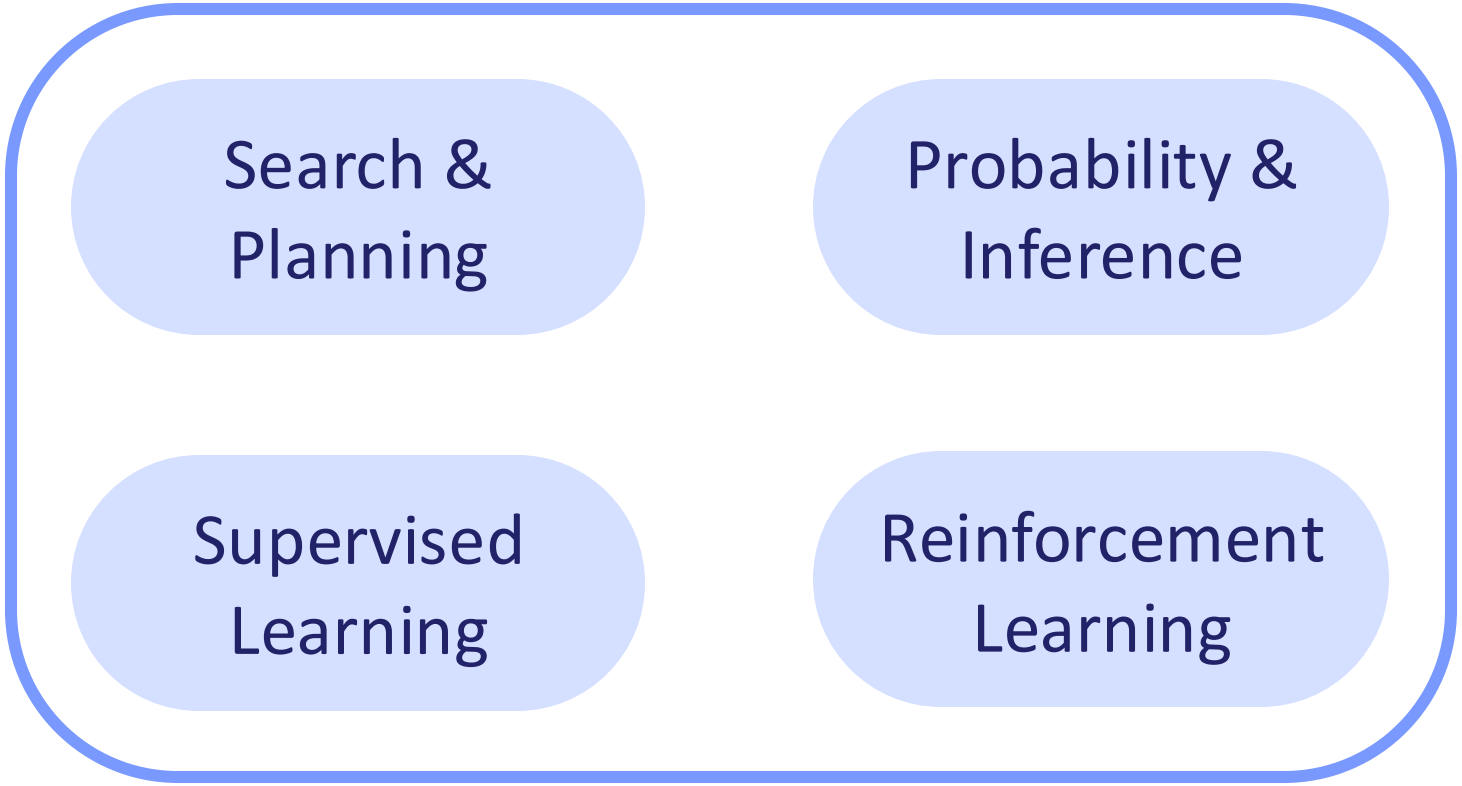
Search

Changing random stuff
until your program works is
"hacky" and "bad coding practice".

But if you do it fast enough it is
"Artificial Intelligence"
and pays 4x your current salary.

Rational Agents blocks

Core Components of Rational Agents:



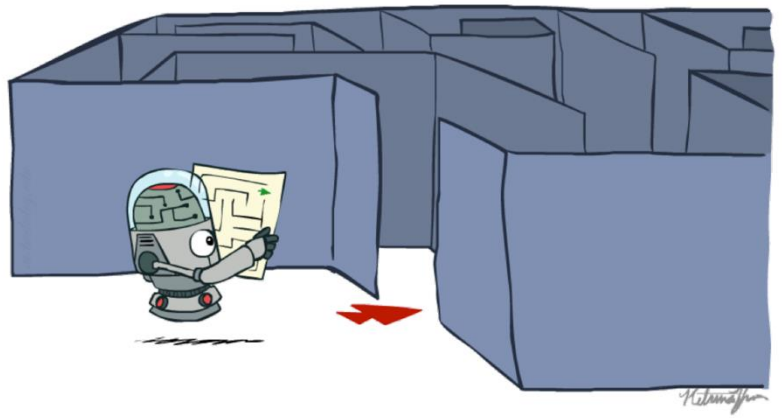
Rational Agents blocks

Search & Planning

Probability & Inference

Supervised Learning

Reinforcement Learning



How can I use my ***model*** of the world to find a ***sequence of actions*** to achieve my ***goal***?

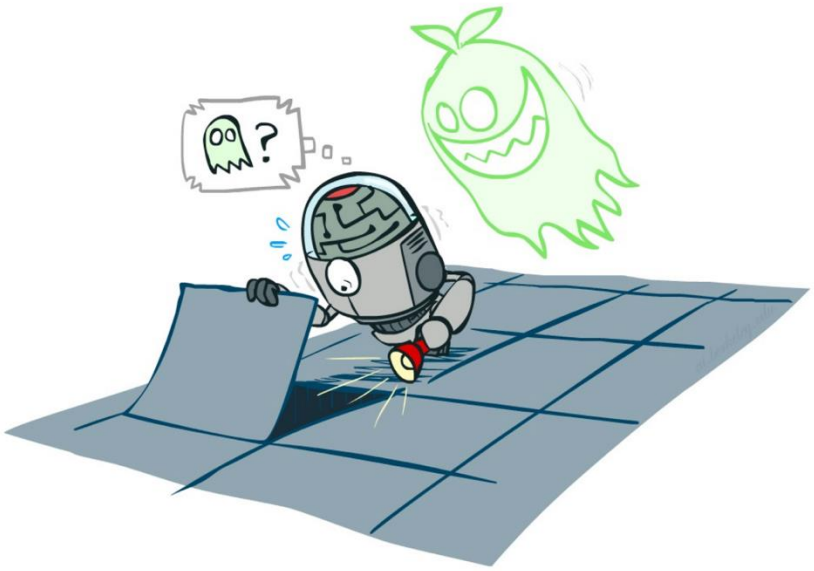
Rational Agents blocks

Search & Planning

Probability & Inference

Supervised Learning

Reinforcement Learning



How can I make sense of ***uncertainty***?

Rational Agents blocks

Search & Planning

Probability & Inference

Supervised Learning

Reinforcement Learning

How can I learn a ***model*** of the world from ***data***?

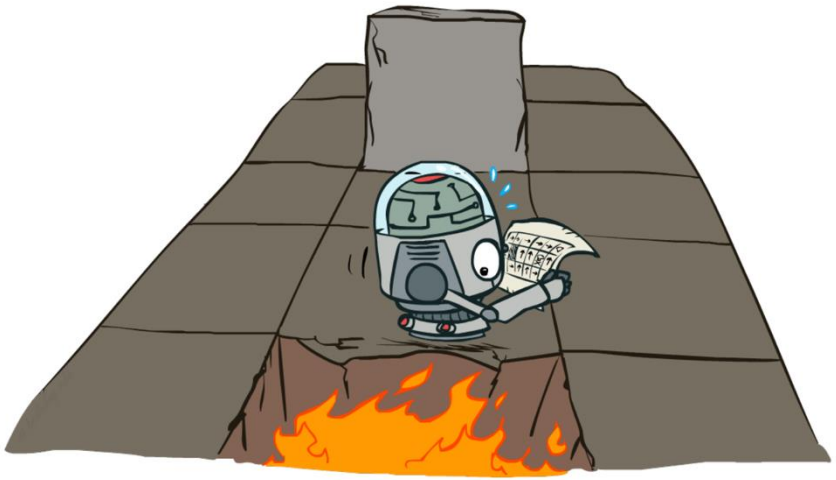
Rational Agents blocks

Search & Planning

Probability & Inference

Supervised Learning

Reinforcement Learning



How can I learn a ***policy*** for any situation so that I can ***maximize utility***?

References

- Main book:
  - David Poole and Alan Mackworth,
    Artificial Intelligence: Foundations of Computational Agents,
    Cambridge University Press
    Fully available online at: https://artint.info
- Additional reference:
  - Stuart Jonathan Russell and Peter Norvig,
    Artificial Intelligence: A Modern Approach,
    Prentice Hall