Introduction to Artificial Intelligence

Lecture 0: Artificial Intelligence

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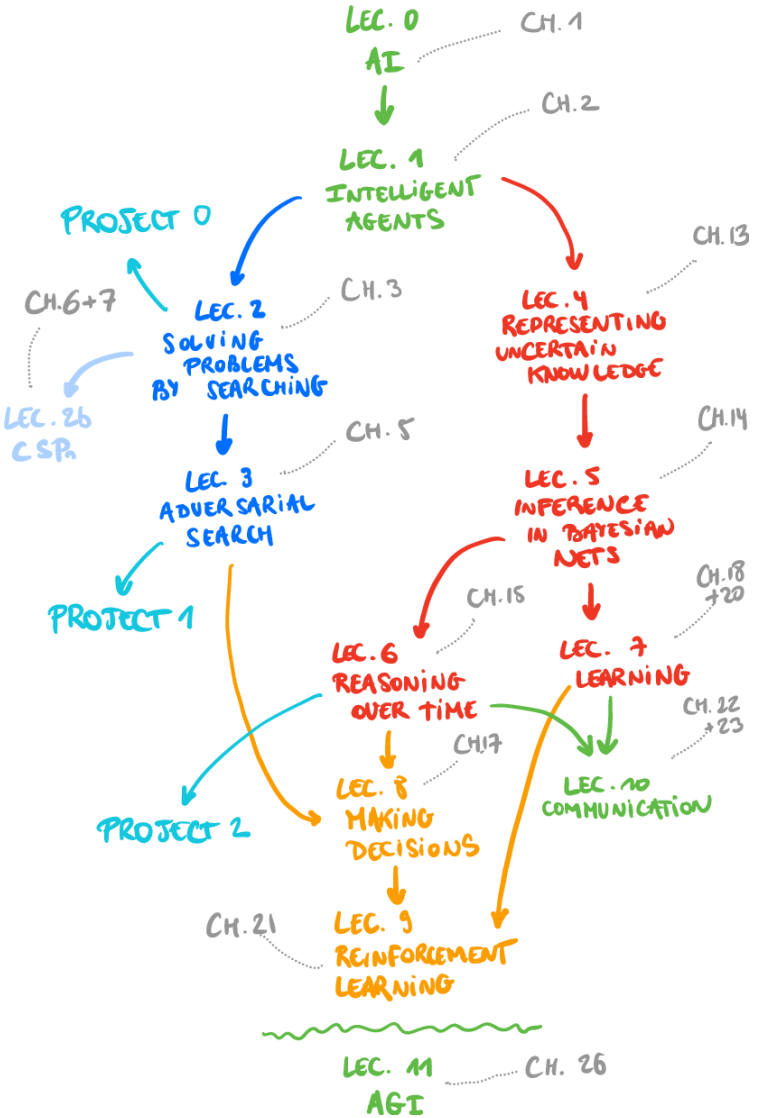
LIÈGE université

Today

- Course outline
- Introduction to Artificial Intelligence
- Intelligent agents

Outline

- Lecture 0: Artificial intelligence
- Lecture 1: Intelligent agents
- Lecture 2: Solving problems by searching
- Lecture 2b: Constraint satisfaction problems (optional)
- Lecture 3: Adversarial search
- Lecture 4: Representing uncertain knowledge
- Lecture 5: Inference in Bayesian networks
- Lecture 6: Reasoning over time
- Lecture 7: Learning
- Lecture 8: Making decisions
- Lecture 9: Reinforcement learning
- Lecture 10: Communication (optional)
- Lecture 11: Artificial General Intelligence and beyond


LEC. 0
AI
CH. 1
LEC. 1
INTELLIGENT AGENTS
CH. 2
PROJECT 0
LEC. 2
SOLVING PROBLEMS BY SEARCHING
CH. 3
CH. 6+7
LEC. 26
CSP
LEC. 4
REPRESENTING UNCERTAIN KNOWLEDGE
CH. 13
LEC. 3
ADVERSARIAL SEARCH
CH. 5
PROJECT 1
LEC. 5
INFERENCE IN BAYESIAN NETS
CH. 14
LEC. 6
REASONING OVER TIME
CH. 15
LEC. 7
LEARNING
CH. 18 +20
PROJECT 2
LEC. 8
MAKING DECISIONS
CH. 17
LEC. 10
COMMUNICATION
CH. 22 +23
CH. 21
LEC. 9
REINFORCEMENT LEARNING
LEC. 11
AGI
CH. 26

My mission

By the end of this course, you will have built autonomous agents that efficiently make decisions in fully informed, partially observable and adversarial settings. Your agents will draw inferences in uncertain and unknown environments and optimize actions for arbitrary reward structures.

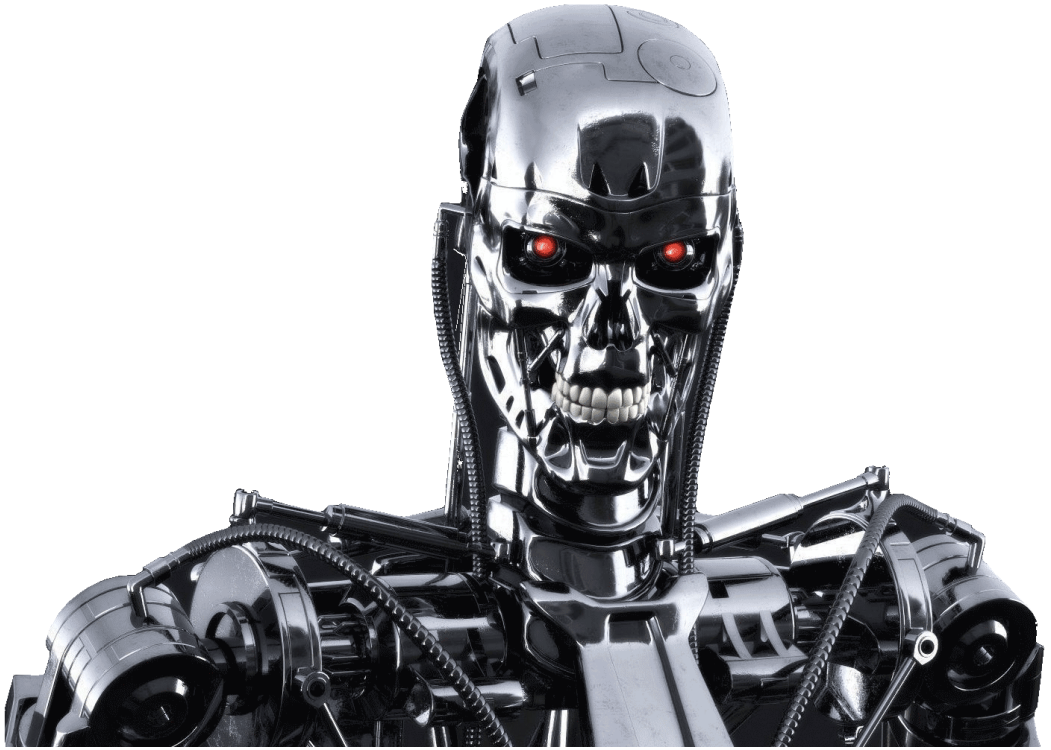
The techniques you learn in this course apply to a wide variety of artificial intelligence problems and will serve as the foundation for further study in any application area you choose to pursue.

Going further

This course is designed as an introduction to the many other courses available at ULiège and (broadly) related to AI, including:

- INFO8006: Introduction to Artificial Intelligence ← you are there
- DATS0001: Foundations of dats science
- ELEN0062: Introduction to Machine Learning
- INFO8010: Deep Learning
- INFO8004: Advanced Machine Learning
- INFO8003: Optimal decision making for complex problems
- INFO0948: Introduction to Intelligent Robotics
- INFO9014: Knowledge representation and reasoning
- ELEN0016: Computer vision

Artificial intelligence



"With artificial intelligence we are summoning the demon" -- Elon Musk

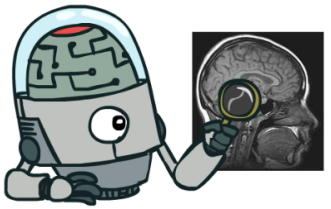
"We're really closer to a smart washing machine than Terminator" -- Fei-Fei Li, Director of Stanford AI Lab.


Rencontre avec Yann Le Cun, directeur de la recherche en AI chez Facebook
Powered by dailymotion
Konbini techno
2:39
Les gens ont des peurs,
des fantasmes.

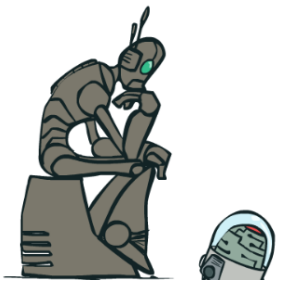
A definition?

Artificial intelligence is the science of making machines or programs that:

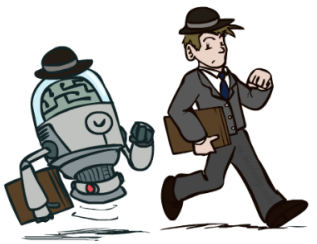
Think like people



Think rationally



Act like people



Act rationally

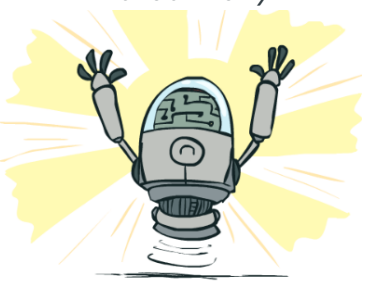


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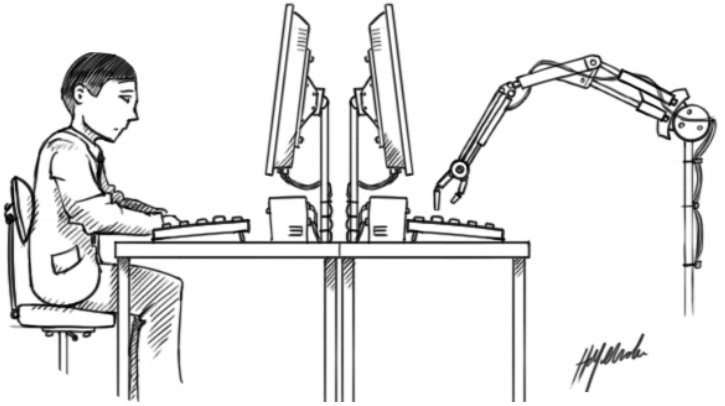
Image credits: CS188, UC Berkeley.

Acting humanly

The Turing test

A computer passes the Turing test (aka the Imitation Game) if a human operator, after posing some written questions, cannot tell whether the written responses come from a person or from a computer.

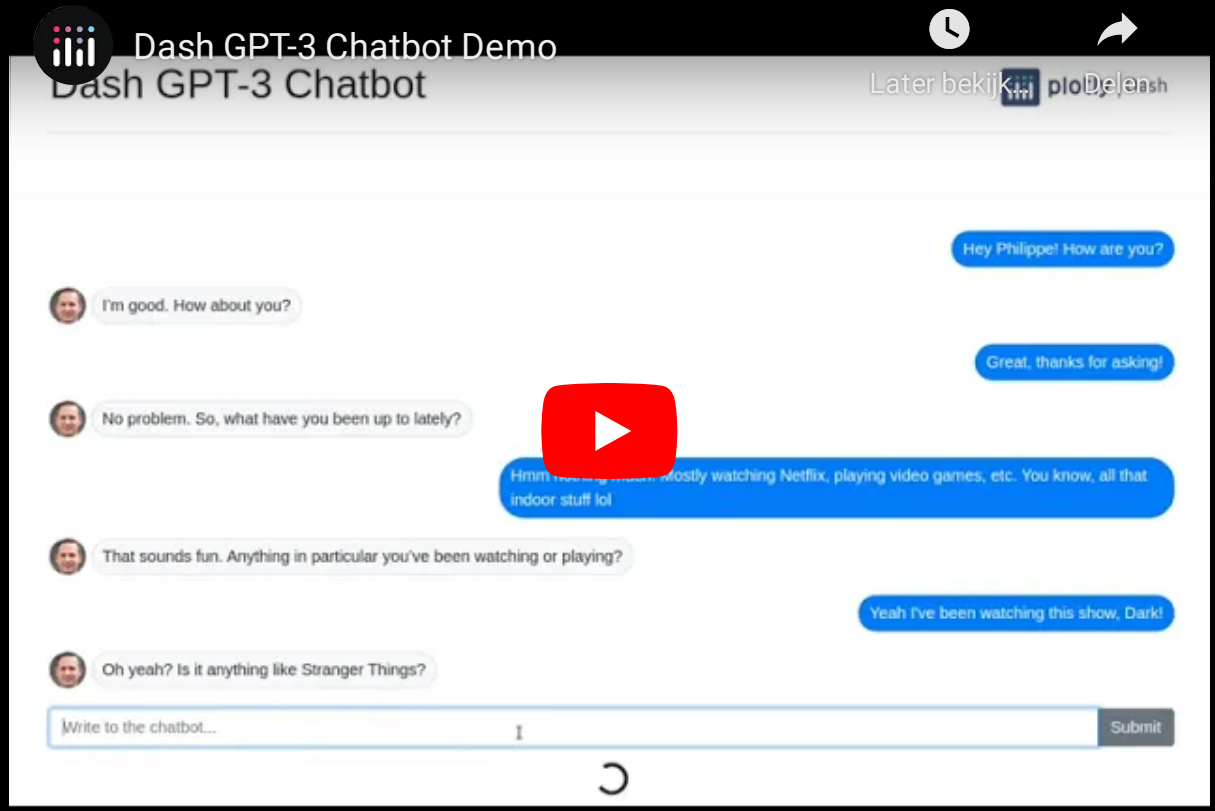


Can machines think?
(Alan Turing, 1950)

An agent would not pass the Turing test without the following requirements:

- natural language processing
- knowledge representation
- automated reasoning
- machine learning
- computer vision (total Turing test)
- robotics (total Turing test)

Despite being proposed almost 70 years ago, the Turing test is still relevant today.



A conversation with GPT-3 (2020)

Let us Turing test an AI!

Limitations of the Turing test

The Turing test tends to focus on human-like errors, linguistic tricks, etc.

However, it seems more important to study the principles underlying intelligence than to replicate an exemplar.

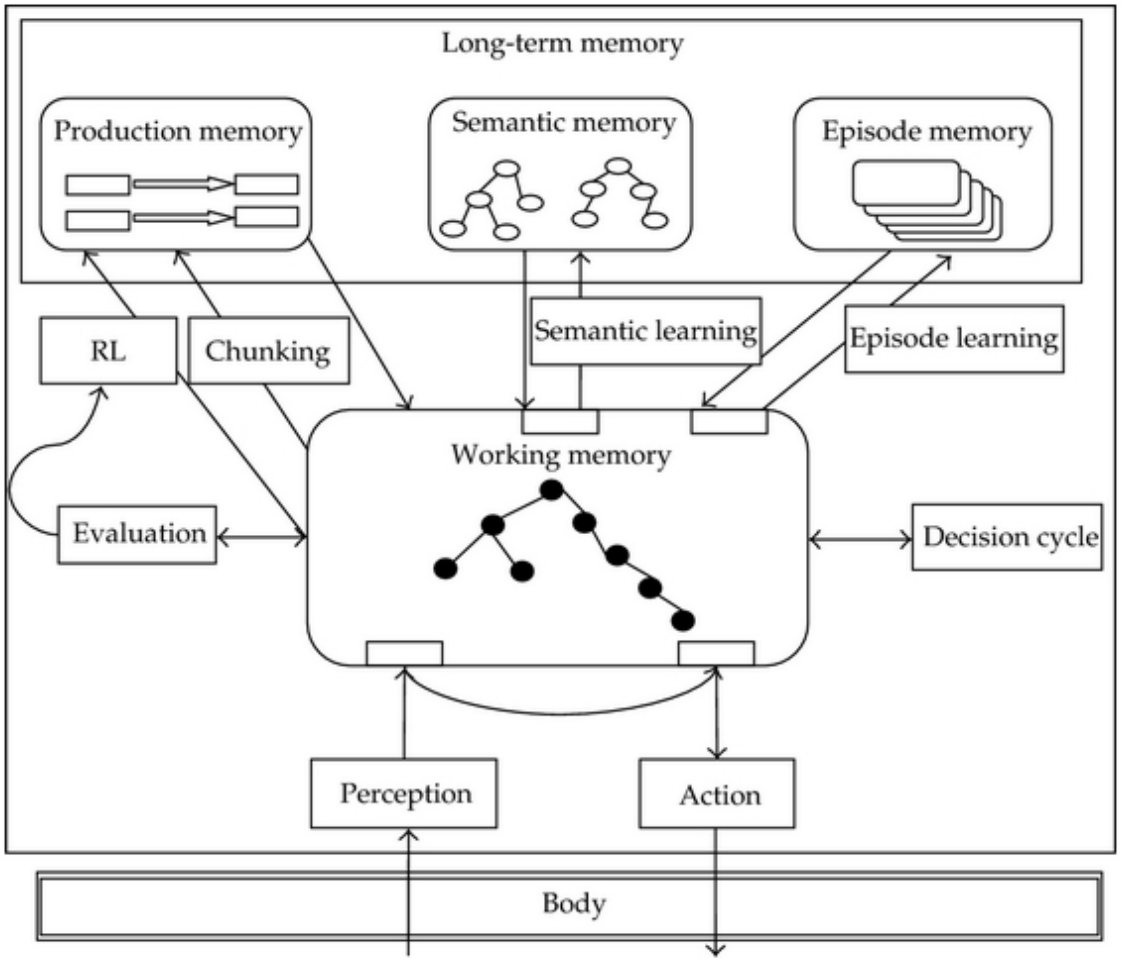
Aeronautics is not defined as the field of making machines
that fly so exactly like pigeons that they can fool even other pigeons.

Thinking humanly

Cognitive science

Study of the human mind and its processes.

- The goal of cognitive science is to form a theory about the structure of the mind, summarized as a comprehensive computer model.
- It includes language, problem-solving, decision-making and perception.
- A cognitive architecture usually follows human-like reasoning and can be used to produce testable predictions (time of delays during problem solving, kinds of mistakes, learning rates, etc).



The modern SOAR cognitive architecture.

Neurobiology and neuroscience

Study of the anatomy and physiology of neural tissue.

- Neurobiology is concerned with the the anatomy and physiology of the brain, from major structures down to neurons and molecules.
- Neuroscience adds to that the study of how the brain works, mechanistically, functionally, and systematically to produce observable behavior.

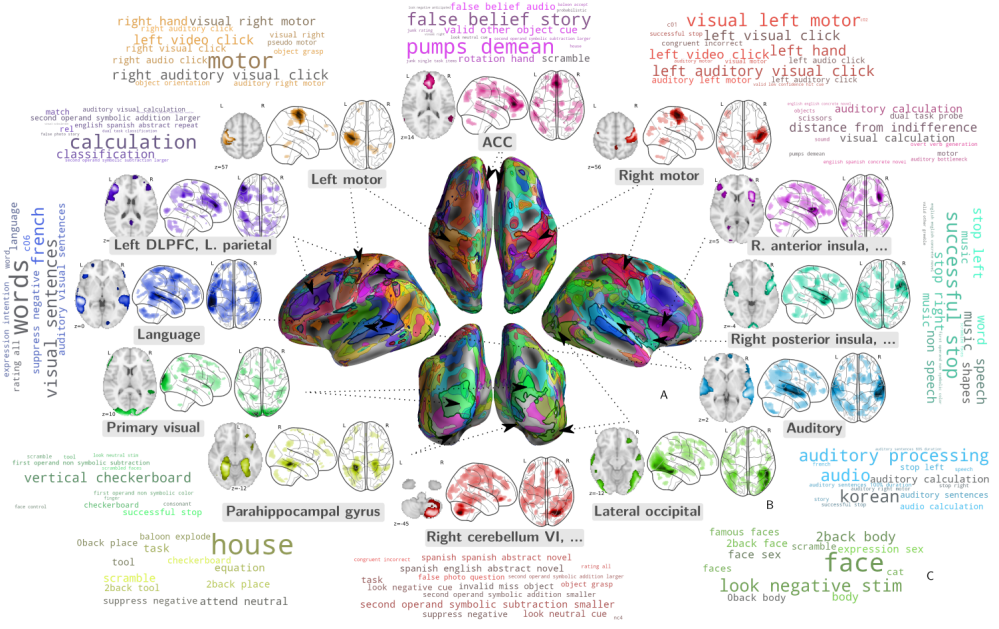


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Image credits: M et al. 2018.

Limitations of cognition and neuroscience for AI

- In linguistics, the argument of poverty of the stimulus states that children do not receive sufficient input to generalize grammatical rules through linguistic input alone.
- (Controversial) Therefore, humans must be biologically pre-wired with innate knowledge for representing language.

How do we know what we know?
(Noam Chomsky, 1980)

For this reason, it may not be possible to implement a fully functioning computer model of the human mind without background knowledge of some sort.

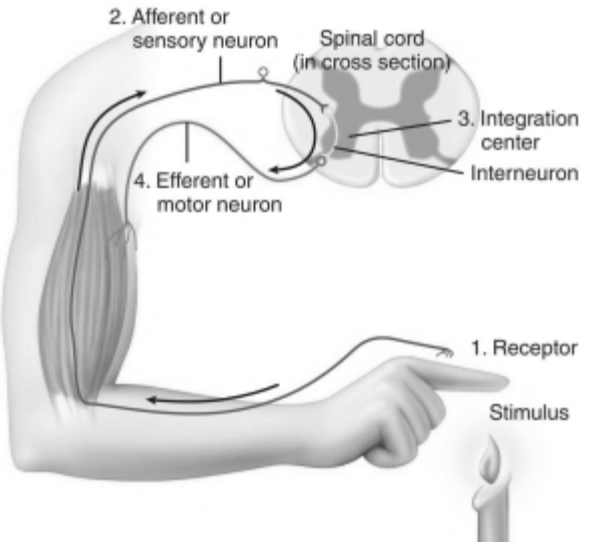
Thinking rationally

The logical approach

- The rational thinking approach is concerned with the study of irrefutable reasoning processes. It ensures that all actions performed by a computer are formally provable from inputs and prior knowledge.
- The "laws of thought" were supposed to govern the operation of the mind. Their study initiated the field of logic and the logicist tradition of AI (1960-1990).

Limitations of logical inference

- Representation of informal knowledge is difficult.
- Hard to define provable plausible reasoning.
- Combinatorial explosion (in time and space).
- Logical inference is only a part of intelligence. It does not cover everything:
  - e.g., might be no provably correct thing to do, but still something must be done;
  - e.g., reflex actions can be more successful than slower carefully deliberated ones.



Pain withdrawal reflexes do not involve inference.

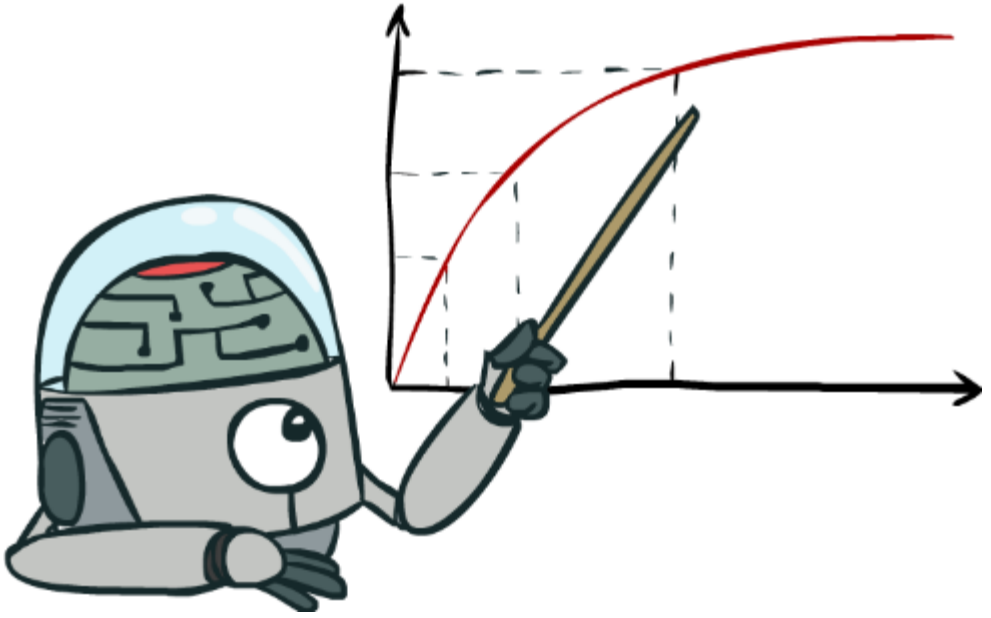
Acting rationally

A rational agent acts so as to achieve the best expected outcome.

- Correct logical inference is just one of several possible mechanisms for achieving this goal.
- Perfect rationality cannot be achieved due to computational limitations!
  - The amount of reasoning is adjusted according to available resources and importance of the result.
- The brain is good at making rational decisions but not perfect either.

Rationality only concerns what decisions are made (not the thought process behind them, human-like or not).

Goals are expressed in terms of the performance or utility of outcomes. Being rational means maximizing its expected performance. The standard of rationality is general and mathematically well defined.



In this course, Artificial intelligence = Maximizing expected performance

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Image credits: CS188, UC Berkeley.

AI prehistory

- Philosophy: logic, methods of reasoning, mind as physical system, foundations of learning, language, rationality.
- Mathematics: formal representation and proof, algorithms, computation, (un)decidability, (in)tractability, probability.
- Psychology: adaptation, phenomena of perception and motor control, psychophysics.
- Economics: formal theory of rational decisions.
- Linguistics: knowledge representation, grammar.
- Neuroscience: plastic physical substrate for mental activity.
- Control theory: homeostatic systems, stability, simple optimal agent designs.

A short history of AI

1940-1950: Early days

- 1943: McCulloch and Pitts: Boolean circuit model of the brain.
- 1950: Turing's "Computing machinery and intelligence".

1950-1970: Excitement and expectations

- 1950s: Early AI programs, including Samuel's checkers program, Newell and Simon's Logic Theorist and Gelernter's Geometry Engine.
- 1956: Dartmouth meeting: "Aritificial Intelligence" adopted.
- 1958: Rosenblatt invents the perceptron.
- 1965: Robinson's complete algorithm for logical reasoning.
- 1966-1974: AI discovers computational complexity.

The Darthmouth workshop (1956)

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.


The Thinking Machine (Artificial Intelligenc...
Later bekijk...
Delen

1970-1990: Knowledge-based approaches

- 1969: Neural network research almost disappears after Minsky and Papert's book (1st AI winter).
- 1969-1979: Early development of knowledge-based systems.
- 1980-1988: Expert systems industrial boom.
- 1988-1993: Expert systems industry busts (2nd AI winter).

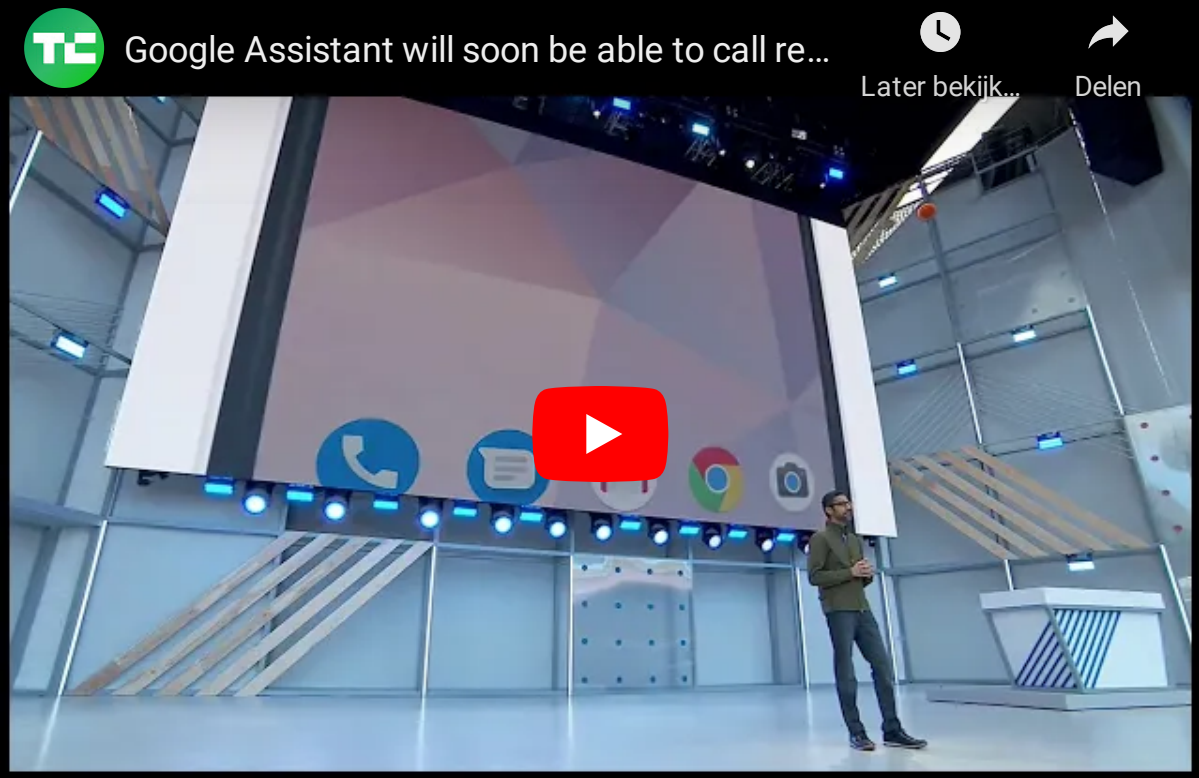
1990-Present: Statistical approaches

- 1985-1995: The return of neural networks.
- 1988-: Resurgence of probability, focus on uncertainty, general increase in technical depth.
- 1995-2010: New fade of neural networks.
- 1995-: Complete intelligent agents and learning systems.
- 2000-: Availability of very large datasets.
- 2010-: Availability of fast commodity hardware (GPUs).
- 2012-: Resurgence of neural networks with deep learning approaches.

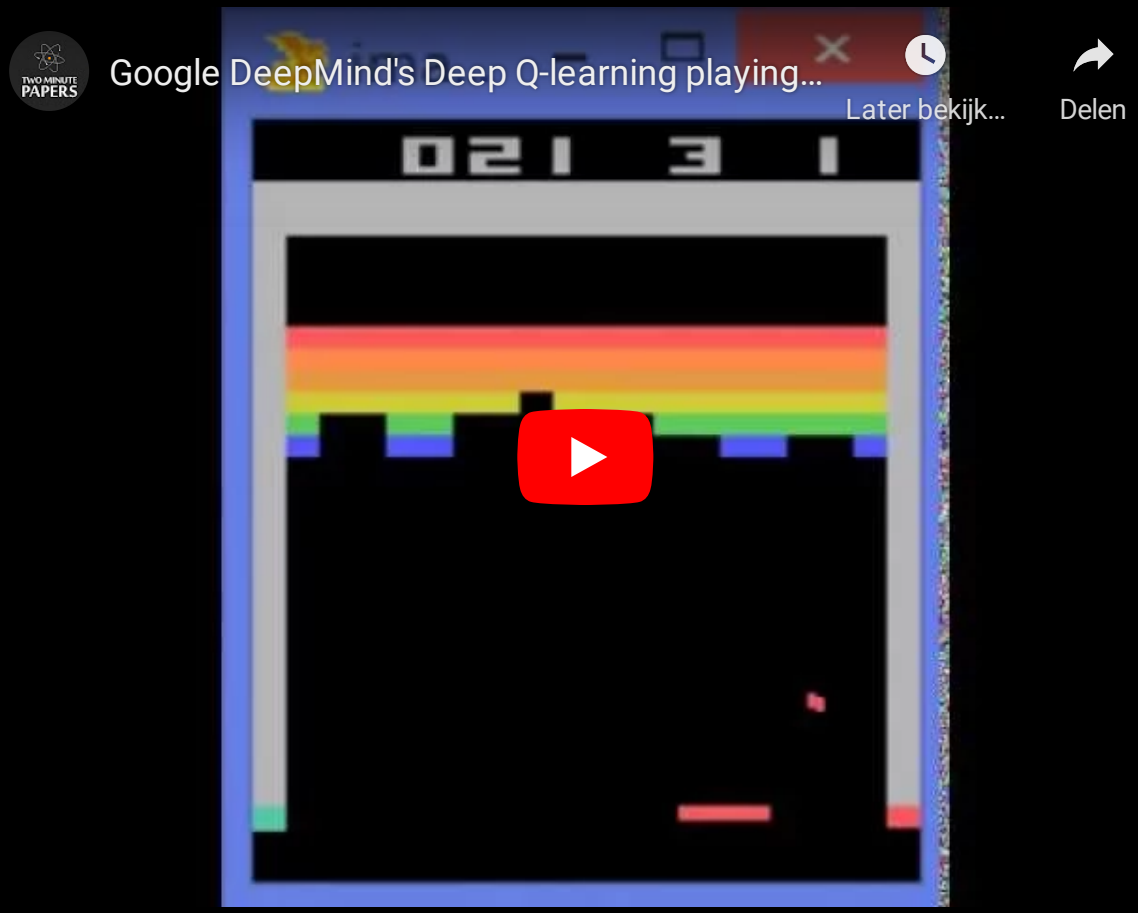
What can an AI do today?

- Translate spoken Chinese to spoken English, live?
- Answer multi choice questions, as good as an 8th grader?
- Converse with a person for an hour?
- Play decently at Chess? Go? Poker? Soccer?
- Buy groceries on the web? in a supermarket?
- Prove mathematical theorems?
- Drive a car safely on a parking lot? in New York?
- Perform a surgery?
- Identify skin cancer better than a dermatologist?
- Write a funny story?
- Write computer code?
- Paint like Vangogh? Compose music?
- Show common sense?

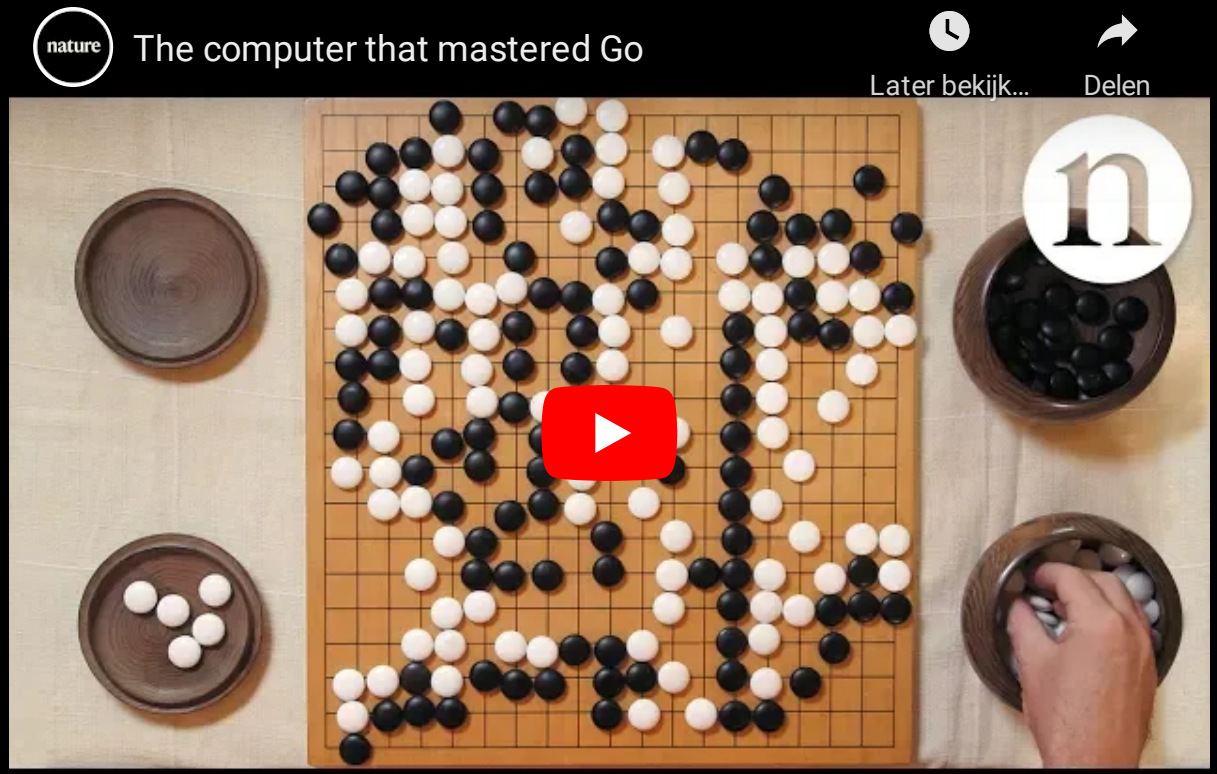
Speech translation and synthesis (2012)



Speech synthesis and question answering (Google, 2018)

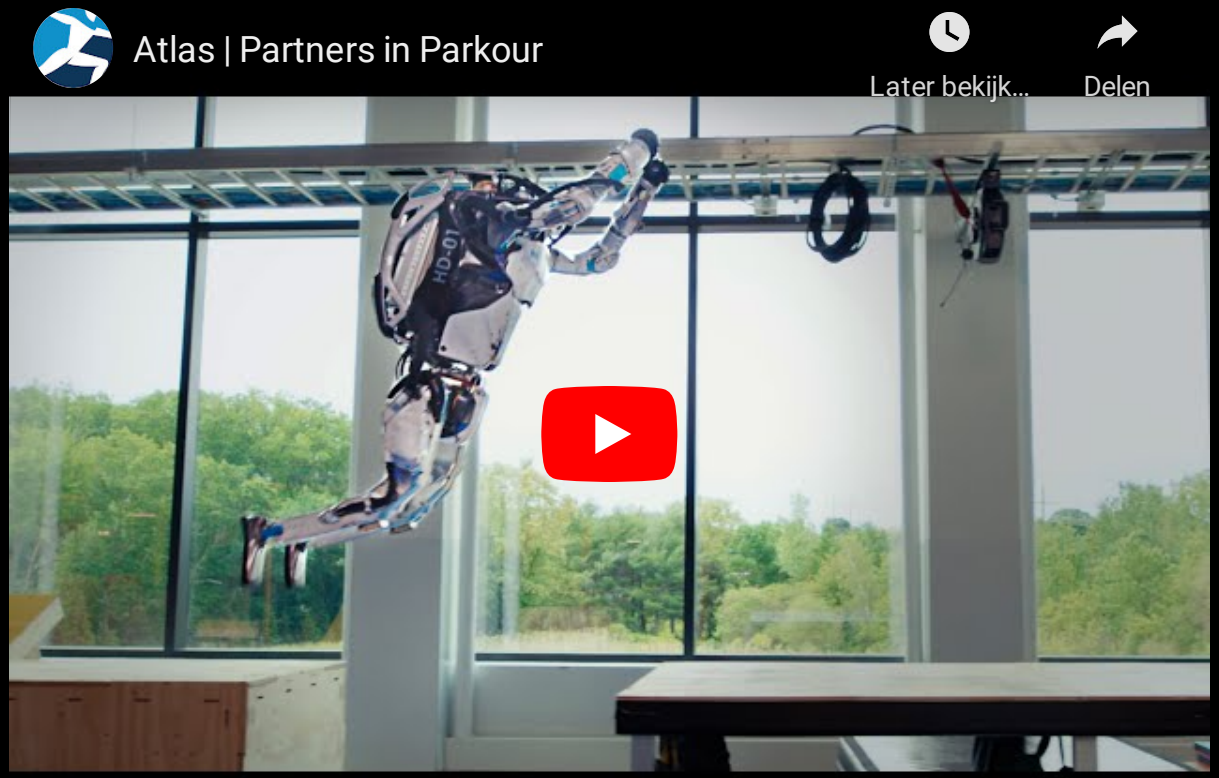


Playing Atari games

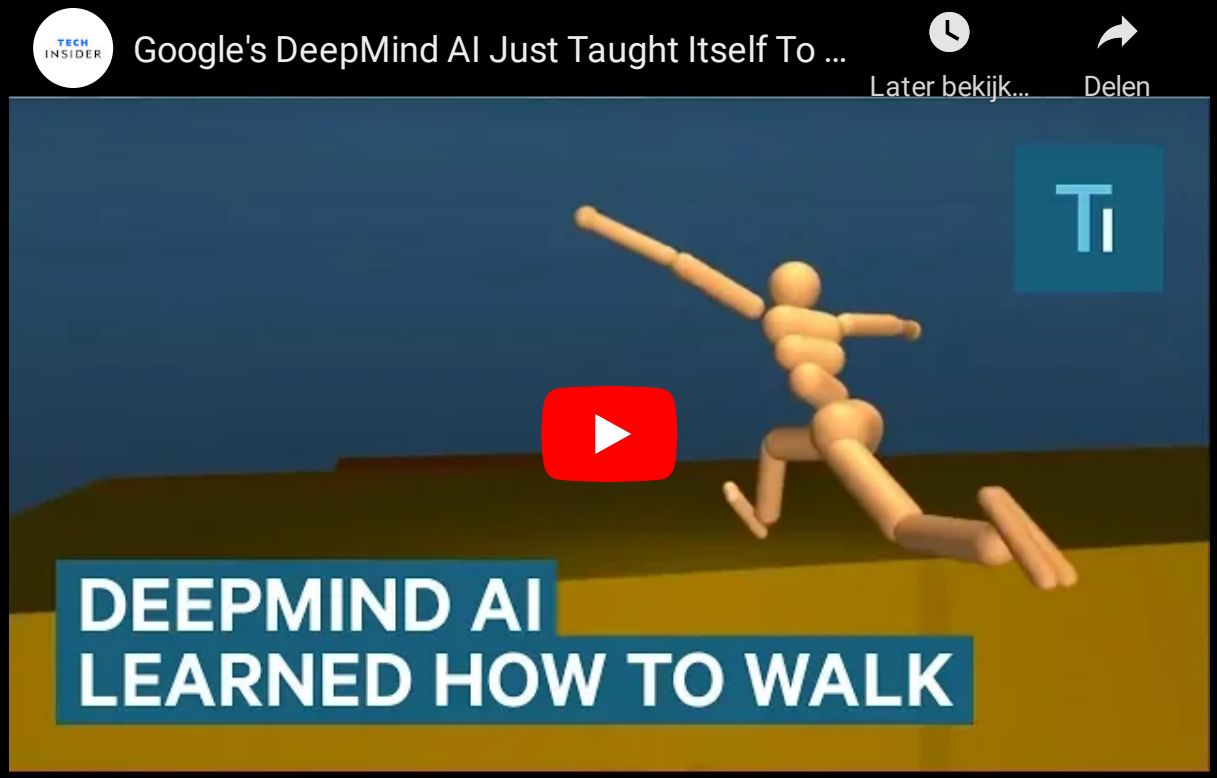


Beat the best human Go players (2016)

Playing soccer (2018)

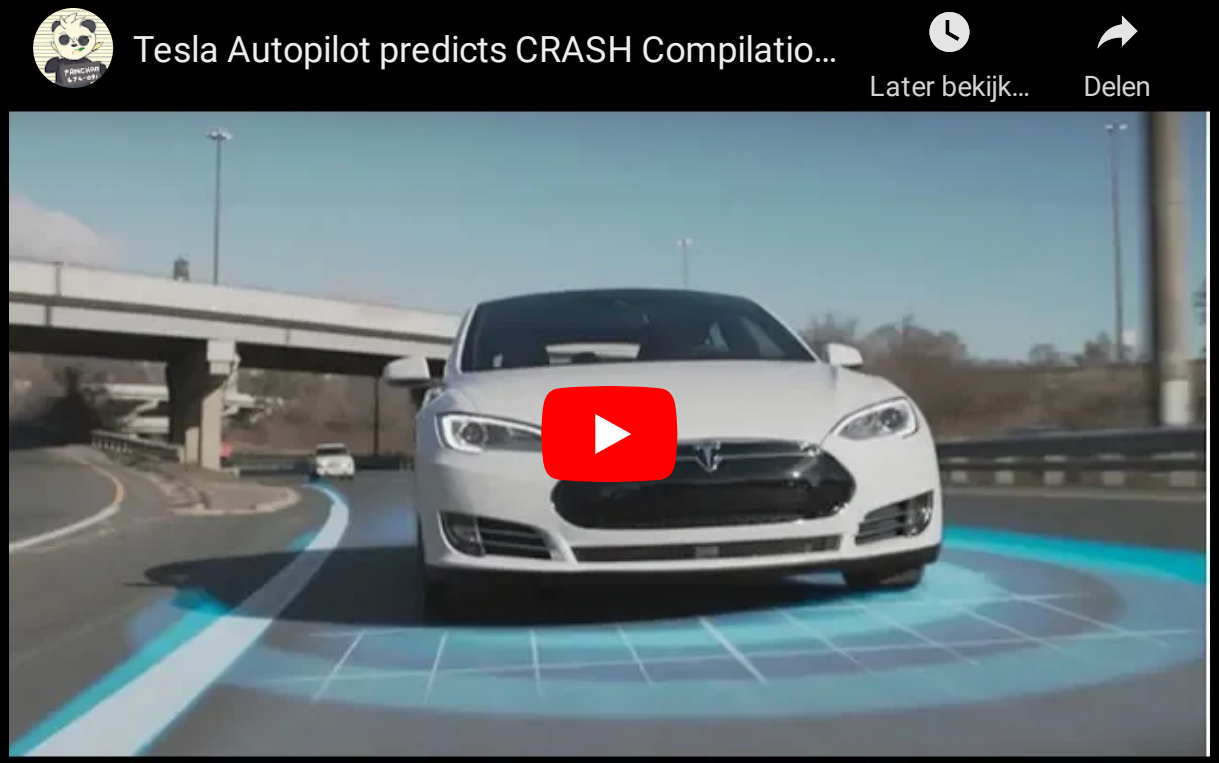


... although some robots might now do better (2021).

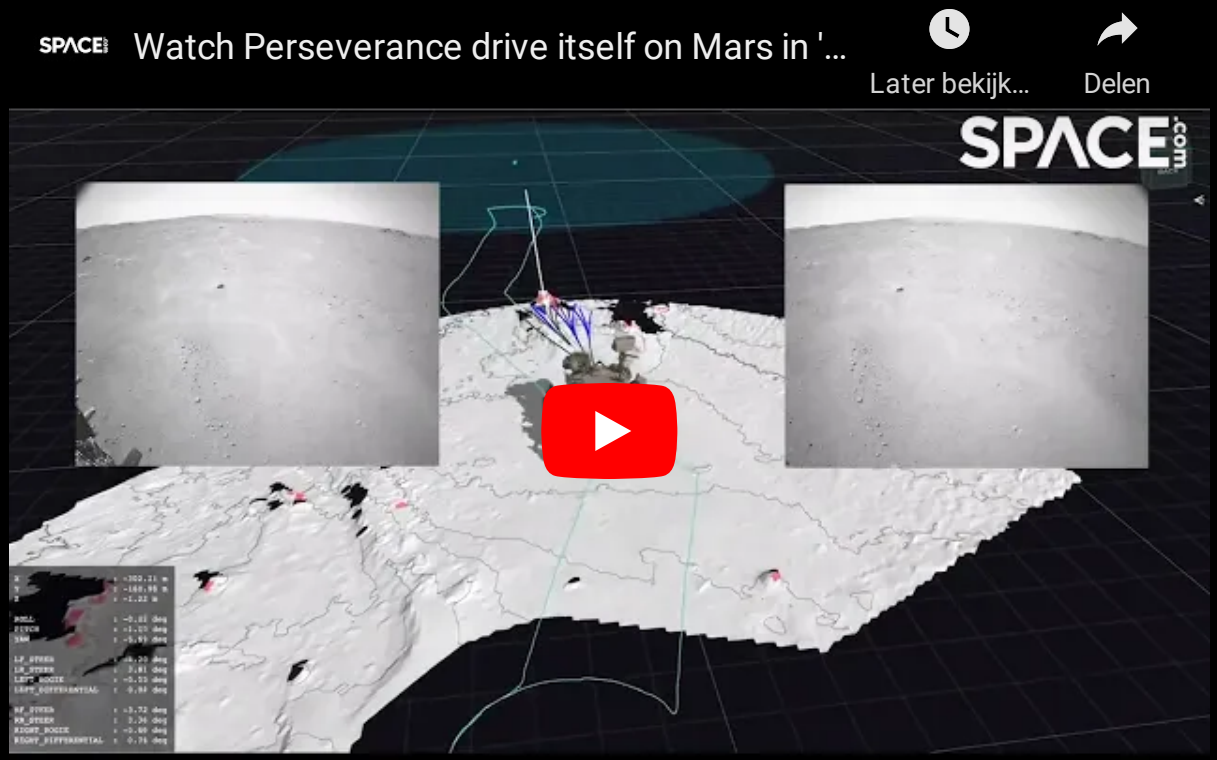


Learning to walk (2017)

Driving a car (NVIDIA, 2016)



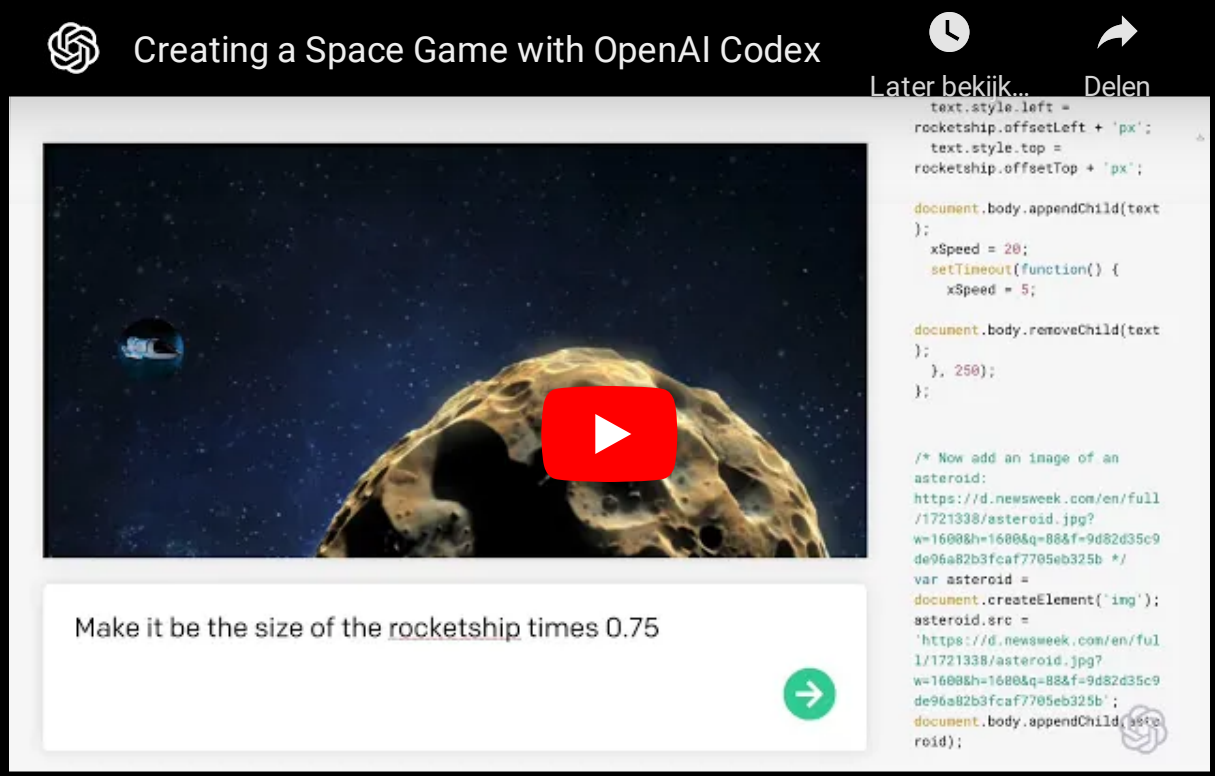
... and preventing accidents.



Driving on Mars.

Detecting skin cancer (2017)

Advance Science (Deepmind, AlphaFold, 2020)



Write computer code (OpenAI, 2021)

Compose music (NVIDIA, 2017)

What is missing?

Intelligence is not just about pattern recognition, which is something most of these works are based on.

It is about modeling the world:

- explaining and understanding what we see;
- imagining things we could see but haven't yet;
- problem solving and planning actions to make these things real;
- building new models as we learn more about the world.

The end.

References

- Turing, Alan M. "Computing machinery and intelligence." Mind 59.236 (1950): 433-460.
- Newell, Allen, and Herbert Simon. "The logic theory machine--A complex information processing system." IRE Transactions on information theory 2.3 (1956): 61-79.
- Chomsky, Noam. "Rules and representations." Behavioral and brain sciences 3.1 (1980): 1-15.