Budapesti University of Technology and Economics
Department of Measurement and Information Systems

Artificial intelligence – VIMIAC10&16-EN

https://www.mit.bme.hu/eng/eng/node/9670/resources

2024 Fall Semester

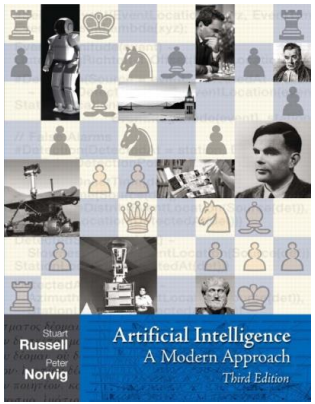
Dr. Gábor Hullám

Some slides were adapted from Berkeley CS188, from Dan Klein and Pieter Abbeel http://ai.berkeley.edu

MŰEGYETEM 1782

Textbook

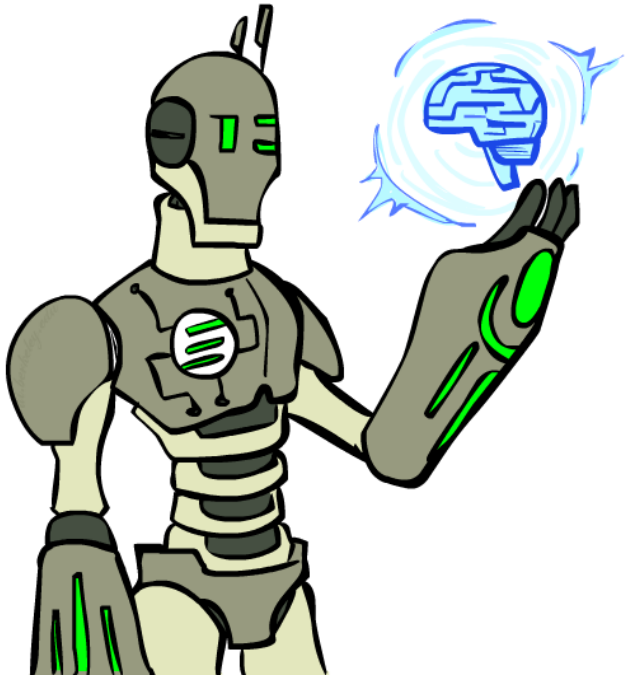
- Not required, but for students who want to read more we recommend
  - Russell & Norvig, AI: A Modern Approach, 4th Ed.



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

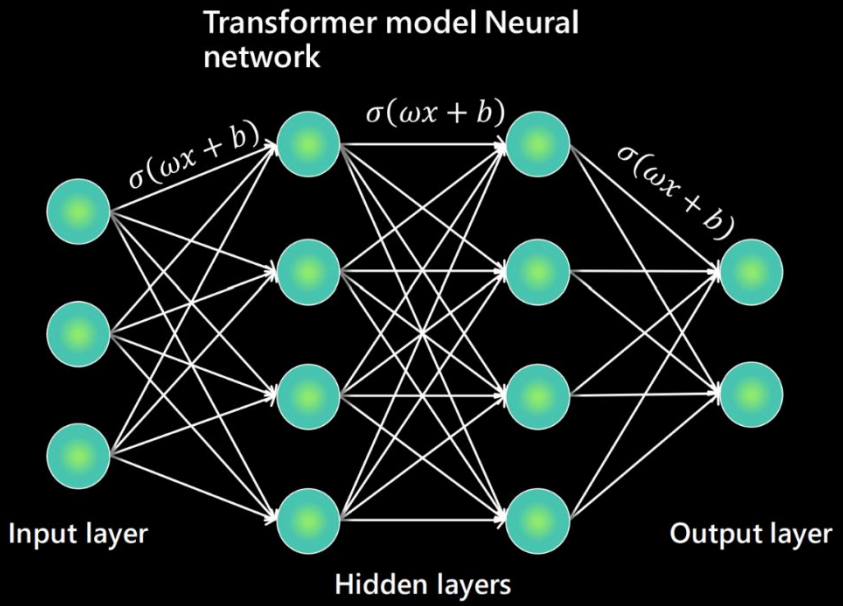
Today

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



LLM - GPT

How large are they?



BERT Large - 2018
345M

GPT2 - 2019
1.5B

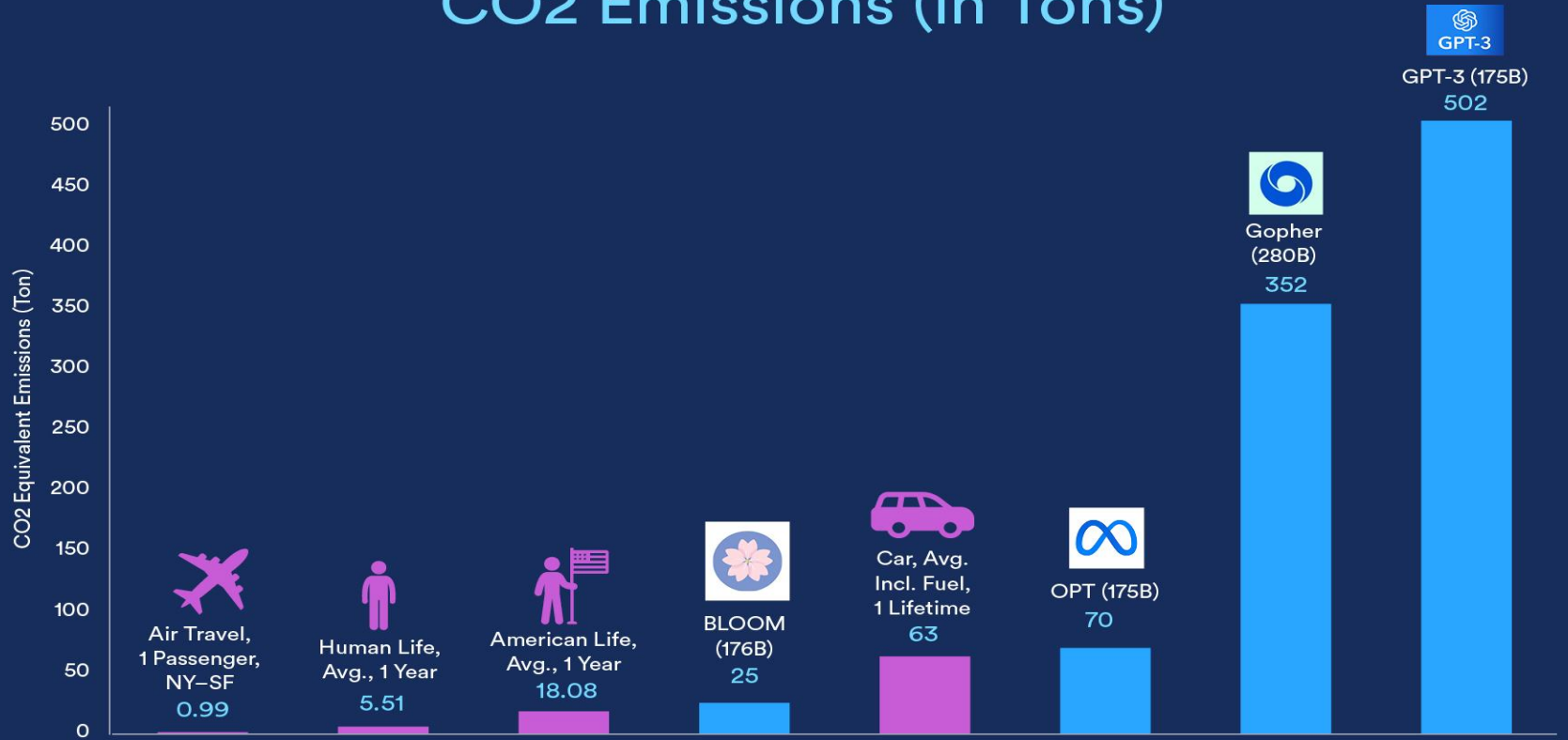
GPT3 - 2020
175B

Turing Megatron NLG 2021
530B

GPT4 – 2023
1.4T (estimated)

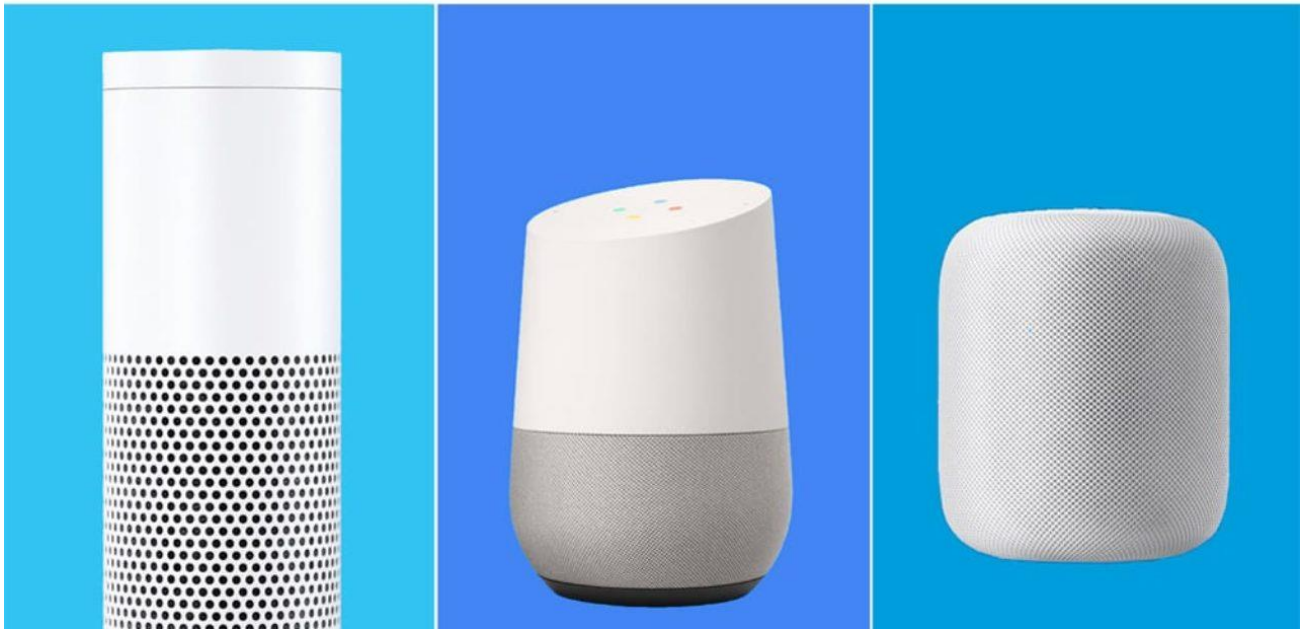
https://microsoft.github.io/Workshop-Interact-with-OpenAI-models/llms/

CO2 Emissions (in Tons)



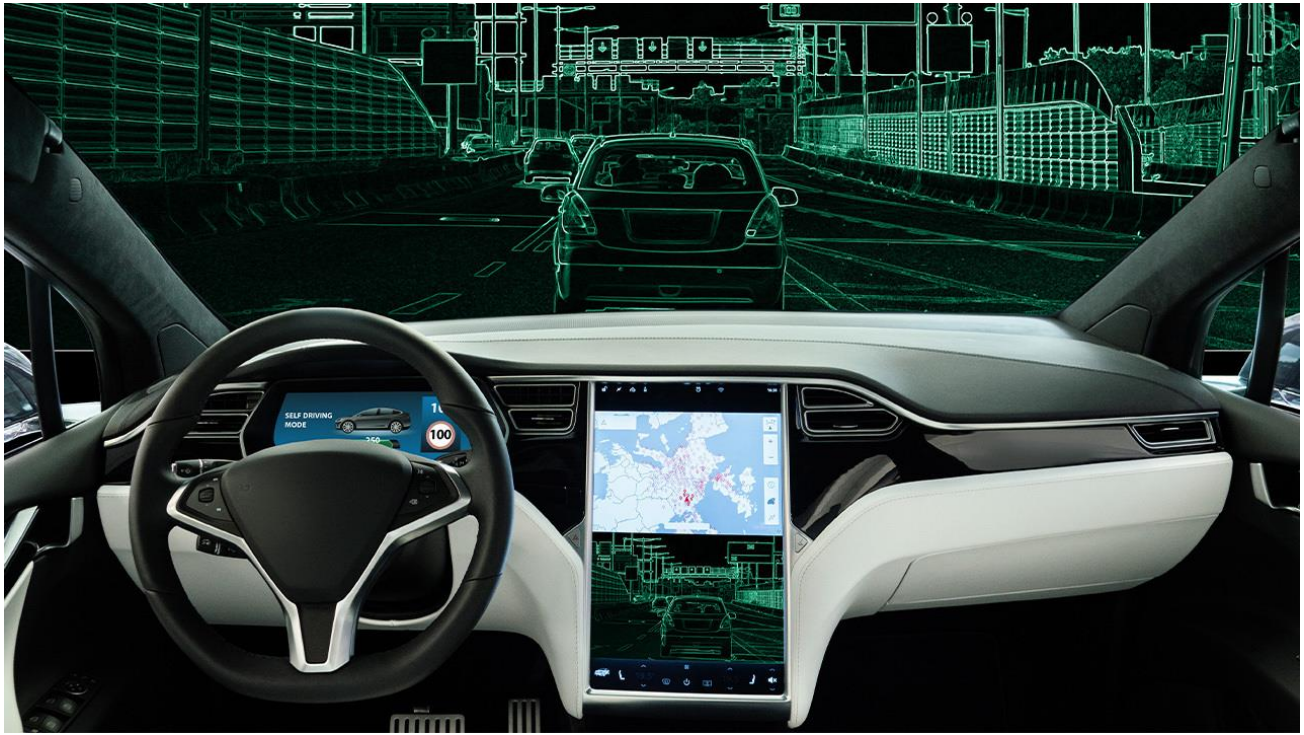
Source: Luccioni et al., 2022; Strubell et al., 2019 | Chart: 2023 AI Index Report

Alexa/Siri/Google assistant



https://www.hellotech.com/blog/alexa-vs-google-vs-siri

ADAS - **Advanced driver-assistance systems**



https://www.pcmag.com/opinions/sorry-elon-fully-autonomous-tesla-vehicles-will-not-happen-anytime-soon

http://www.care-o-bot.de/en/care-o-bot-3.html

Fraunhofer Institute for Manufacturing Engineering and Automation IPA

Computational power: human bain vs supercomputer

	Frontier supercomputer (June 2020)	Human brain
Speed	1.102 exaFLOPS	~1 exaFLOPS (estimate)
Power requirements	21 MW	10–20 W
Dimensions	680 m^2 (7,300 sq ft)	1.3–1.4 kg (2.9–3.1 lb)
Cost	$600 million	Not applicable
Cabling	145 km (90 miles)	850,000 km (528,000 miles) of axons and dendrites
Memory	75 TB/s read; 35 TB/s write; 15 billion IOPS flash storage system, along with the 700 PB Orion site-wide Lustre file system	2.5 PB (petabyte)
Storage	58 billion transistors	125 trillion synapses, which can store 4.7 bits of information each

The Hewlett Packard Enterprise Frontier, or OLCF-5, is the world's first exascale supercomputer, hosted at the Oak Ridge Leadership Computing Facility (OLCF) in Tennessee. It is compared here with the human brain. For sources see (6–11).

https://www.brownstoneresearch.com/bleeding-edge/the-power-of-the-human-brain/

https://bgr.com/general/power-of-the-human-brain-vs-super-computer/

Computational power vs „brainpower”

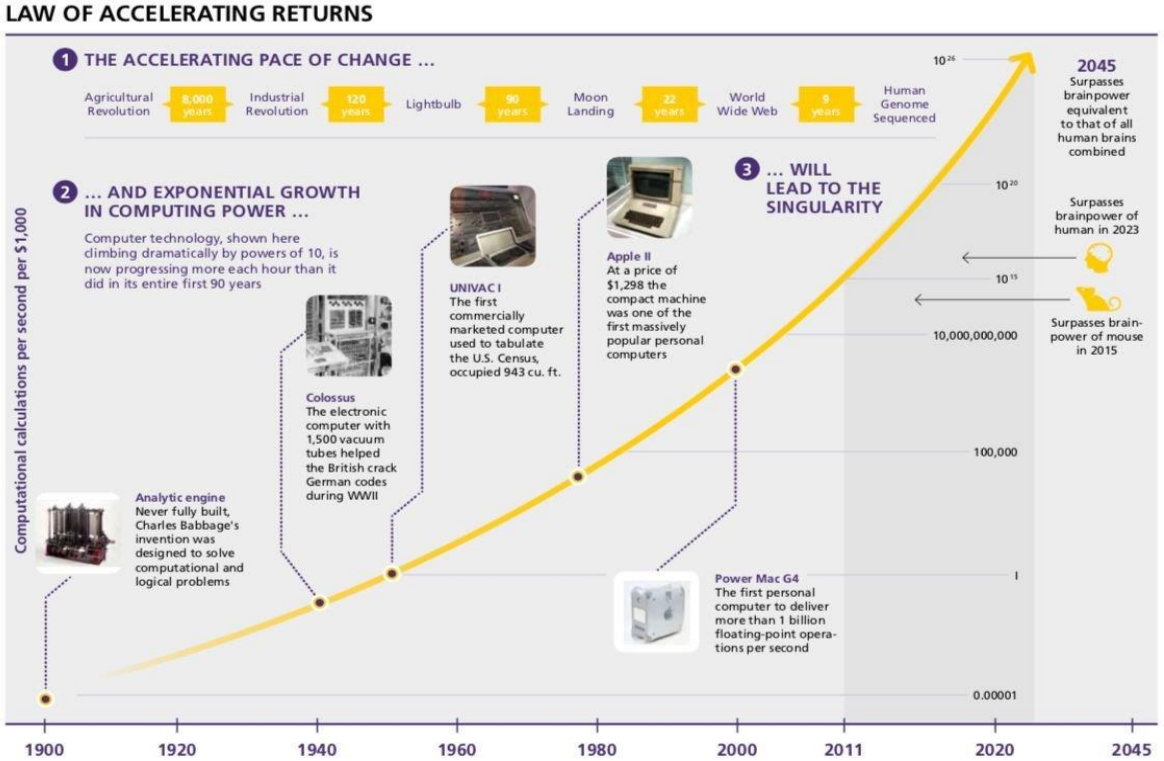
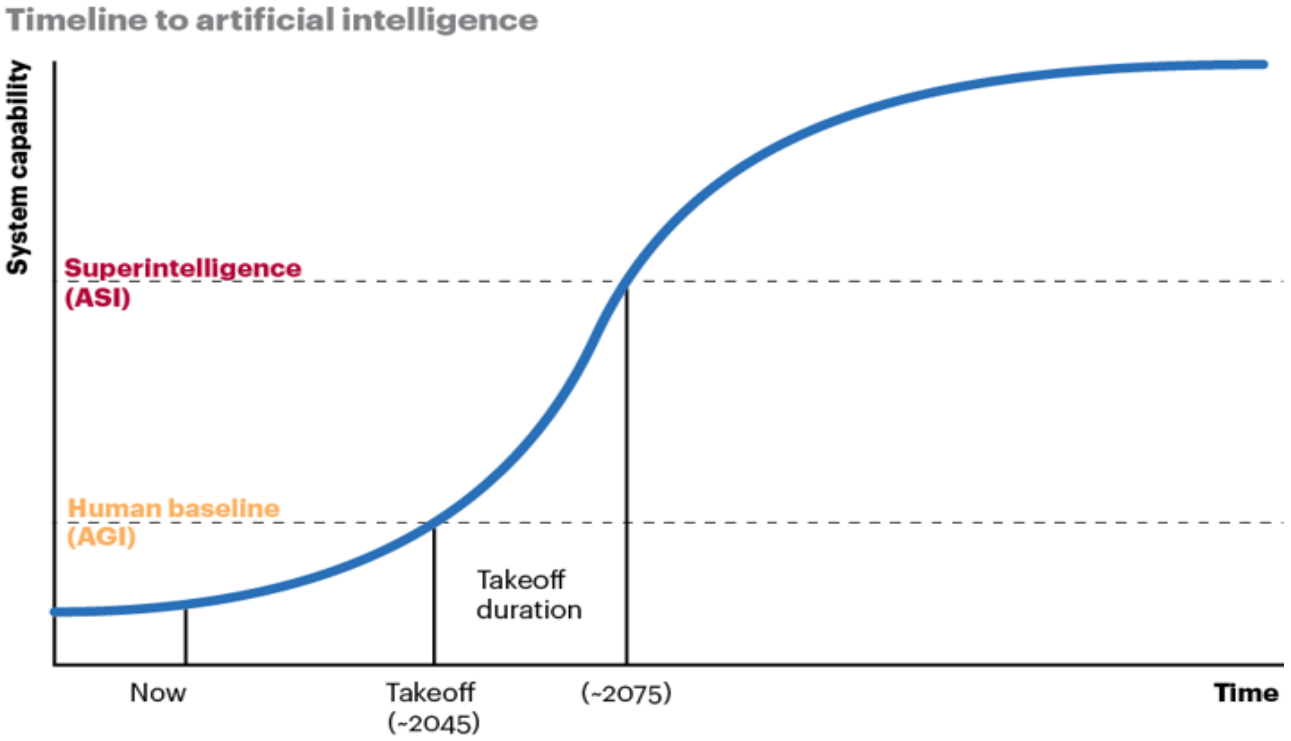


Figure 12: Ray Kurzweil's Law of Accelerating Returns depicts the exponential growth of computer processing power and technology innovations throughout history, and anticipates computers will exceed human intelligence in the future; **Source:** TIME / Wikipedia

source dhl via @mikequindazzi

Predicted eras of AI



Note: AI is artificial intelligence, ASI is artificial superintelligence, and AGI is artificial general intelligence.

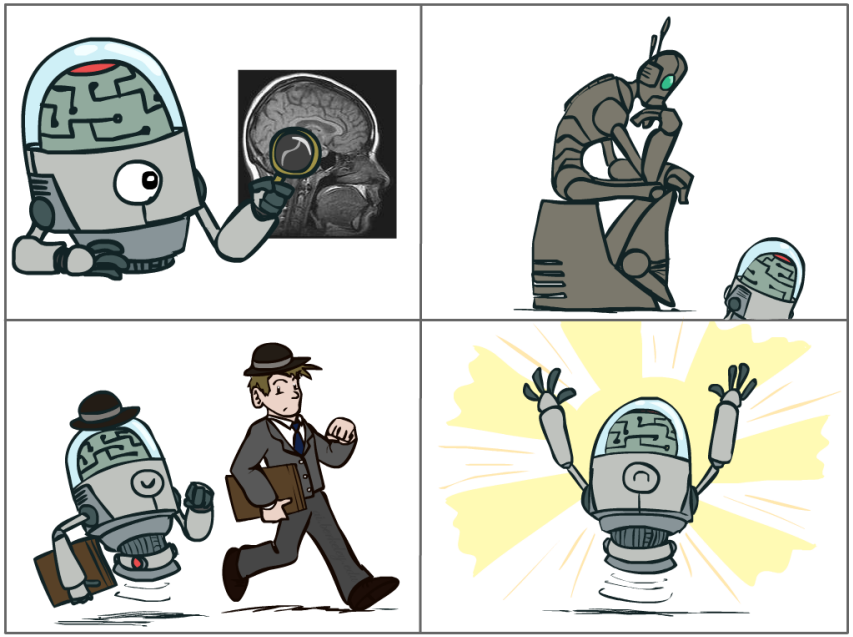
Sources: WaitButWhy.com, Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies;* A.T. Kearney analysis

What is AI?

The science of making machines that:

Think like people

Think rationally



Act like people

Act rationally

Rational Decisions

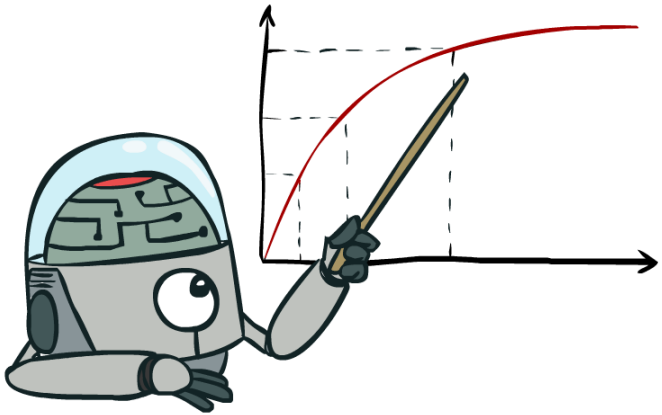
We'll use the term **rational** in a very specific, technical way:

- 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:

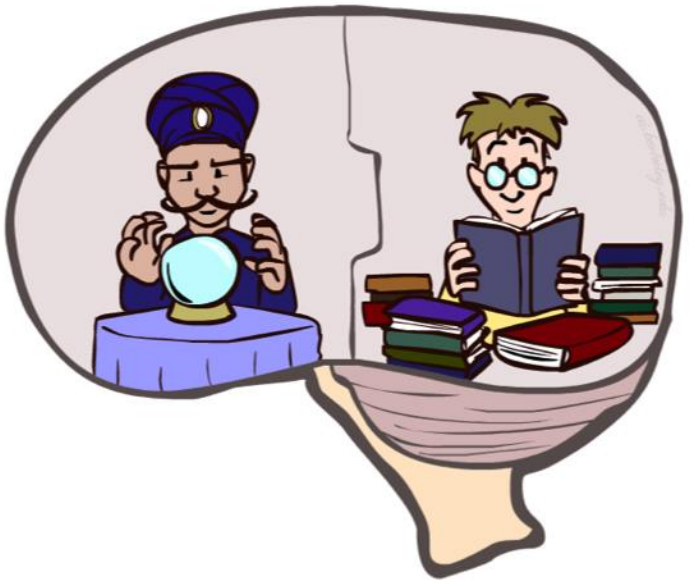
Computational Rationality

Maximize Your Expected Utility

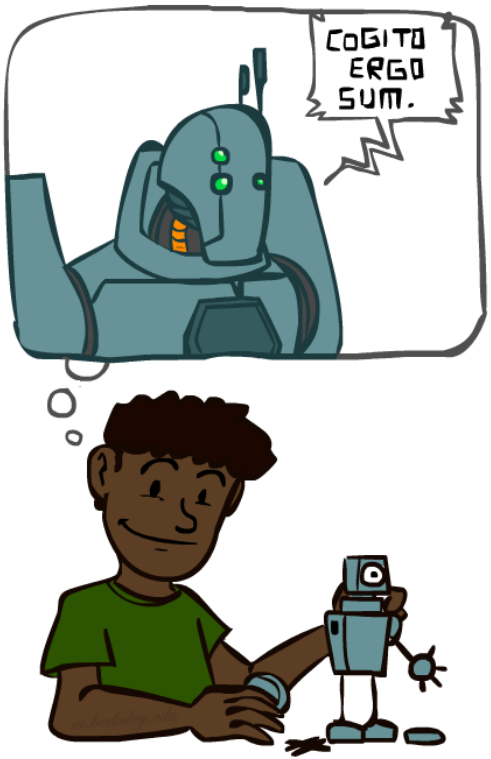


What About the Brain?

- 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

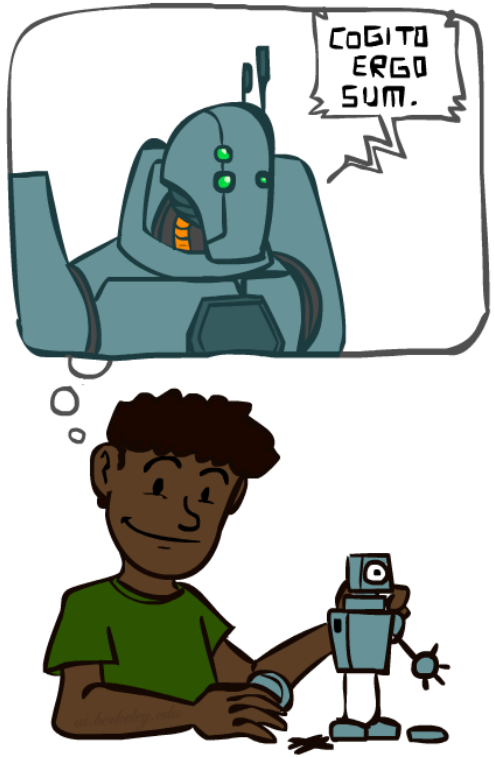


A (Short) History of AI

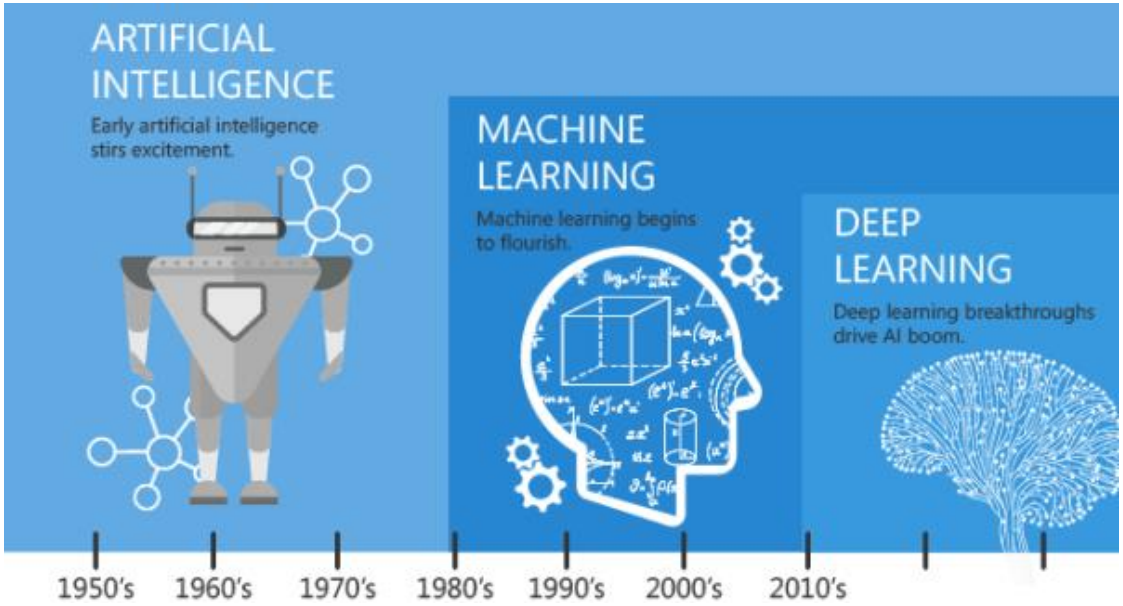


A (Short) History of AI

- 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, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems… “AI Spring”?
- 2000—: Where are we now?



AI – ML - DL

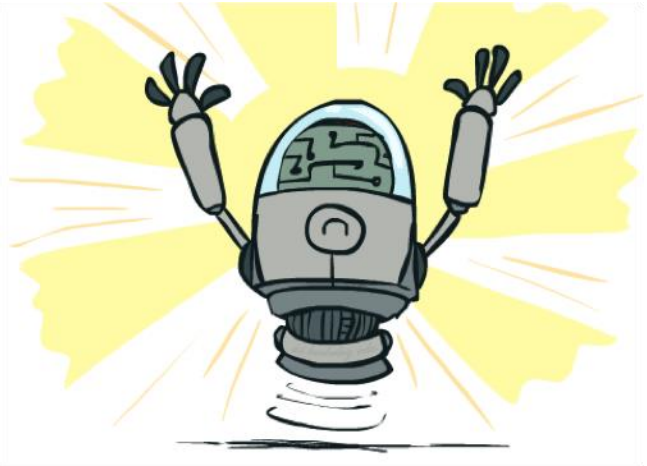


https://shawnennis.com/the-technology-of-machine-learning-with-ai

What Can AI Do?

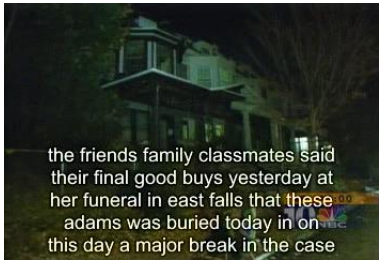
Quiz: Which of the following can be done at present?

- ✓ Play a decent game of table tennis?
- ✓ Play a decent game of Jeopardy?
- ✓ Drive safely along a curving mountain road?
- ? Drive safely along Telegraph Avenue?
- ✓ Buy a week's worth of groceries on the web?
- ✗ Buy a week's worth of groceries at a market?
- ? Discover and prove a new mathematical theorem?
- ✗ Converse successfully with another person for an hour?
- ? Perform a surgical operation?
- ✓ Put away the dishes and fold the laundry?
- ✓ Translate spoken Chinese into spoken English in real time?
- ✗ Write an intentionally funny story?



Natural Language

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

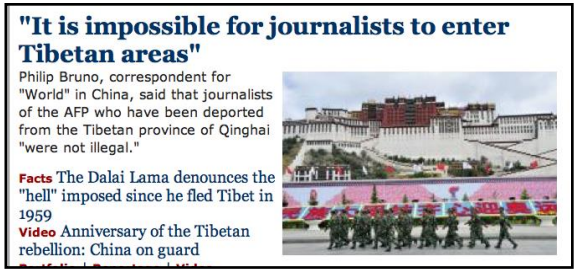


- Language processing technologies
  - Question answering
  - Machine translation


"Il est impossible aux journalistes de rentrer dans les régions tibétaines"

Bruno Philip, correspondant du "Monde" en Chine, estime que les journalistes de l'AFP qui ont été expulsés de la province tibétaine du Qinghai "n'étaient pas dans l'illégalité".

Les faits Le dalaï-lama dénonce l'"enfer" imposé au Tibet depuis sa fuite, en 1959
Vidéo Anniversaire de la rébellion


"It is impossible for journalists to enter Tibetan areas"

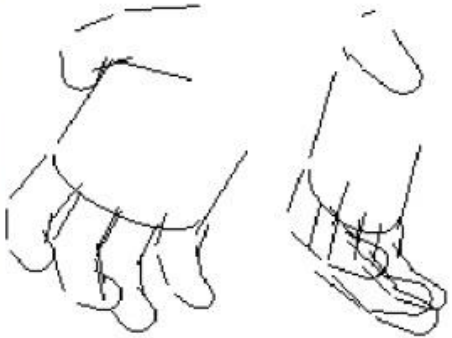
Philip Bruno, correspondent for "World" in China, said that journalists of the AFP who have been deported from the Tibetan province of Qinghai "were not illegal."

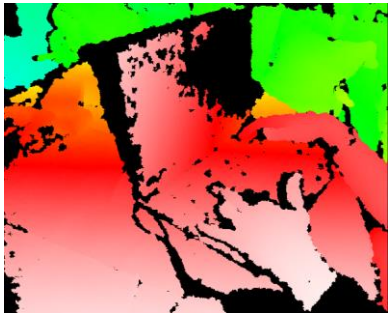
Facts The Dalai Lama denounces the "hell" imposed since he fled Tibet in 1959
Video Anniversary of the Tibetan rebellion: China on guard

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

Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification

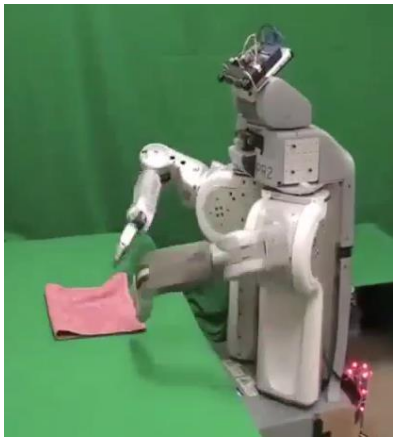


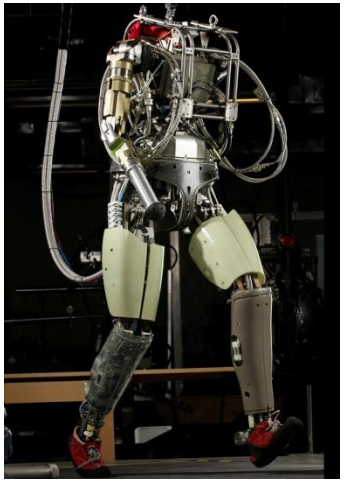


Images from Erik Sudderth (left), wikipedia (right)

Robotics

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





Images from UC Berkeley, Boston Dynamics, RoboCup, Google

Logic

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

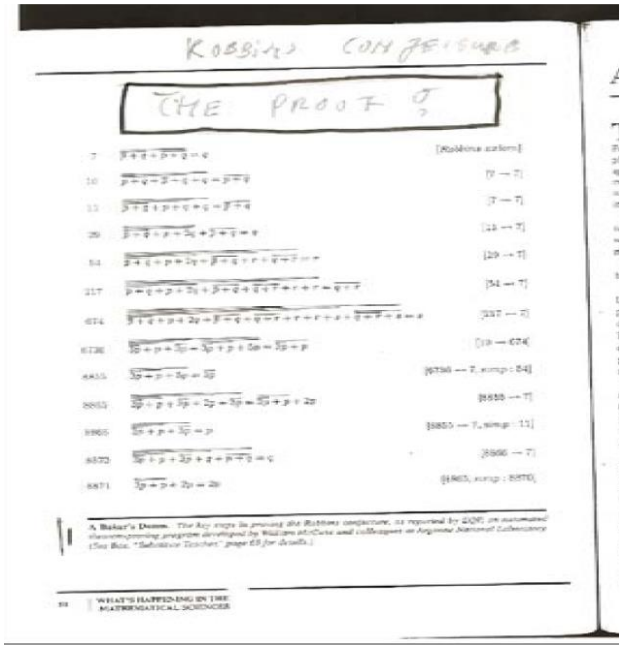
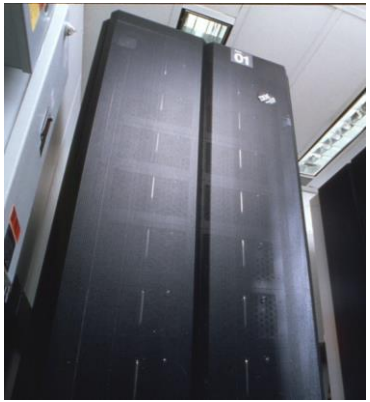


Image from Bart Selman

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

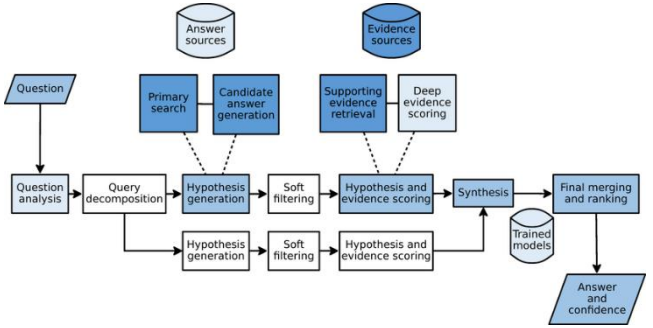


- Open question:
  - How does human cognition deal with the search space explosion of chess?
  - Or: how can humans compete with computers at all??
- 1996: Kasparov Beats Deep Blue
  “I could feel --- I could smell --- a new kind of intelligence across the table.”
- 1997: Deep Blue Beats Kasparov
  “Deep 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

IBM Watson (2011): Jeopardy

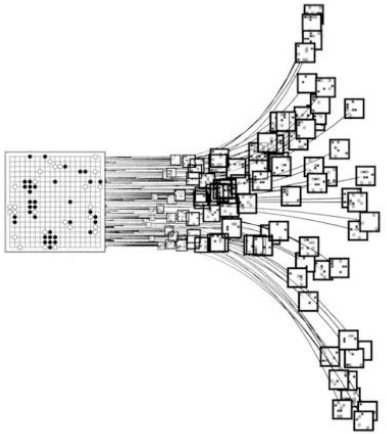
- IBM Grand Challenge
  - 1997: Deep Blue wins
  - 1999-2006<: Blue Gene, protein structure prediction
  - 2011: Watson
    - Speech recognition
    - Inference
    - Gameplaying



Go (2017)

AlphaGo

- Google DeepMind
- Monte Carlo tree search
- 2016: 9 dans
- **2017: AlphaGo beats world champion**



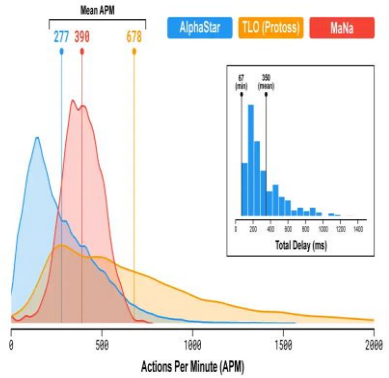
ARTICLE

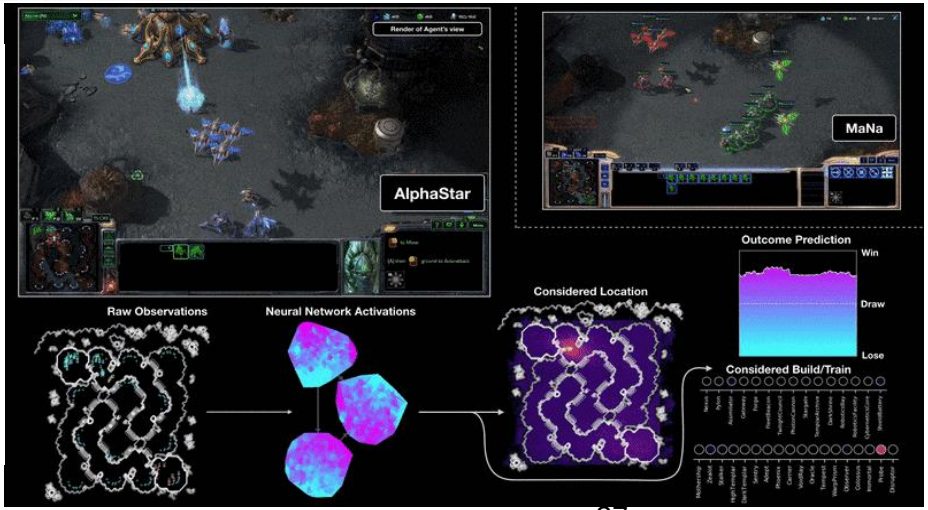
doi:10.1038/nature16961

Mastering the game of Go with deep neural networks and tree search

David Silver[1]*, Aja Huang[1]*, Chris J. Maddison[1], Arthur Guez[1], Laurent Sifre[1], George van den Driessche[1], Julian Schrittwieser[1], Ioannis Antonoglou[1], Veda Panneershelvam[1], Marc Lanctot[1], Sander Dieleman[1], Dominik Grewe[1], John Nham[2], Nal Kalchbrenner[1], Ilya Sutskever[2], Timothy Lillicrap[1], Madeleine Leach[1], Koray Kavukcuoglu[1], Thore Graepel[1] & Demis Hassabis[1]

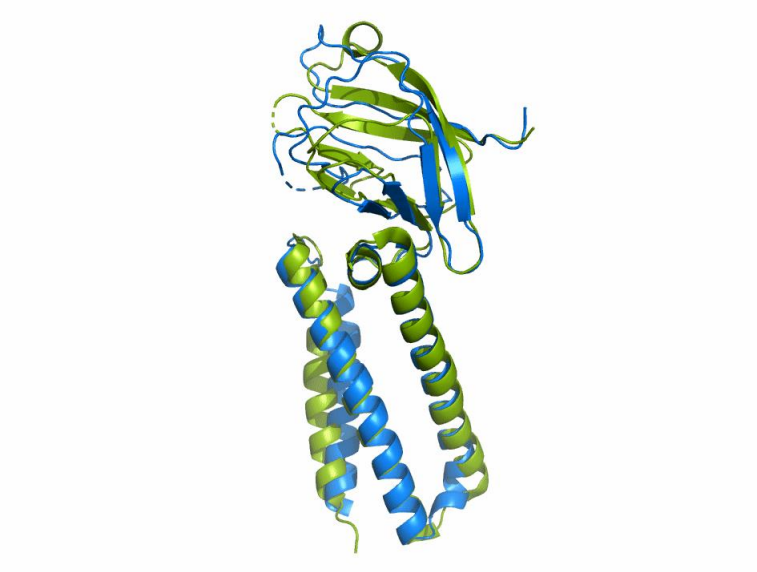
StarCraft2 – AlphaStar 2019





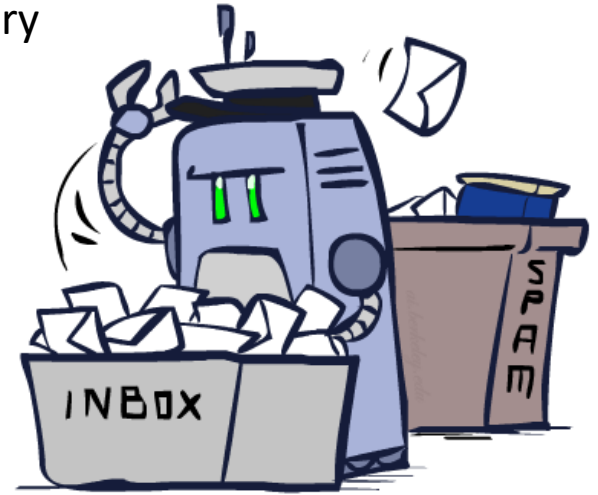
AlphaFold (2020)

- John Jumper, Kathryn Tunyasuvunakool, Pushmeet Kohli, Demis Hassabis, and the AlphaFold Team, “Computational predictions of protein structures associated with COVID-19”, Version 3, DeepMind website, 4 August 2020, https://deepmind.com/research/open-source/computational-predictions-of-protein-structures-associated-with-COVID-19

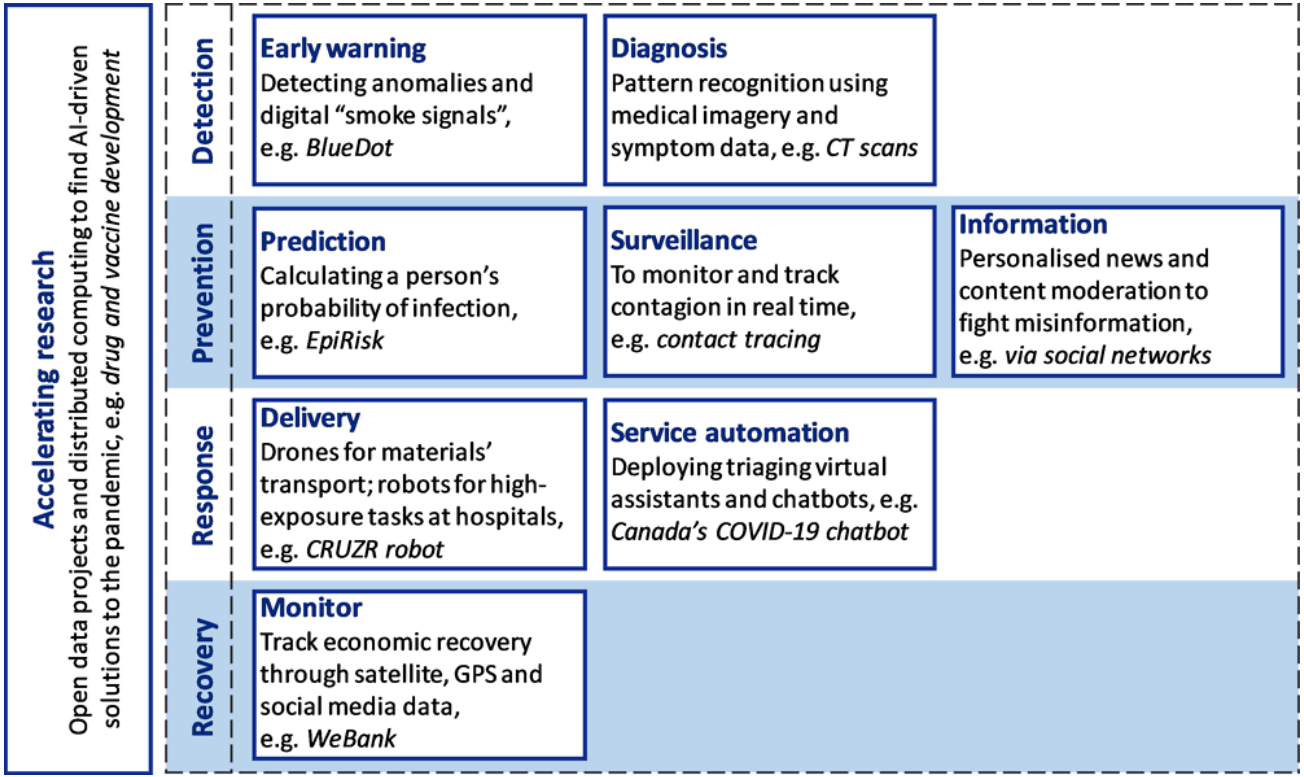


Decision Making

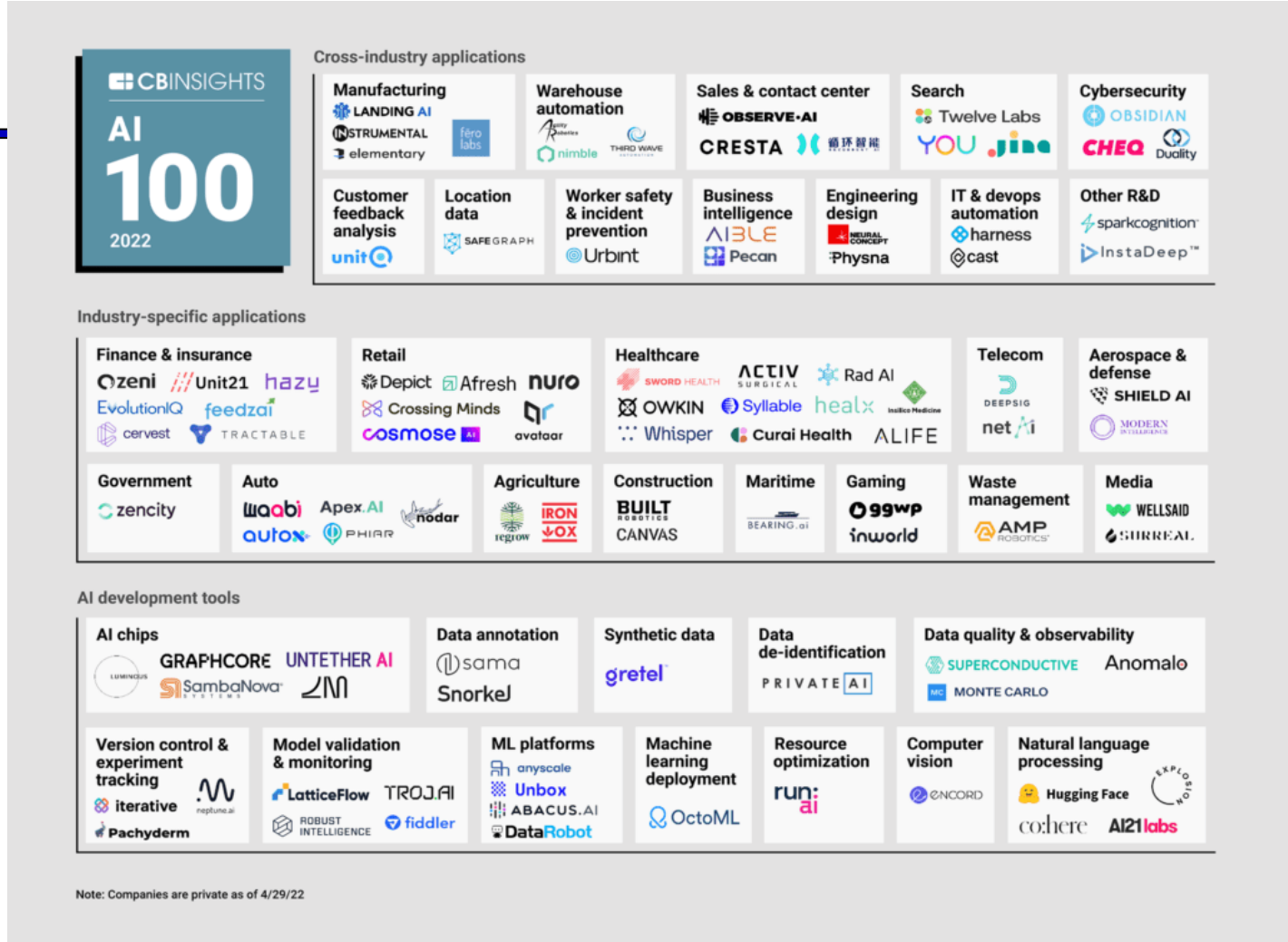
- Applied AI involves many kinds of automation
  - Scheduling, e.g. airline routing, military
  - Route planning, e.g. Google maps
  - Medical diagnosis
  - Web search engines
  - Spam classifiers
  - Automated help desks
  - Fraud detection
  - Product recommendations
  - … Lots more!



COVID-19 AI applications



Top AI Startups 2022



Note: Companies are private as of 4/29/22

Top AI Startups

Healthcare

- Surgical technologies (ACTIV Surgical)
- orphan drug discovery (Healx)

Finance and Insurance category

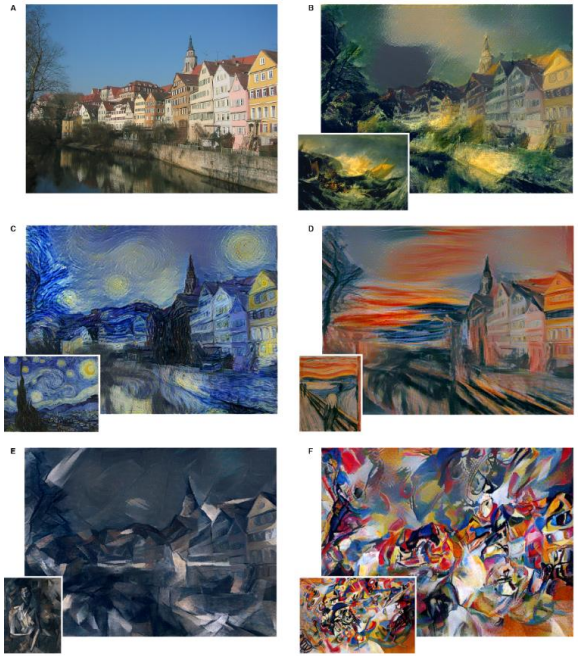
- visual damage assessment of cars (Tractable)

New players

- **Whisper** develops sound separation technology to improve hearing aid performance
- **Canvas Construction** focuses on artificial intelligence-driven robotics for drywall construction.
- **Agility Robotics** is developing humanoid robots for warehouse and logistics use cases

Learning artistic style

- Gatys, L.A., Ecker, A.S. and Bethge, M., 2015. A neural algorithm of artistic style. *arXiv preprint arXiv:1508.06576*.

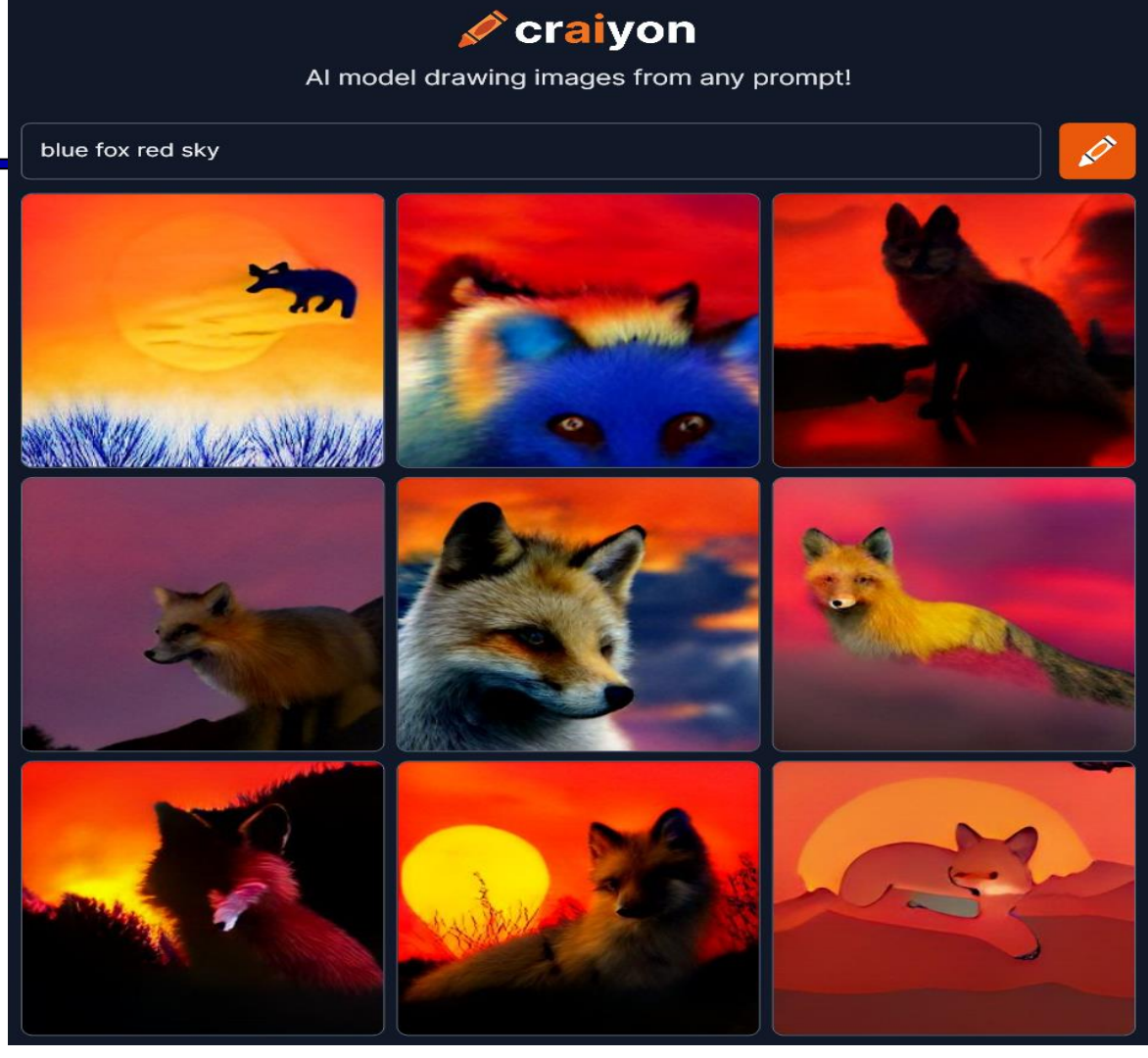


„AI won an art contest, and artists are furious”

https://edition.cnn.com/2022/09/03/tech/ai-art-fair-winner-controversy/index.html

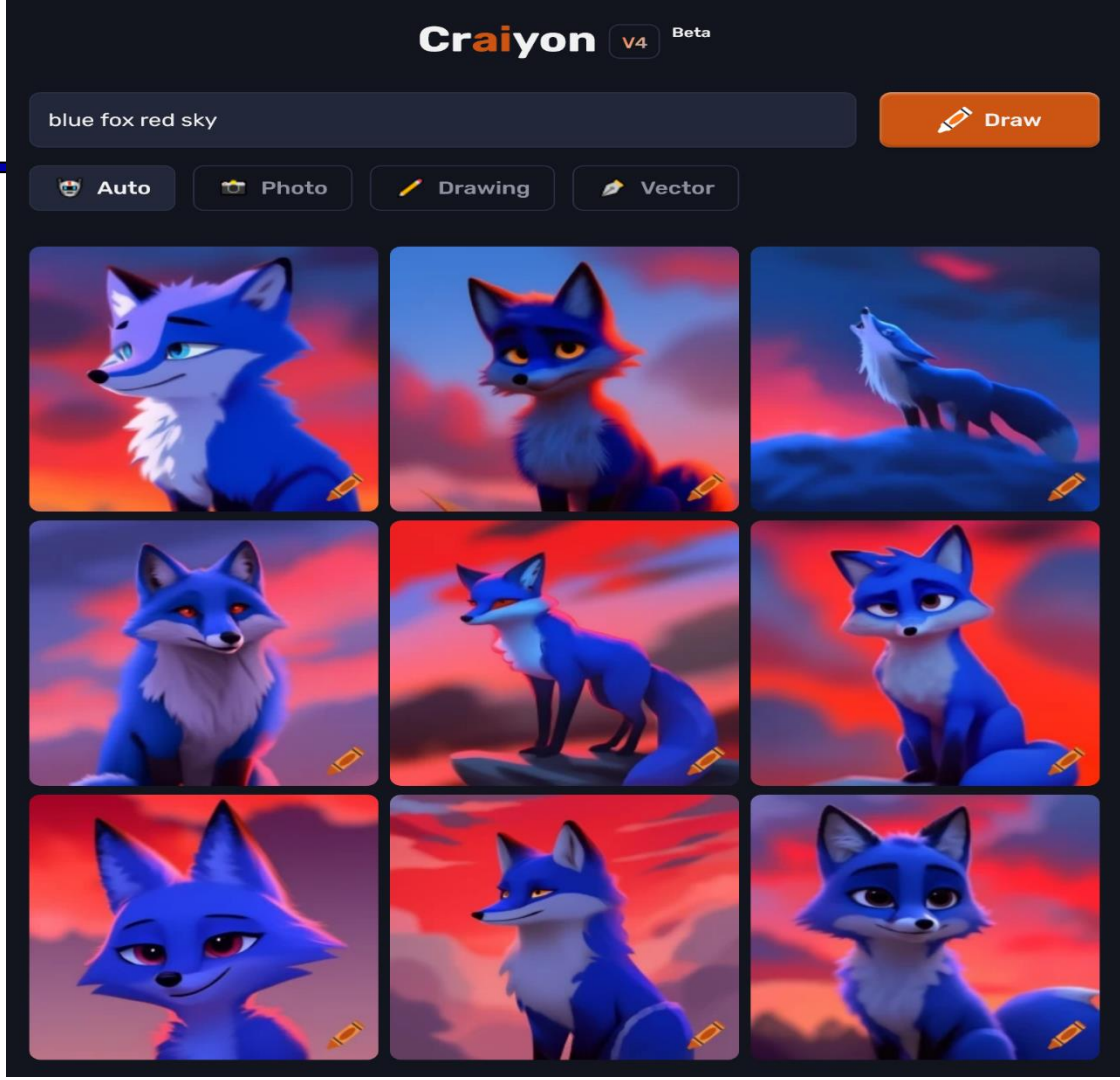
AI-art 2023

- https://www.craiyon.com/



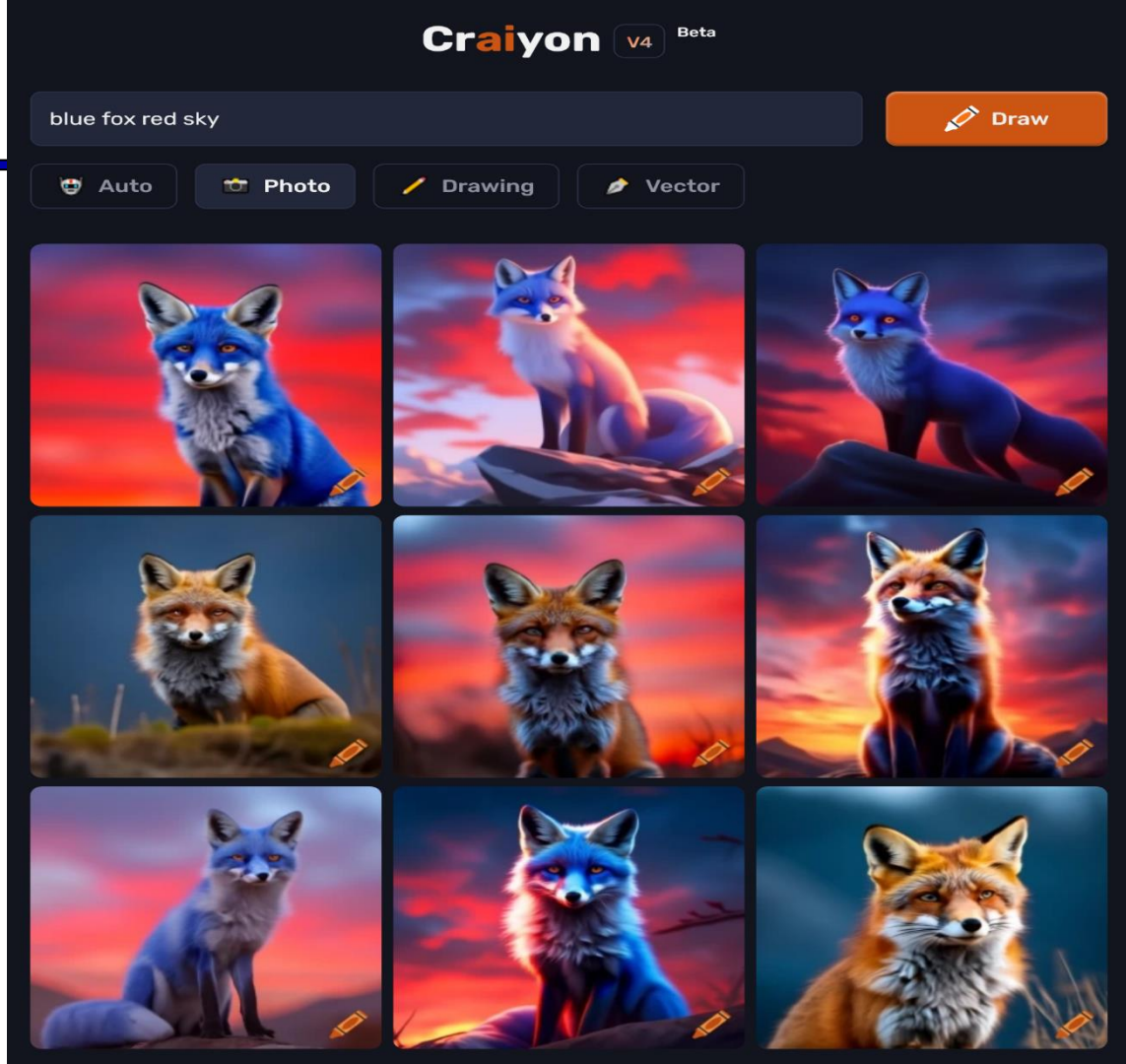
AI-art 2024

- https://www.craiyon.com/



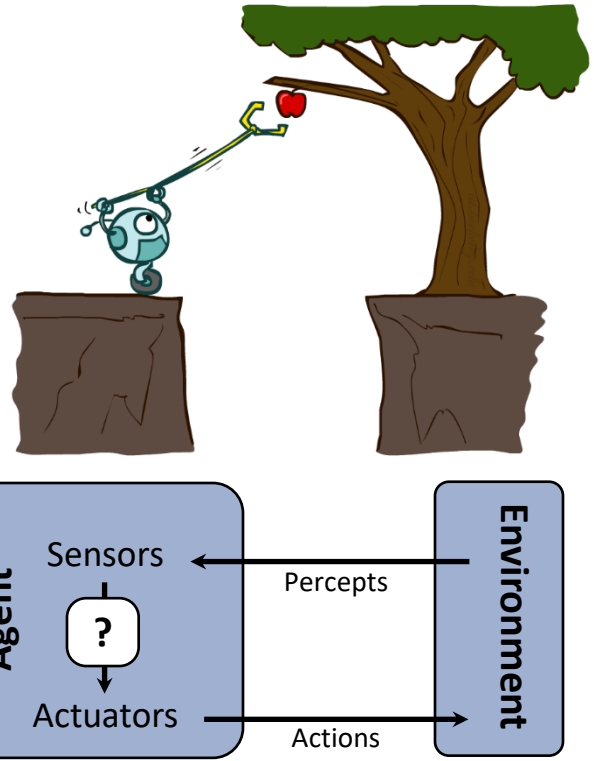
AI-art 2024

- https://www.craiyon.com/

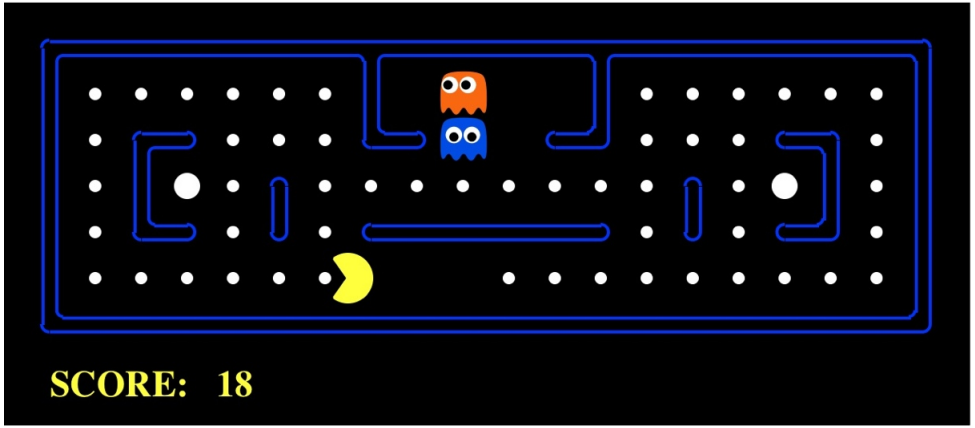


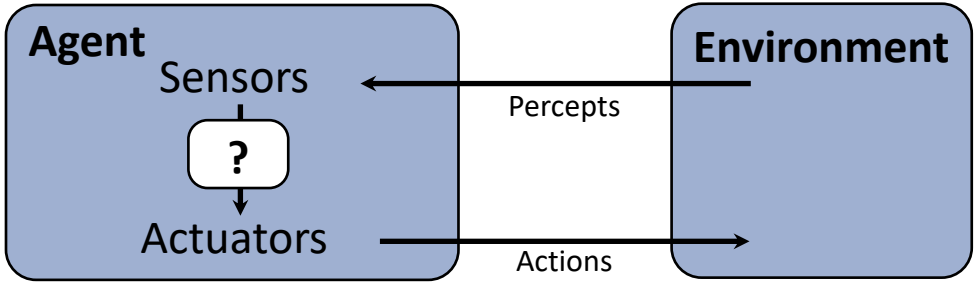
Designing Rational Agents

- 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





Pac-Man is a registered trademark of Namco-Bandai Games, used here for educational purposes

Demo1: pacman-l1.mp4 or L1D2

Environment

The environment greatly influences the design and expected capabilities of the agent to be used

- Fully/partially observable=> the agent may need memory (internal state record)
- Discrete/continuous => the agent may not be able to distinguish all possible states
- Stochastic/deterministic => the agent may need to develop several possible scenarios
- Single agent/multiple agents => the agent may have to behave randomly or according to a certain strategy

Course Topics

- Part I: Making Decisions
  - Fast search / planning
  - Constraint satisfaction
  - Adversarial and uncertain search
- Part II: Reasoning under Uncertainty
  - Bayesian networks
  - Decision theory
  - Machine learning
- Throughout: Applications
  - Natural language, vision, robotics, games, …