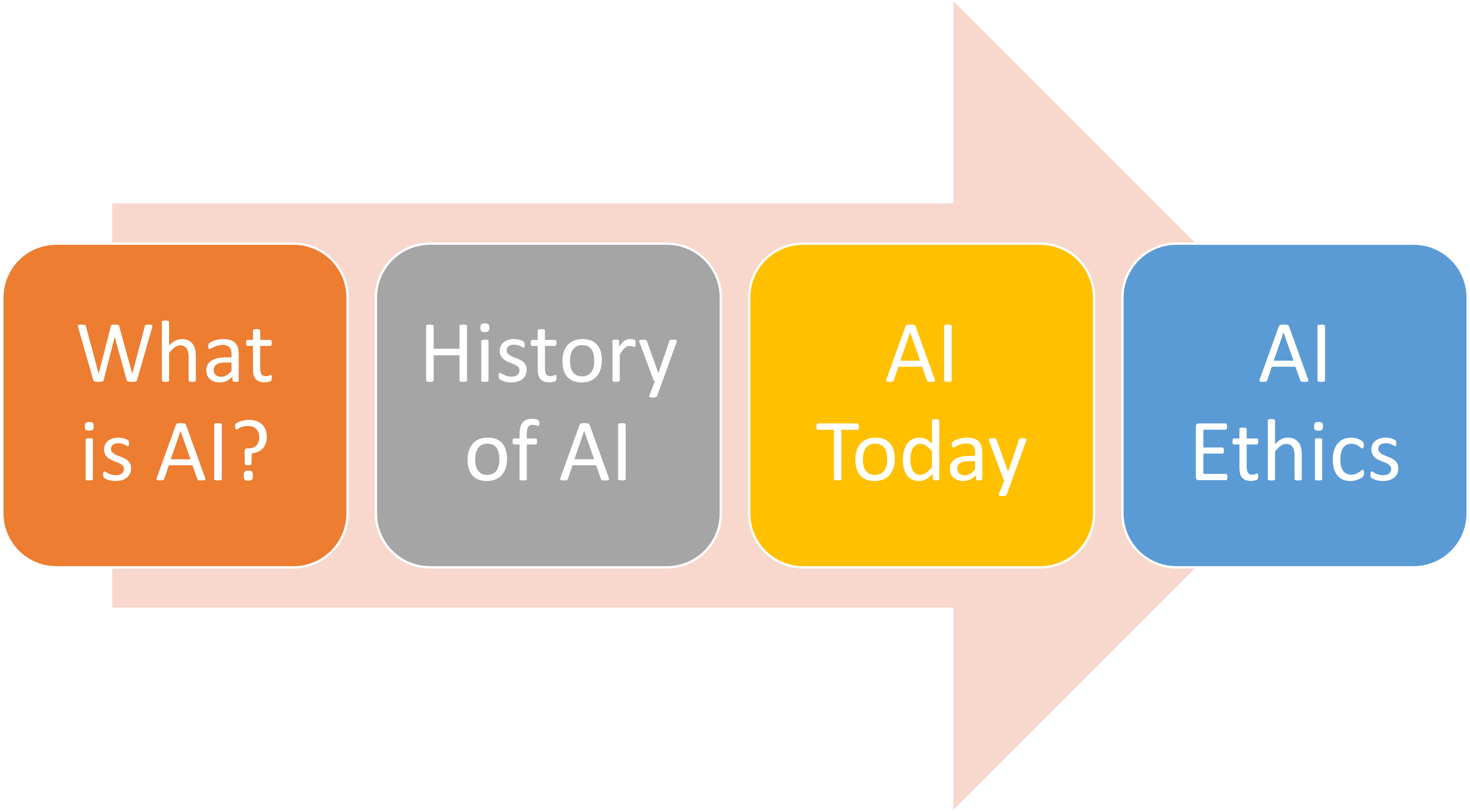
CS 5/7320 Artificial Intelligence

Introduction

AIMA Chapter 1

Slides by Michael Hahsler based on slides by Svetlana Lazepnik with figures and cover art from the AIMA textbook.

Topics



What is AI?

History of AI

AI Today

AI Ethics

What is AI?

ASIMO (**Advanced Step in Innovative Mobility**) is a humanoid robot created by Honda in 2000

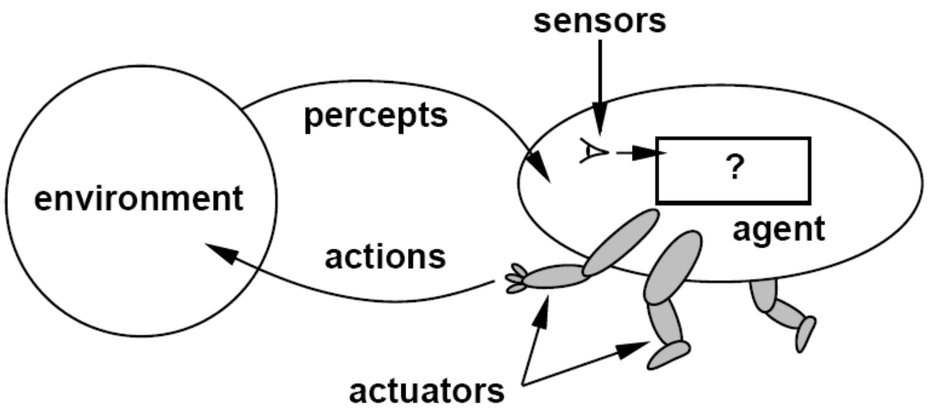
What is it the Goal of AI?

An **artificial general intelligence (AGI)** is a hypothetical intelligent agent which can understand or learn any intellectual task that human beings or other animals can. [Wikipedia entry on AGI]

Narrow AI focuses on solving a specific subproblem.

Intelligent agents need to:

- Represent knowledge
- Reason and plan
- Learn
- Communicate



Agent interacting with the environment [AIMA textbook]

What is it the Goal of AI?

An **artificial general intelligence (AGI)** is a hypothetical intelligent agent which can understand or learn any intellectual task that human beings or other animals can.

Create an agent that

thinks like a human?

acts like a human?

thinks rationally?

acts rationally?

Thinking Like a Human

The brain as an information processing machine.

- Requires scientific theories of how the brain works

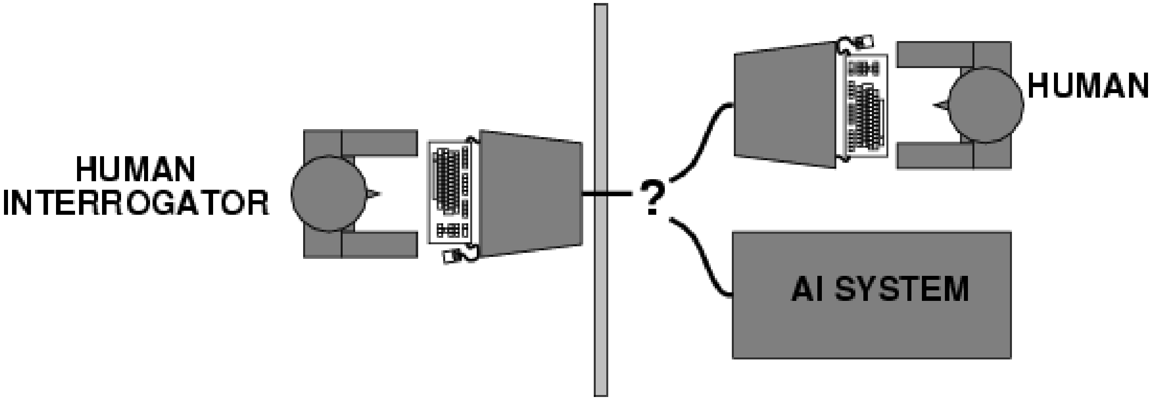
How to understand cognition as a computational process?

- Introspection: try to think about how we think.
- Predict the behavior of human subjects.
- Image the brain, examine neurological data

= Cognitive Sciences

Acting Like a Human

- Alan Turing (1950) "Computing machinery and intelligence"
- The Turing Test tries to define what acting like a human means



- What capabilities would a computer need to have to pass the Turing Test?
  - Natural language processing
  - Knowledge representation
  - Automated reasoning
  - Machine learning

- Turing predicted that by the year 2000, machines would be able to fool 30% of human judges for five minutes. ChatGPT in 2023 is probably doing a lot better than that!

Turing Test: Criticism

What are some potential problems with the Turing Test?

- Some human behavior is not intelligent.
- Some intelligent behavior may not be human.
- Human observers may be easy to fool.
  - A lot depends on expectations.
  - *Anthropomorphic fallacy* (humans tend to humanize things)
  - Imitate intelligence without intelligence. E.g., the chatbots ELIZA (1964).

Is passing the Turing test a good scientific goal?

- Engineering perspective: Not a good way to solve practical problems.
- We can create useful intelligent agents without trying to imitate humans.

Chinese Room Argument

INPUT
DATA
RULE LEDGER
OUTPUT

Thought experiment of John Searle (1980): Imitate intelligence using rules.

What about ChatGPT?

Thinking Rationally

- Idealized or “right” way of thinking.
- **Logic:** Patterns of argument that always yield correct conclusions when supplied with correct premises
  - “Socrates is a man; all men are mortal; therefore, Socrates is mortal.”
  - Beginning with Aristotle (385 BC), philosophers and mathematicians have attempted to formalize the rules of logical thought.
- ***Logic*-based approach to AI:** Describe problem in formal logical notation and apply general deduction procedures to solve it.
- Problems with the logic-based approach to AI
  - Describing real-world problems and knowledge in logical notation is hard.
  - Computational complexity of finding the solution.
  - A lot of intelligent or “rational” behavior in an uncertain world cannot be defined by simple rules.

What about the logical implication

$$study\ hard \Rightarrow A\ in\ AI$$

Should it be

$$study\ hard\ AND\ be\ lucky \Rightarrow A\ in\ AI$$

Acting rationally: Rational Agents

A rational agent acts to achieve the best expected outcome:

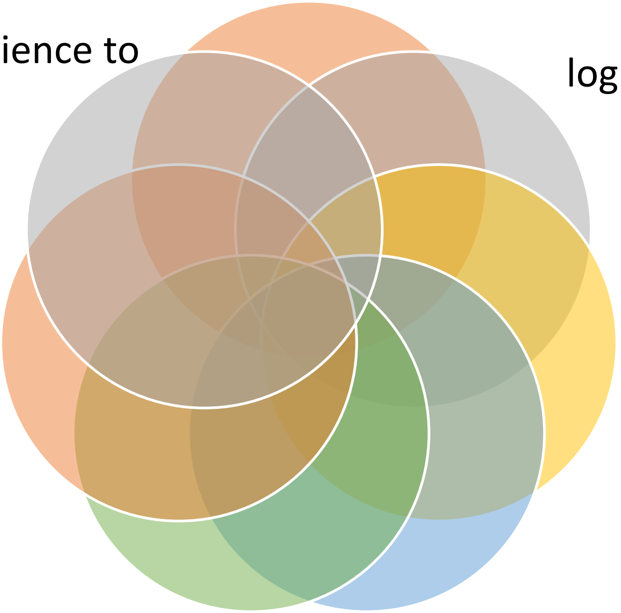
- Goals are application-dependent and are expressed in terms of the **utility of outcomes.**
- Being rational means acting to **maximizing your expected utility.** Expectation means that different outcomes are possible (probabilities).
- In practice, utility optimization is subject to the agent's knowledge and computational constraints (**bounded rationality** or bounded optimality).

Acting rationally: Rational Agents

Advantages of the “expected utility maximization” formulation

- **Generality**: an optimization that goes beyond explicit reasoning with rules.
- **Practicality**: can be adapted to many real-world problems.
- Amenable to good scientific and engineering methodology including simulation and experimentation.
- Only concerns the decisions/actions that are made, not the cognitive process behind them. Avoids philosophy and psychology in favor of a clearly defined objective.

Fields Related to AI



Philosophy
logic, methods of reasoning, mind vs. matter, foundations of learning and knowledge

Machine learning
design of systems that use experience to improve performance

Mathematics
logic, probability, optimization

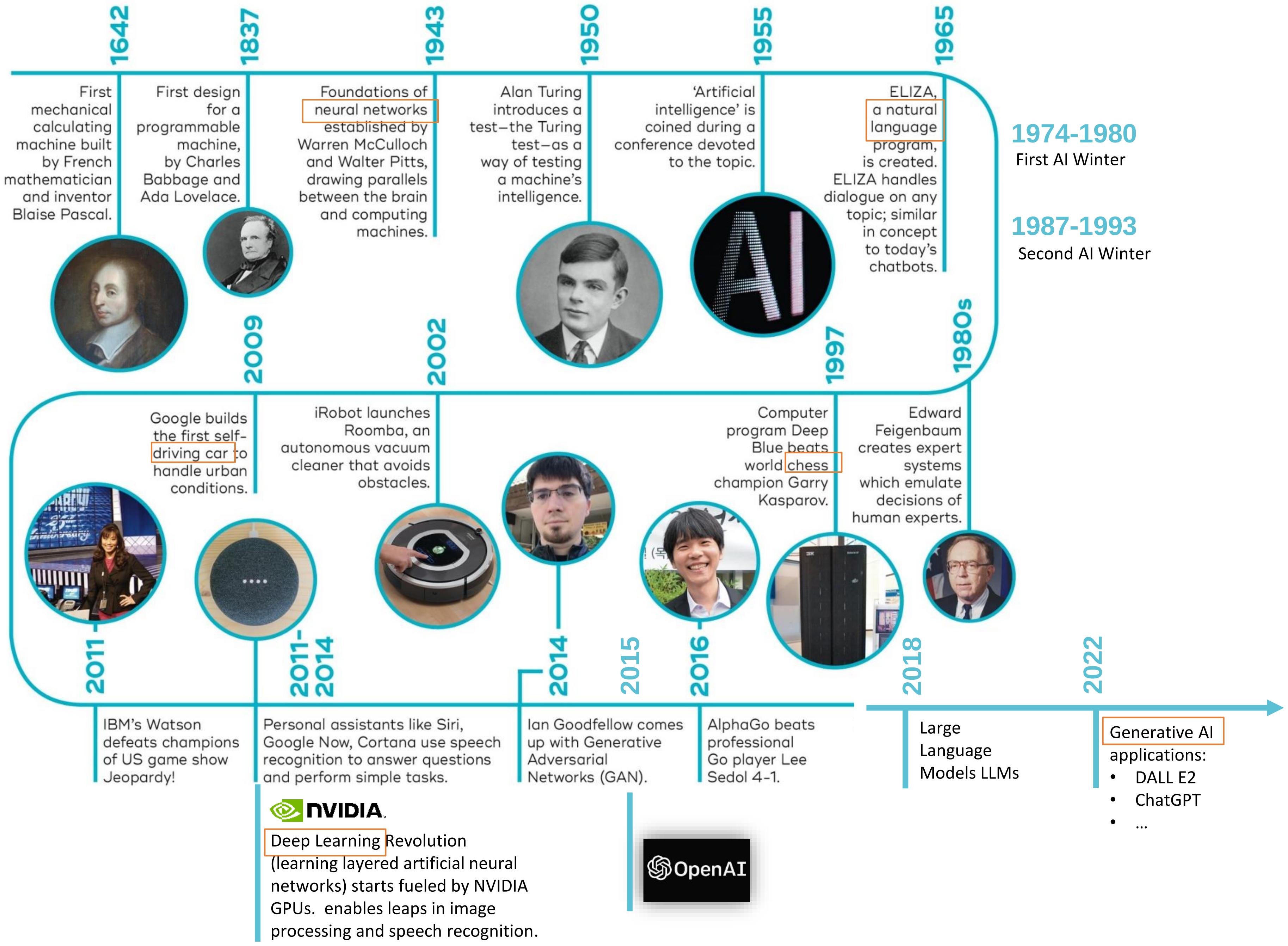
Linguistics
rules of language, language acquisition

Economics
utility, decision theory

Cognitive science
computational models of human intelligence

Neuroscience
biological basis of intelligence

History of AI



1642

First mechanical calculating machine built by French mathematician and inventor Blaise Pascal.

1837

First design for a programmable machine, by Charles Babbage and Ada Lovelace.

1943

Foundations of neural networks established by Warren McCulloch and Walter Pitts, drawing parallels between the brain and computing machines.

1950

Alan Turing introduces a test—the Turing test—as a way of testing a machine's intelligence.

1955

'Artificial intelligence' is coined during a conference devoted to the topic.

1965

ELIZA, a natural language program, is created. ELIZA handles dialogue on any topic; similar in concept to today's chatbots.

1974-1980

First AI Winter

1987-1993

Second AI Winter

1980s

Edward Feigenbaum creates expert systems which emulate decisions of human experts.

1997

Computer program Deep Blue beats world chess champion Garry Kasparov.

2002

iRobot launches Roomba, an autonomous vacuum cleaner that avoids obstacles.

2009

Google builds the first self-driving car to handle urban conditions.

2011

IBM's Watson defeats champions of US game show Jeopardy!

2011-2014

Personal assistants like Siri, Google Now, Cortana use speech recognition to answer questions and perform simple tasks.

NVIDIA

Deep Learning Revolution (learning layered artificial neural networks) starts fueled by NVIDIA GPUs. enables leaps in image processing and speech recognition.

2014

Ian Goodfellow comes up with Generative Adversarial Networks (GAN).

2015

OpenAI

2016

AlphaGo beats professional Go player Lee Sedol 4-1.

2018

Large Language Models LLMs

2022

Generative AI applications:

- DALL E2
- ChatGPT
- …

Source: https://qbi.uq.edu.au/brain/intelligent-machines/history-artificial-intelligence + additions

AI is harder than originally thought

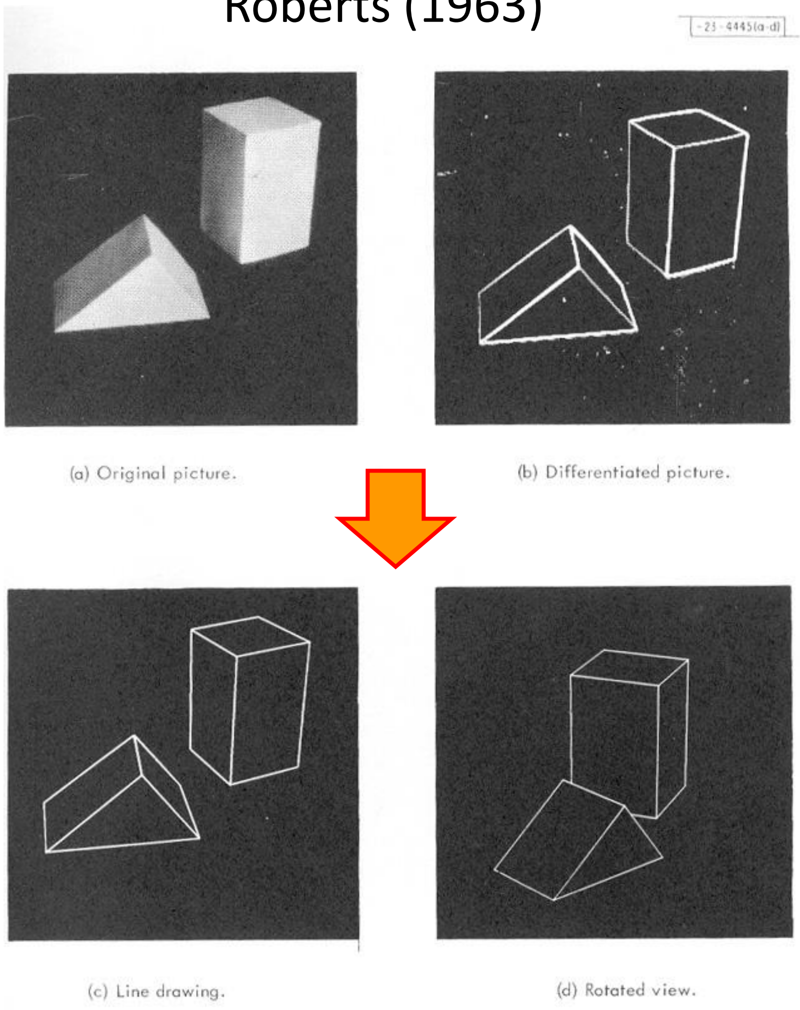
Herbert Simon, 1957

“It is not my aim to surprise or shock you--- but … there are now in the world machines that think, that learn and that create. Moreover, their ability to do these things is going to increase rapidly until---in a visible future---the range of problems they can handle will be coextensive with the range to which human mind has been applied. ***More precisely: within 10 years a computer would be chess champion, and an important new mathematical theorem would be proved by a computer****.”*

Simon’s prediction came true --- but 40 years later instead of 10

From Blocks World to Modern Object Recognition

Roberts (1963)



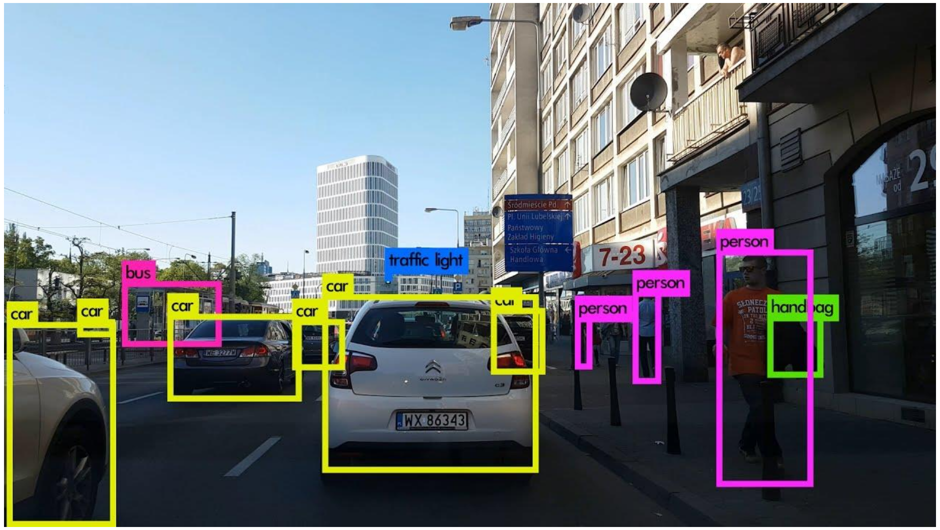
(a) Original picture.

(b) Differentiated picture.

(c) Line drawing.

(d) Rotated view.

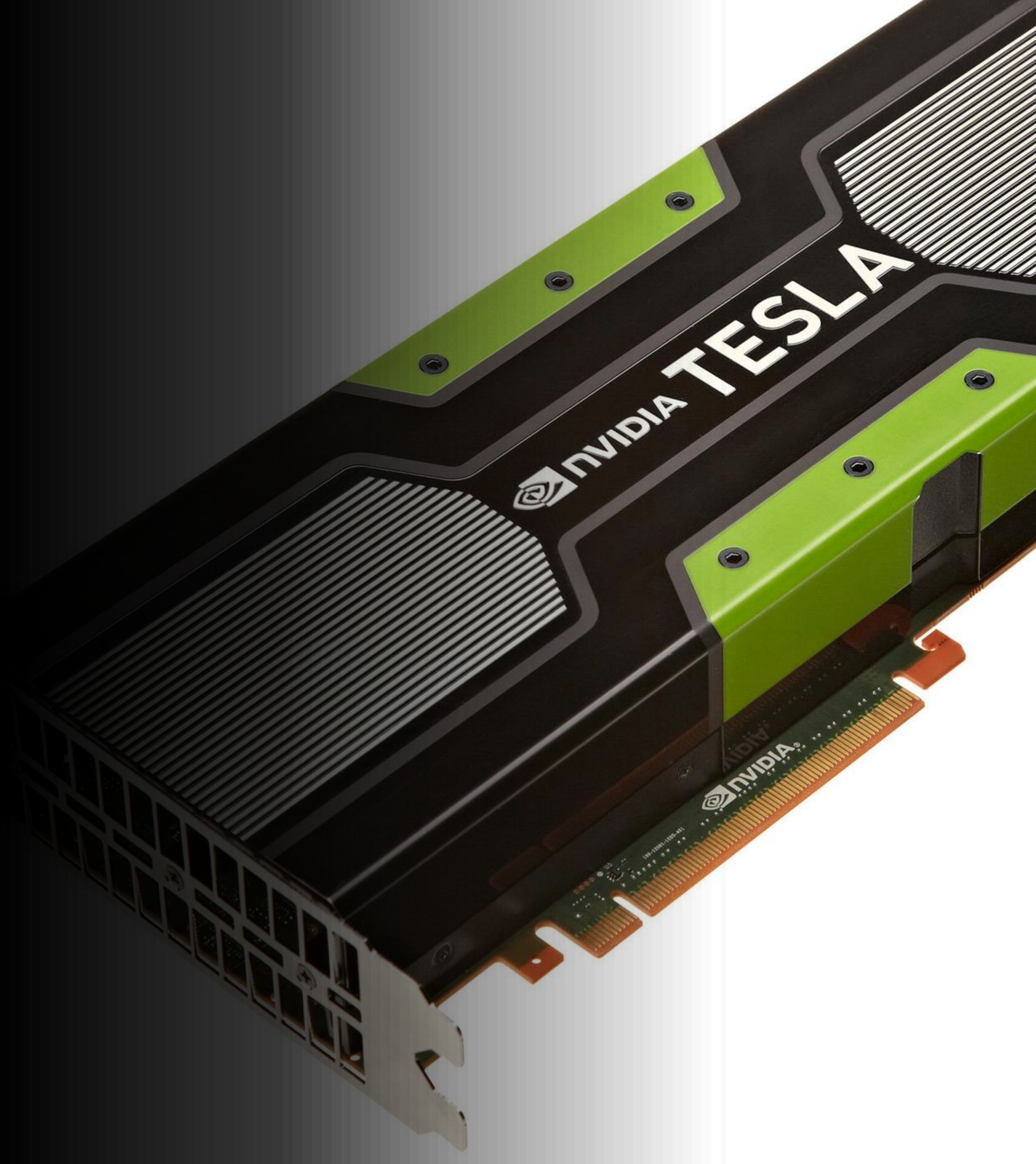
Now



This is a lot harder!
But we can do it now….

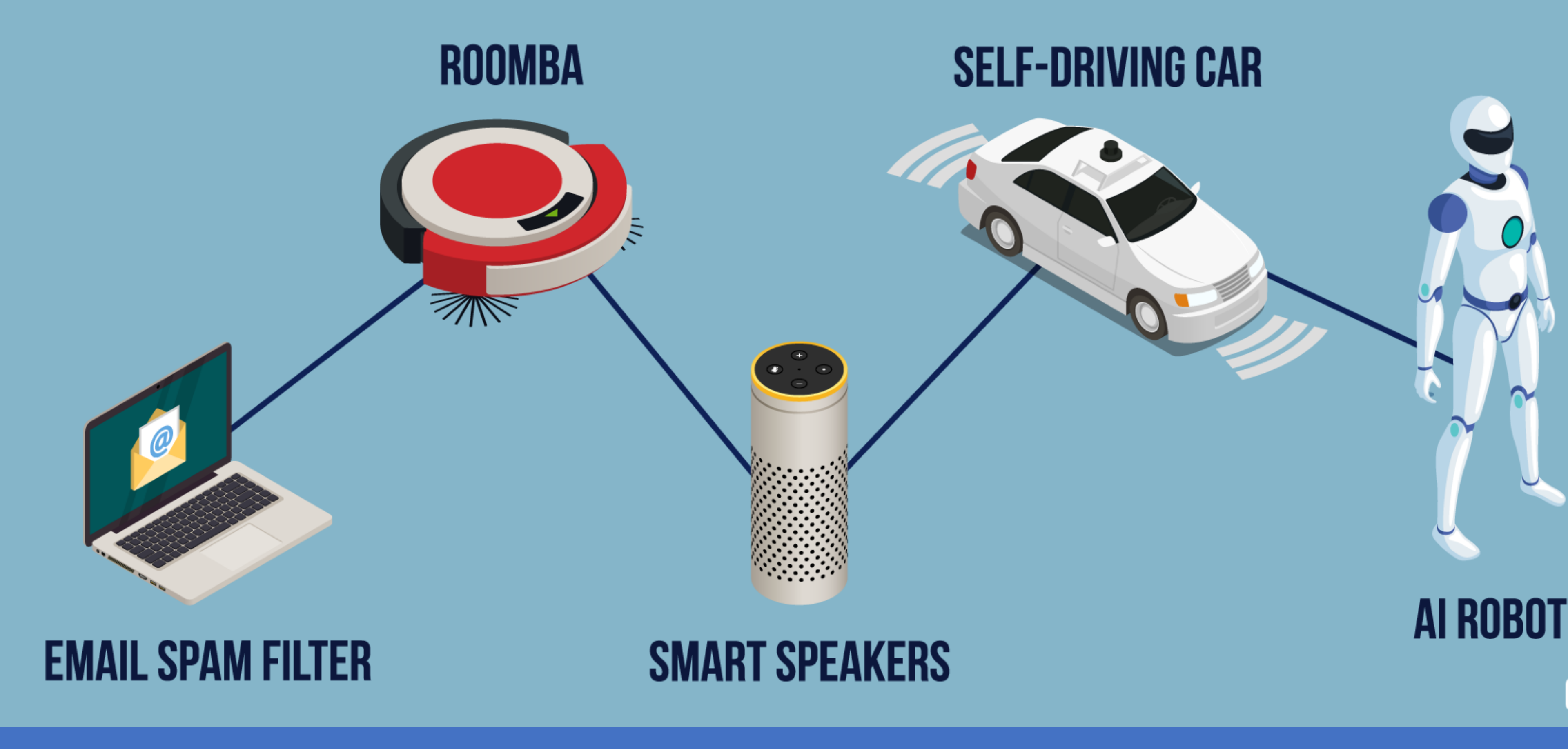
What accounts for recent successes in AI?

- Faster computers and specialized hardware (GPUs).
- Lots of data (the Internet, text, sensors) and storage (cloud)
- Dominance of machine learning.
- New optimization methods (deep learning).



The AI Effect:
AI gets no respect?

- As soon as a machine gets good at performing some task, the task is no longer considered to require much intelligence
- Calculating ability used to be prized – not anymore
- Chess was thought to require high intelligence
  - Now, massively parallel computers essentially use brute force search to beat grand masters
- Learning once thought uniquely human
  - Ada Lovelace (1842): “The Analytical Engine has no pretensions to *originate* anything. It can do *whatever we know how to order it* to perform.”
  - Now machine learning is a well-developed discipline
- Similar picture with animal intelligence… “Even a monkey can do this!”


ROOMBA
SELF-DRIVING CAR
EMAIL SPAM FILTER
SMART SPEAKERS
AI ROBOT

AI Today

IBM Watson

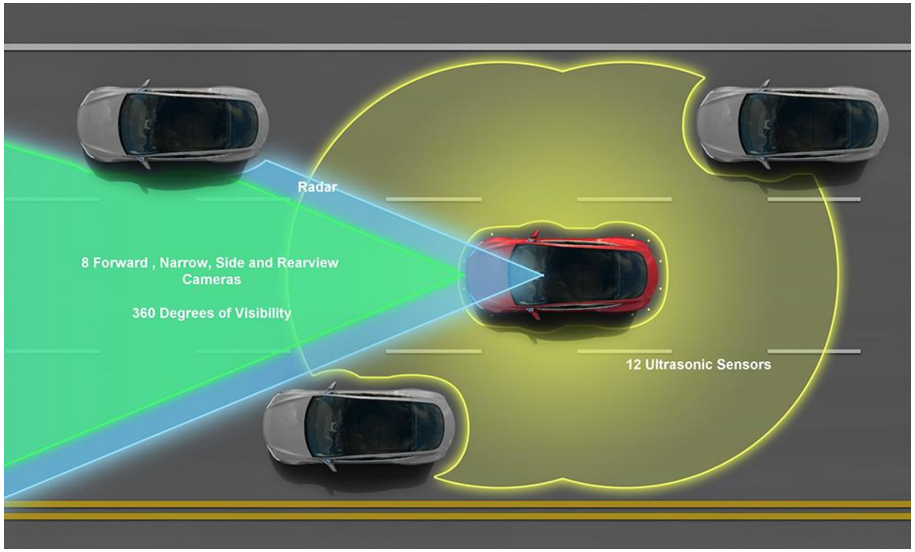
- http://www.research.ibm.com/deepqa/
- NY Times article
- Trivia demo
- YouTube video
- IBM Watson wins on Jeopardy (February 2011)

Self-driving cars

SAE Levels
Level 1 - Driver Assistance
Level 2 - Partial Automation
Level 3 - Conditional Automation
Level 4 - High Automation
Level 5 - Full Automation

Components

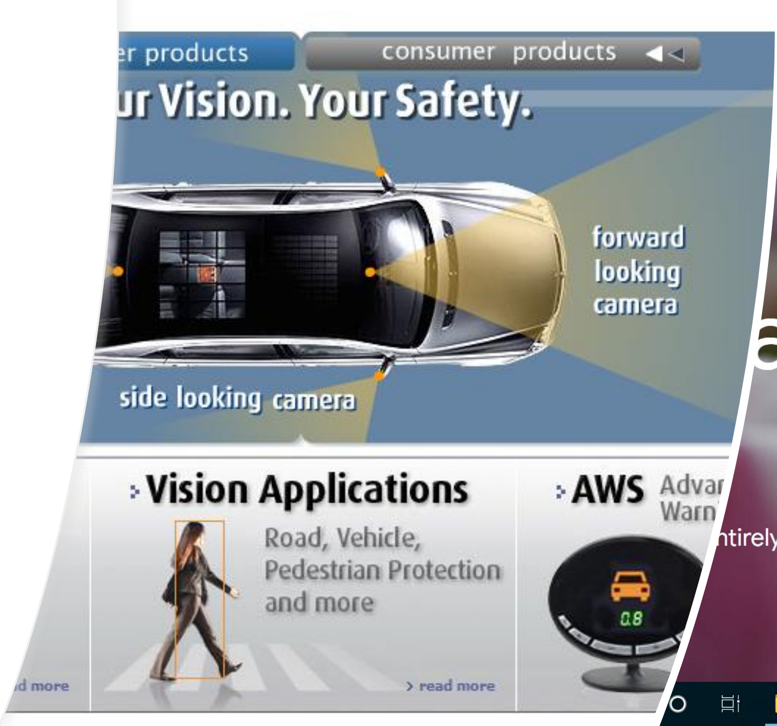
- Sensing
- Maps
- Path planning

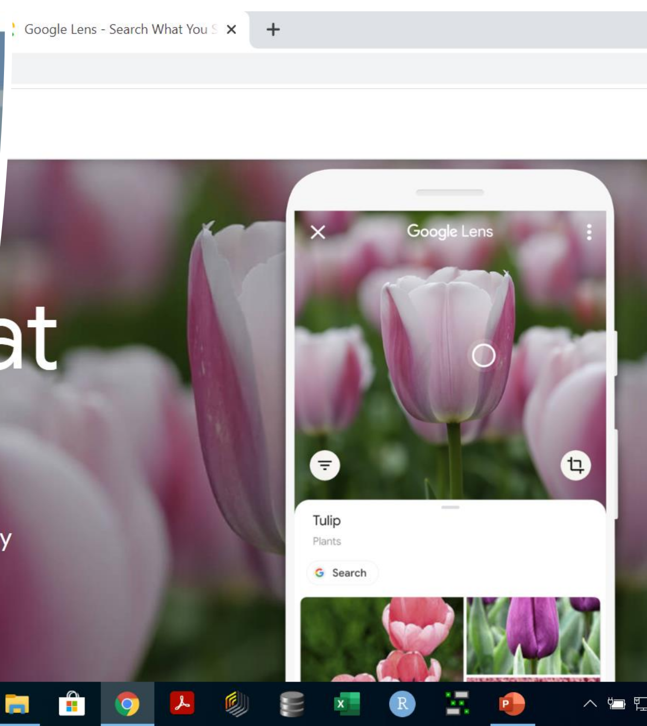

Radar
8 Forward , Narrow, Side and Rearview Cameras
360 Degrees of Visibility
12 Ultrasonic Sensors

Vision and Image Processing

- OCR, read license plates, handwriting recognition (e.g., mail sorting)
- Face detection/recognition: now standard for smart phone cameras
- Visual search: Google Google Lense
- Vehicle safety systems: [Mobileye](#)
- Image generation

All these technologies can now operate now at superhuman performance.



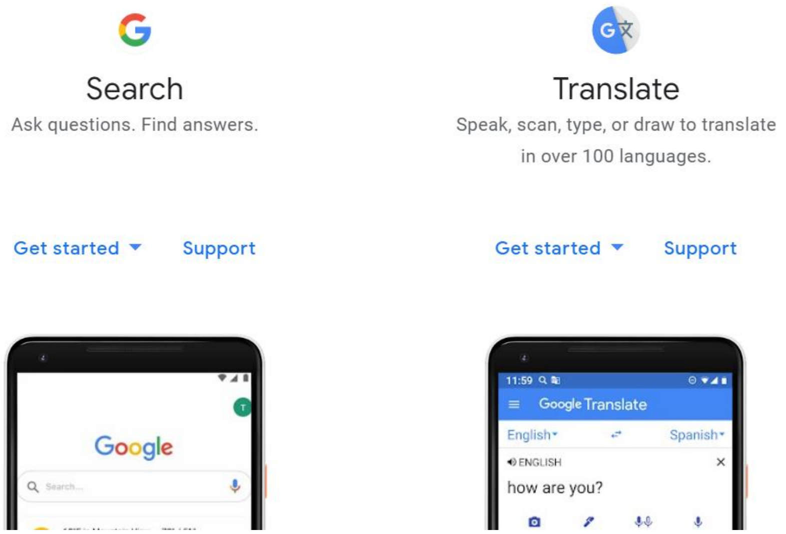


Natural Language

- Text-to-speech synthesis
- Automatic speech recognition
- Machine translation
- Text generation (Question/Answer systems)

All these technologies can now operate now with close to or even superhuman performance.

Language understanding is still elusive!



Search

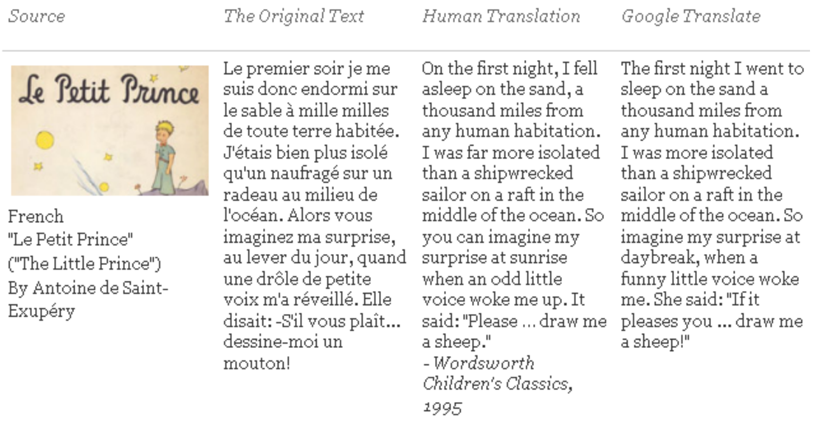
Ask questions. Find answers.

Get started ▾ Support

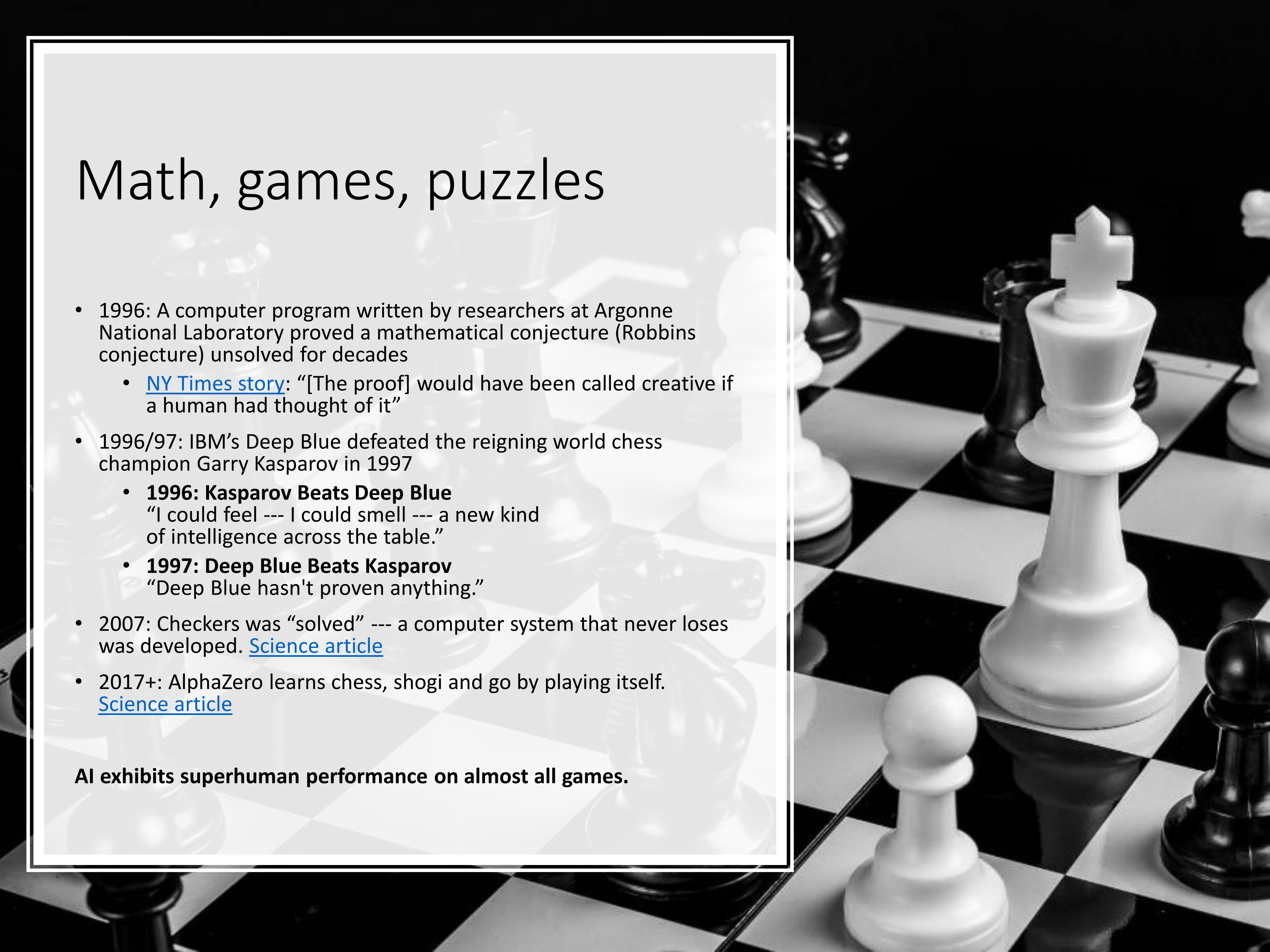
Translate

Speak, scan, type, or draw to translate in over 100 languages.

Get started ▾ Support



Source	*The Original Text*	*Human Translation*	*Google Translate*
Le Petit Prince French "Le Petit Prince" ("The Little Prince") By Antoine de Saint-Exupéry	Le premier soir je me suis donc endormi sur le sable à mille milles de toute terre habitée. J'étais bien plus isolé qu'un naufragé sur un radeau au milieu de l'océan. Alors vous imaginez ma surprise, au lever du jour, quand une drôle de petite voix m'a réveillé. Elle disait: -S'il vous plaît... dessine-moi un mouton!	On the first night, I fell asleep on the sand, a thousand miles from any human habitation. I was far more isolated than a shipwrecked sailor on a raft in the middle of the ocean. So you can imagine my surprise at sunrise when an odd little voice woke me up. It said: "Please ... draw me a sheep." *- Wordsworth Children's Classics, 1995*	The first night I went to sleep on the sand a thousand miles from any human habitation. I was more isolated than a shipwrecked sailor on a raft in the middle of the ocean. So imagine my surprise at daybreak, when a funny little voice woke me. She said: "If it pleases you ... draw me a sheep!"

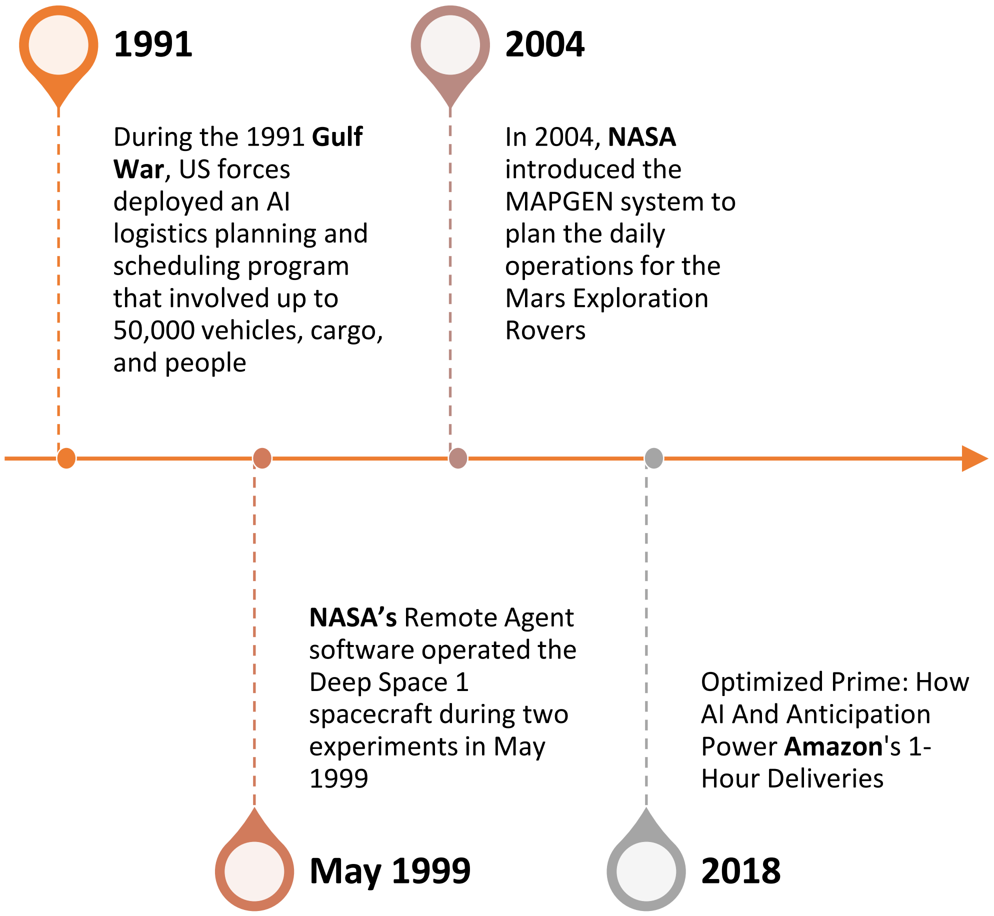


Math, games, puzzles

- 1996: A computer program written by researchers at Argonne National Laboratory proved a mathematical conjecture (Robbins conjecture) unsolved for decades
  - NY Times story: "[The proof] would have been called creative if a human had thought of it"
- 1996/97: IBM's Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
  - **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."
- 2007: Checkers was "solved" --- a computer system that never loses was developed. Science article
- 2017+: AlphaZero learns chess, shogi and go by playing itself. Science article

AI exhibits superhuman performance on almost all games.

Logistics Scheduling Planning



1991

During the 1991 **Gulf War**, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people

May 1999

NASA’s Remote Agent software operated the Deep Space 1 spacecraft during two experiments in May 1999

2004

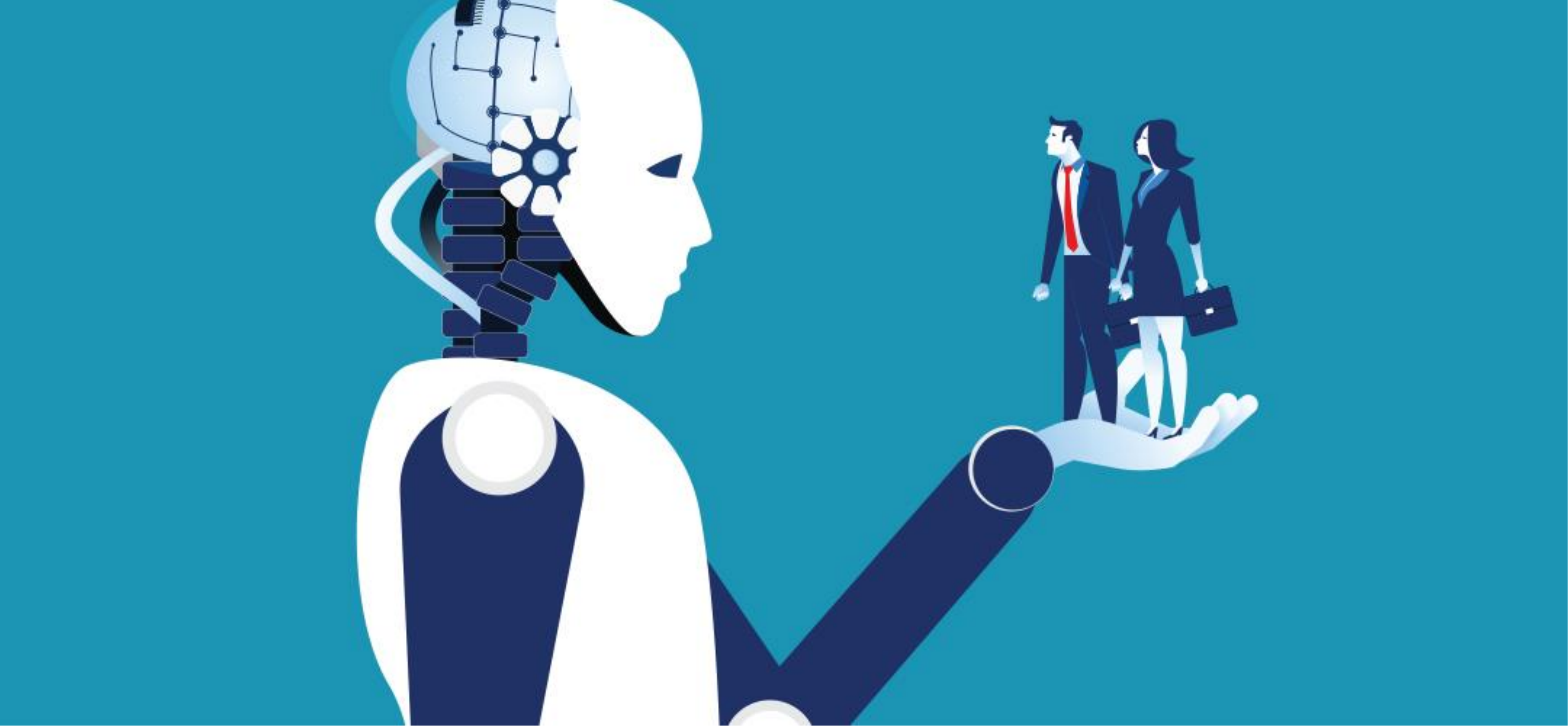
In 2004, **NASA** introduced the MAPGEN system to plan the daily operations for the Mars Exploration Rovers

2018

Optimized Prime: How AI And Anticipation Power **Amazon**'s 1-Hour Deliveries

Information agents

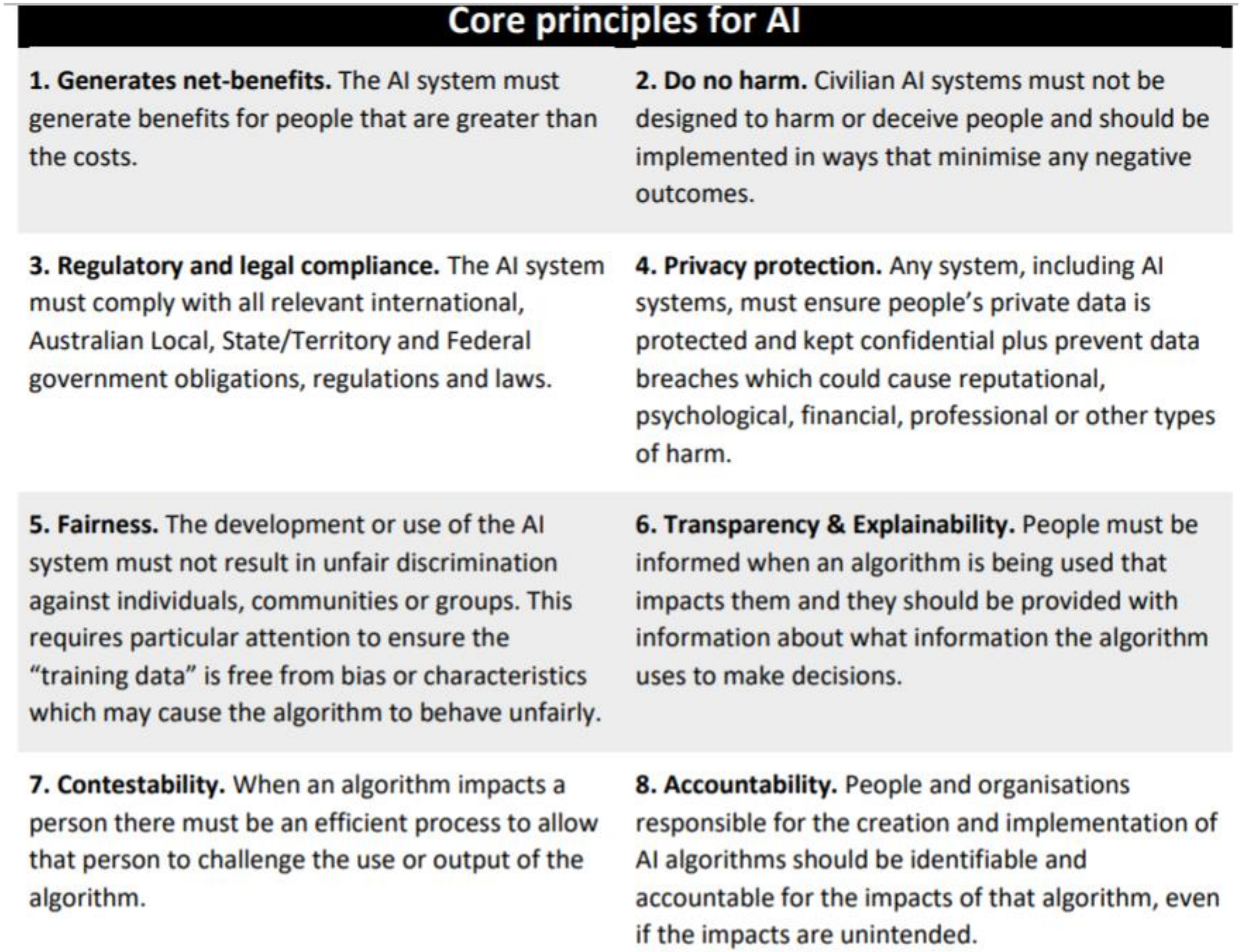
- Natural Language interface to other agents
- Search engines
- Recommendation systems
- Spam filtering
- Automated helpdesks
- Medical diagnosis systems
- Fraud detection
- Automated trading



AI Ethics

A new Frontier for Fairness and Freedom

Australia: AI Ethics Framework for Industry
A set of **voluntary AI Ethics Principles** (2019)



Core principles for AI

1. Generates net-benefits. The AI system must generate benefits for people that are greater than the costs.

2. Do no harm. Civilian AI systems must not be designed to harm or deceive people and should be implemented in ways that minimise any negative outcomes.

3. Regulatory and legal compliance. The AI system must comply with all relevant international, Australian Local, State/Territory and Federal government obligations, regulations and laws.

4. Privacy protection. Any system, including AI systems, must ensure people's private data is protected and kept confidential plus prevent data breaches which could cause reputational, psychological, financial, professional or other types of harm.

5. Fairness. The development or use of the AI system must not result in unfair discrimination against individuals, communities or groups. This requires particular attention to ensure the "training data" is free from bias or characteristics which may cause the algorithm to behave unfairly.

6. Transparency & Explainability. People must be informed when an algorithm is being used that impacts them and they should be provided with information about what information the algorithm uses to make decisions.

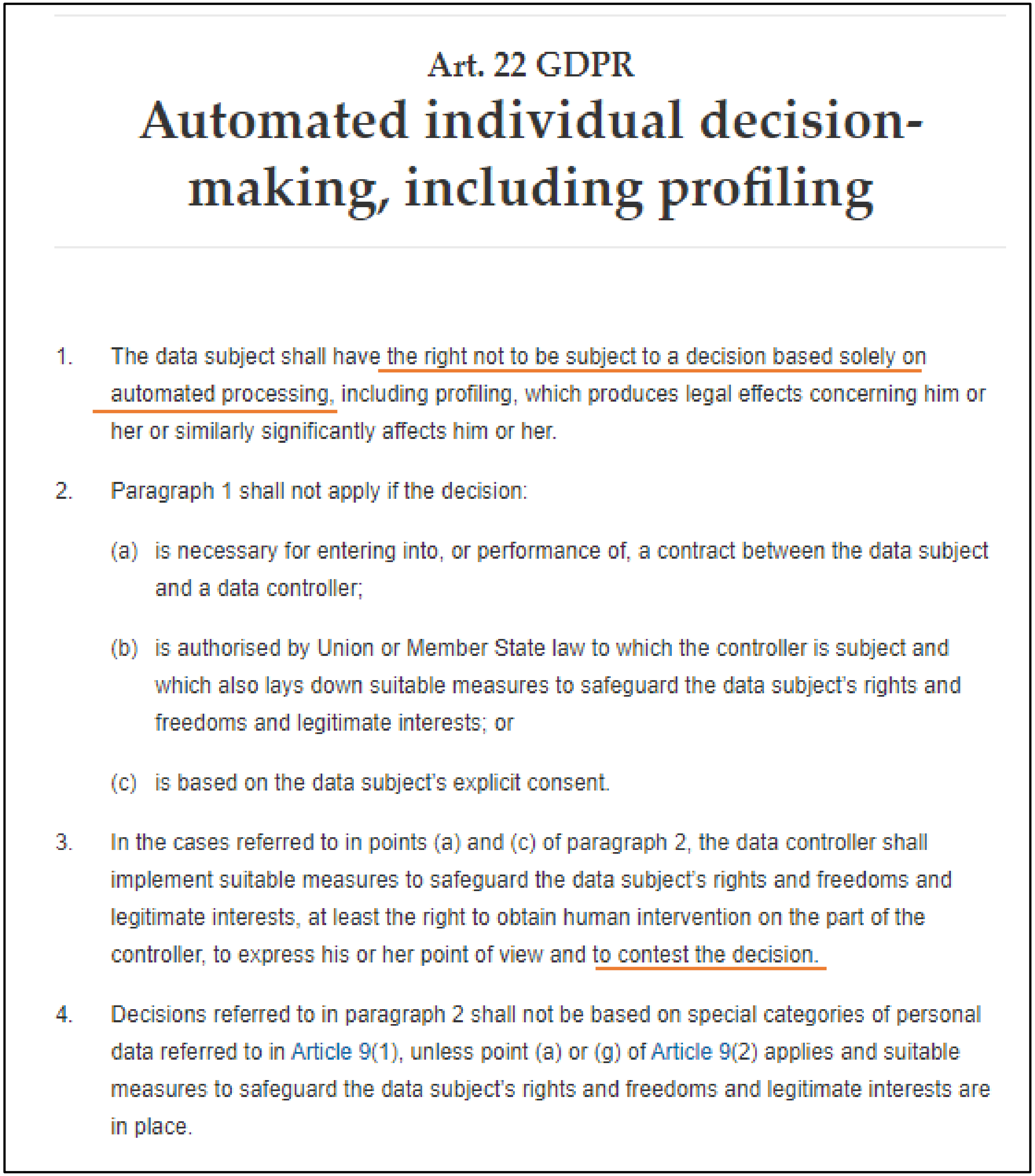
7. Contestability. When an algorithm impacts a person there must be an efficient process to allow that person to challenge the use or output of the algorithm.

8. Accountability. People and organisations responsible for the creation and implementation of AI algorithms should be identifiable and accountable for the impacts of that algorithm, even if the impacts are unintended.

https://consult.industry.gov.au/strategic-policy/artificial-intelligence-ethics-framework/supporting_documents/ArtificialIntelligenceethicsframeworkdiscussionpaper.pdf

European Union

Has regulations since 2016 included in the General Data Protection Regulation (GDPR)



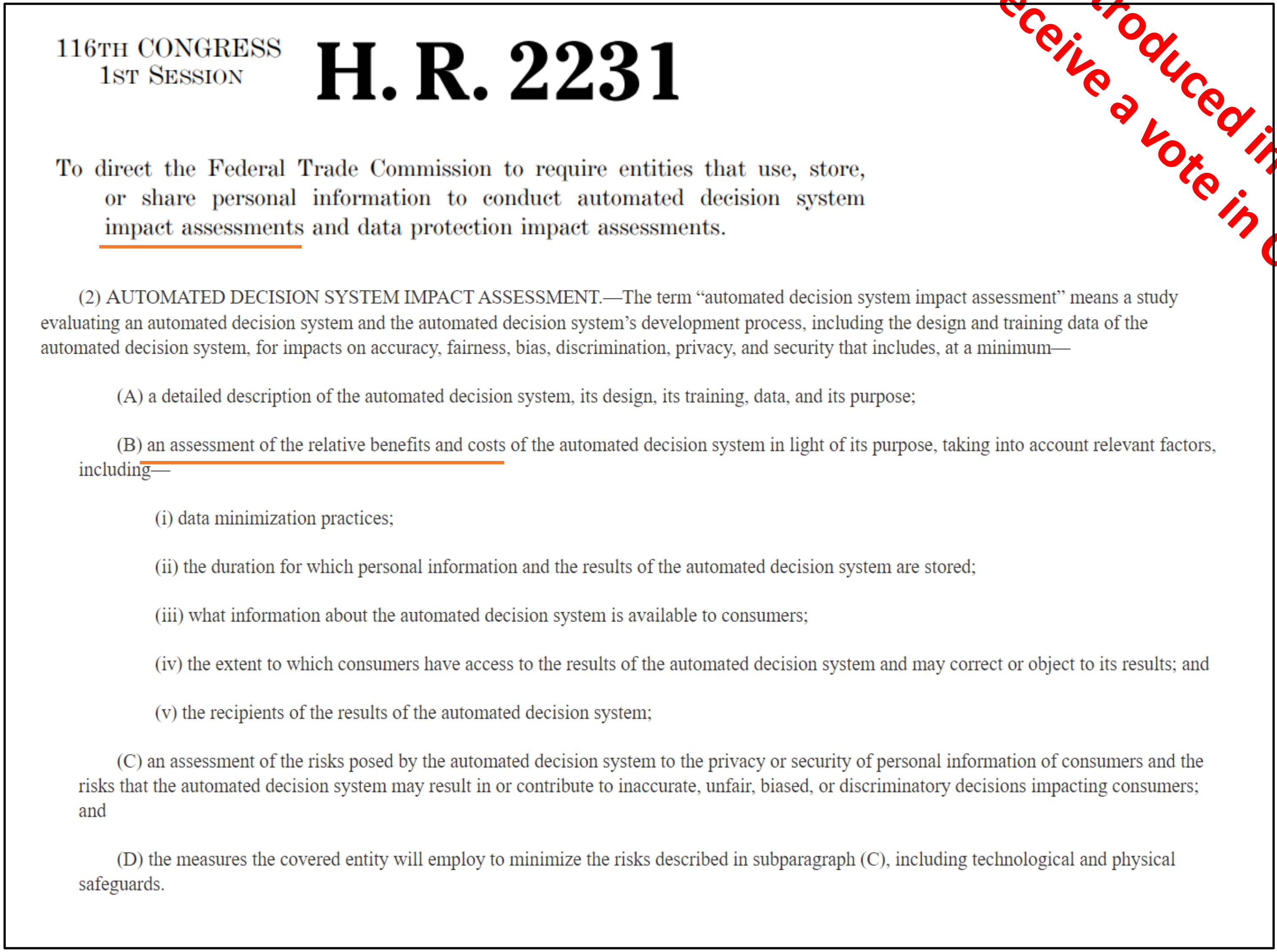
Art. 22 GDPR

Automated individual decision-making, including profiling

1. The data subject shall have the right not to be subject to a decision based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her.
2. Paragraph 1 shall not apply if the decision:
   (a) is necessary for entering into, or performance of, a contract between the data subject and a data controller;
   (b) is authorised by Union or Member State law to which the controller is subject and which also lays down suitable measures to safeguard the data subject's rights and freedoms and legitimate interests; or
   (c) is based on the data subject's explicit consent.
3. In the cases referred to in points (a) and (c) of paragraph 2, the data controller shall implement suitable measures to safeguard the data subject's rights and freedoms and legitimate interests, at least the right to obtain human intervention on the part of the controller, to express his or her point of view and to contest the decision.
4. Decisions referred to in paragraph 2 shall not be based on special categories of personal data referred to in Article 9(1), unless point (a) or (g) of Article 9(2) applies and suitable measures to safeguard the data subject's rights and freedoms and legitimate interests are in place.

[Art. 22 GDPR – Automated individual decision-making, including]

The US



116th CONGRESS
1st Session

H. R. 2231

To direct the Federal Trade Commission to require entities that use, store, or share personal information to conduct automated decision system impact assessments and data protection impact assessments.

(2) AUTOMATED DECISION SYSTEM IMPACT ASSESSMENT.—The term "automated decision system impact assessment" means a study evaluating an automated decision system and the automated decision system's development process, including the design and training data of the automated decision system, for impacts on accuracy, fairness, bias, discrimination, privacy, and security that includes, at a minimum—

(A) a detailed description of the automated decision system, its design, its training, data, and its purpose;

(B) an assessment of the relative benefits and costs of the automated decision system in light of its purpose, taking into account relevant factors, including—

(i) data minimization practices;

(ii) the duration for which personal information and the results of the automated decision system are stored;

(iii) what information about the automated decision system is available to consumers;

(iv) the extent to which consumers have access to the results of the automated decision system and may correct or object to its results; and

(v) the recipients of the results of the automated decision system;

(C) an assessment of the risks posed by the automated decision system to the privacy or security of personal information of consumers and the risks that the automated decision system may result in or contribute to inaccurate, unfair, biased, or discriminatory decisions impacting consumers; and

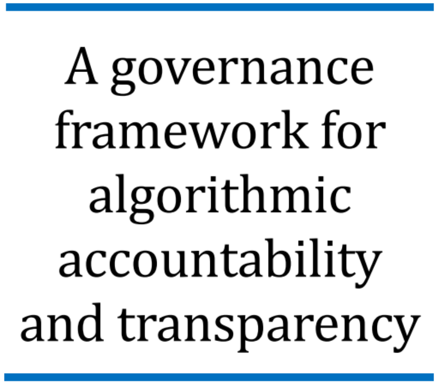
(D) the measures the covered entity will employ to minimize the risks described in subparagraph (C), including technological and physical safeguards.

Did not receive a vote in Congress.

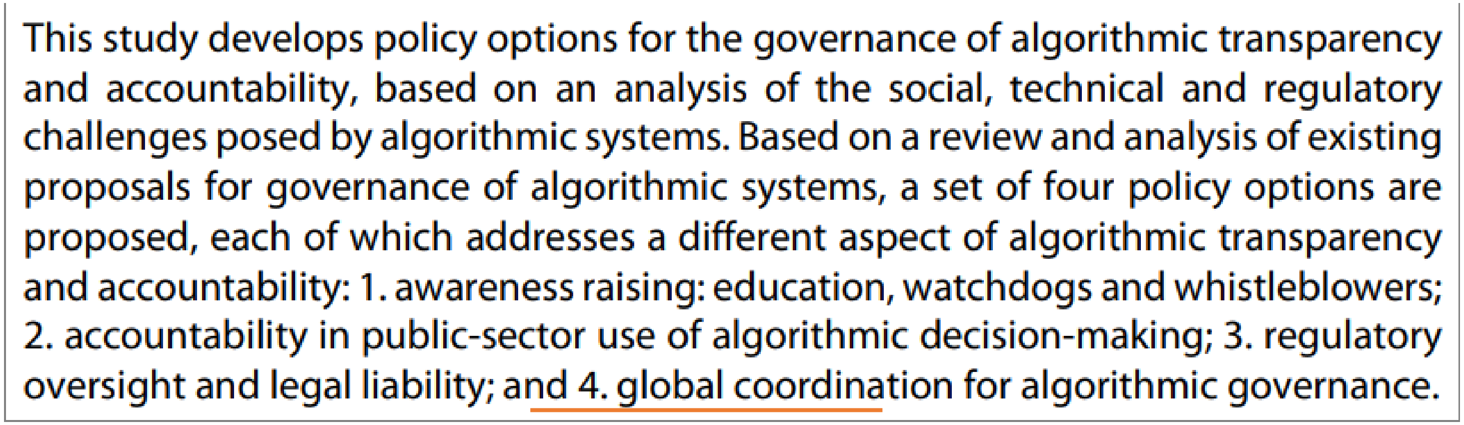
Bill Introduced in 2019

European Union Study (2019)

European Parliament



A governance framework for algorithmic accountability and transparency



This study develops policy options for the governance of algorithmic transparency and accountability, based on an analysis of the social, technical and regulatory challenges posed by algorithmic systems. Based on a review and analysis of existing proposals for governance of algorithmic systems, a set of four policy options are proposed, each of which addresses a different aspect of algorithmic transparency and accountability: 1. awareness raising: education, watchdogs and whistleblowers; 2. accountability in public-sector use of algorithmic decision-making; 3. regulatory oversight and legal liability; and 4. global coordination for algorithmic governance.

https://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_STU(2019)624262

Algorithmic Bias and Fairness

“**Algorithmic bias** describes systematic and repeatable errors in a computer system that create unfair outcomes, such as privileging one arbitrary group of users over others” Wikipedia

Pre-existing bias

- Social and institutional norms influence design and training data choices.
- For example: Evaluate job applicants for a job which is historically almost exclusively held by males.

Technical bias

- Limitations of a program or computational power.
- For example: instead of a random sample, the program uses the first n data points.

Emergent bias

- Use of algorithms for new data without checking for bias (e.g., existing correlations in the data).
- Use of an algorithm for an unanticipated application.

What type of AI do we cover in this course?

Create a narrow AI agent that

~~thinks like a human?~~

~~acts like a human?~~

~~thinks rationally?~~

acts rationally.

That is, use machines to solve a specific hard problem that traditionally would have been thought to require human intelligence.