

Artificial Intelligence and Machine Learning Past, Present, and Future

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Lisboa, Portugal

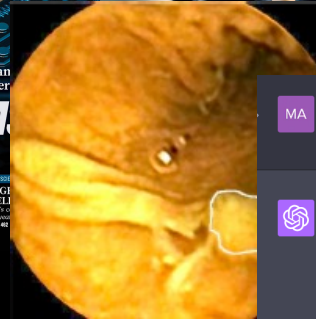


ELLIS Unit Lisbon

COST INTERACT, Lisbon, 2024

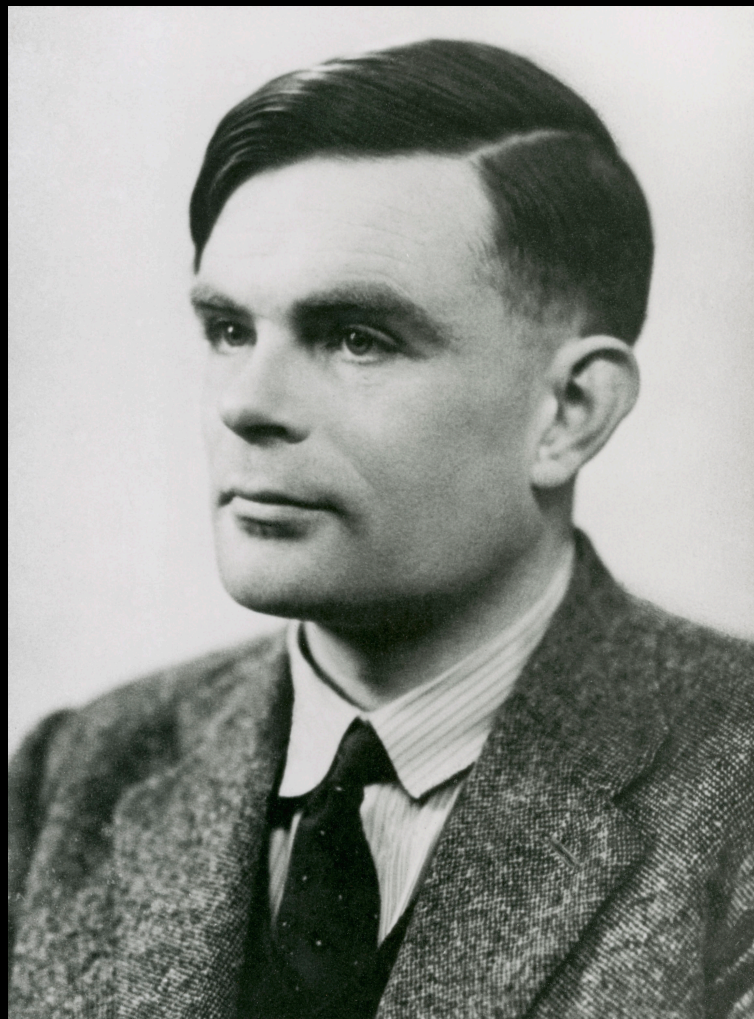
Artificial Intelligence (AI):

- **Simulation of intelligence** by machines (namely, computers)
- Behaviour of an (artificial) system that **humans** see as **intelligent**



MA Provide a short definition of what is artificial intelligence.

Artificial Intelligence (AI) is a field of computer science dedicated to the creation of systems capable of performing tasks that normally require human intelligence. These tasks include learning from experience, understanding natural language, recognizing patterns, solving problems, making decisions, and exhibiting creativity. The goal of AI is to make machines smarter and more human-like in their functioning, and it ranges from simple rule-based systems to complex machine learning and deep learning models.



M I N D
A QUARTERLY REVIEW
OF
PSYCHOLOGY AND PHILOSOPHY

— — — — —
I.—COMPUTING MACHINERY AND
INTELLIGENCE

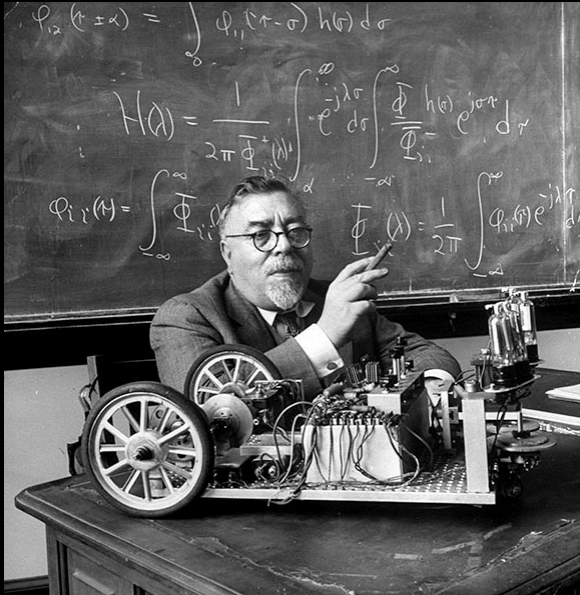
BY A. M. TURING

1. *The Imitation Game.*

I PROPOSE to consider the question, 'Can machines think?' This should begin with definitions of the meaning of the terms 'machine' and 'think'. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words 'machine' and 'think' are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, 'Can machines think?' is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.

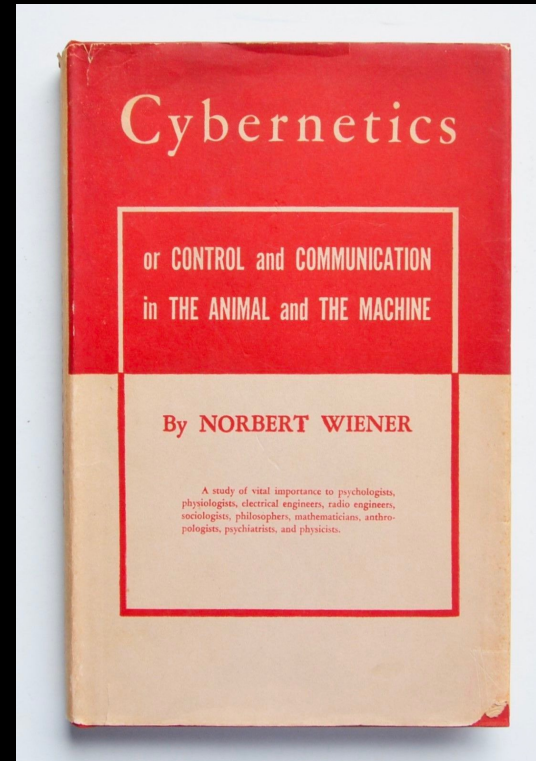
The new form of the problem can be described in terms of a game which we call the 'imitation game'. It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart

Cybernetics: Norbert Wiener



one of the great mathematicians of the 20th century

formalized the concept of **feedback** control



1948

“a study of vital importance to psychologists, physiologists, electrical engineers, radio engineers, sociologists, phylosophers, mathematicians, anthropologists, psychiatrists, and physicists.”

1956 Dartmouth Conference: The Founding Fathers of AI



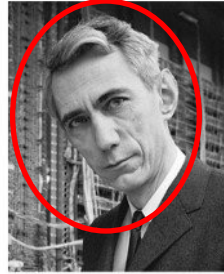
John MacCarthy

Turing award



Marvin Minsky

Turing award



Claude Shannon



Ray Solomonoff

Turing award



Alan Newell

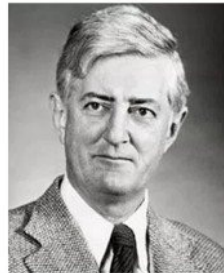


Herbert Simon

Turing award
Nobel prize



Arthur Samuel



Oliver Selfridge



Nathaniel Rochester

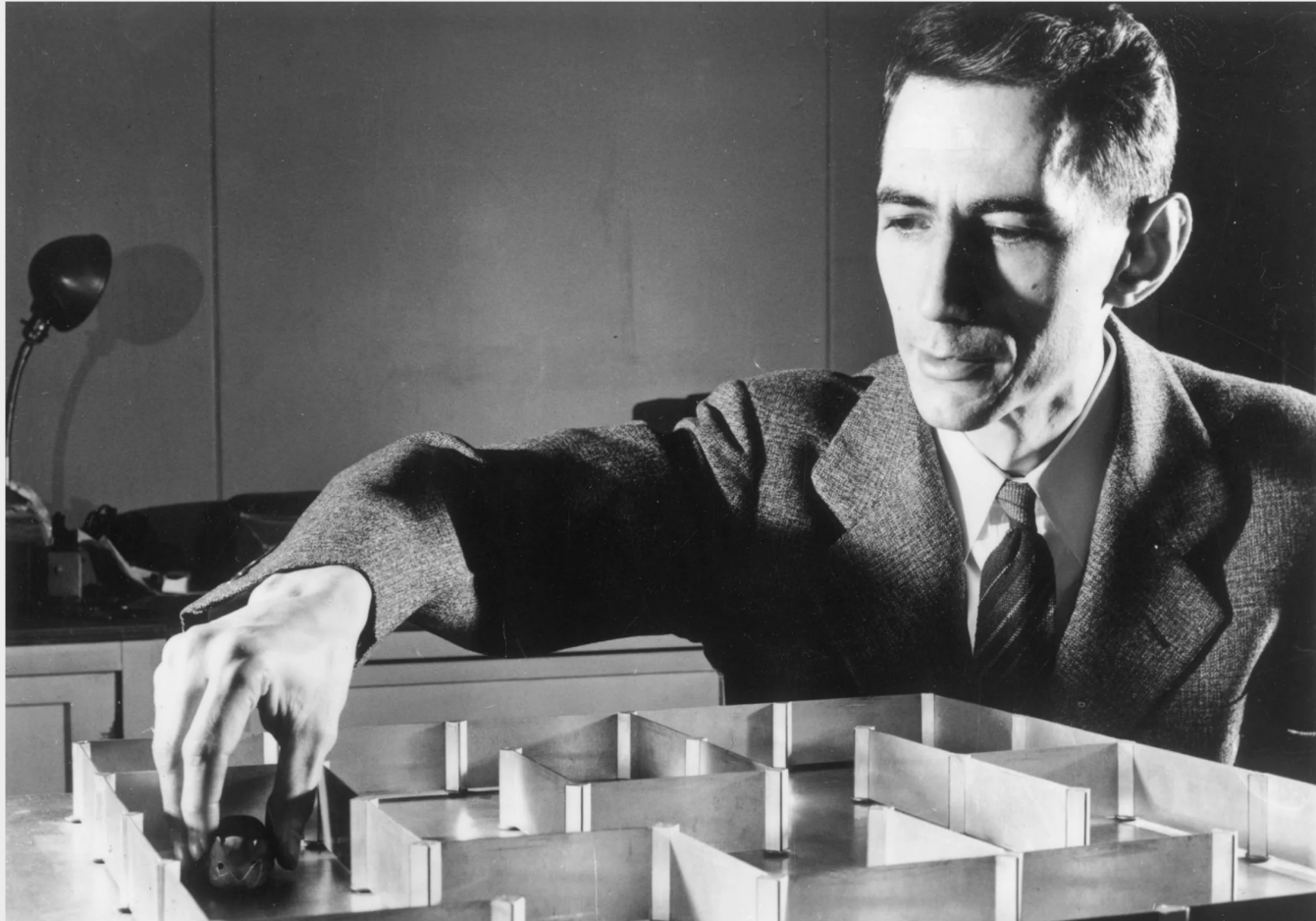


Trenchard More

How Claude Shannon Helped Kick-start Machine Learning

> The “father of information theory” also paved the way for AI

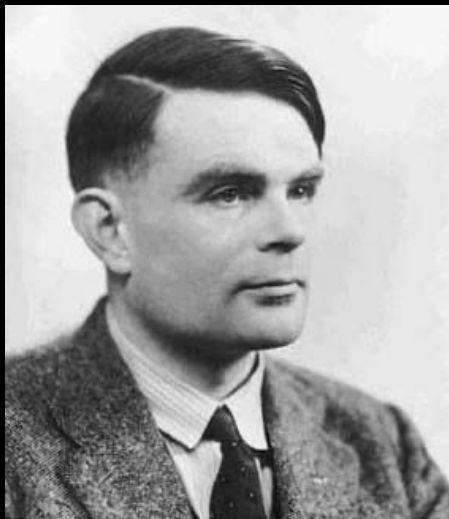
BY [RODNEY BROOKS](#) | 25 JAN 2022 | 3 MIN READ | [🔖](#)



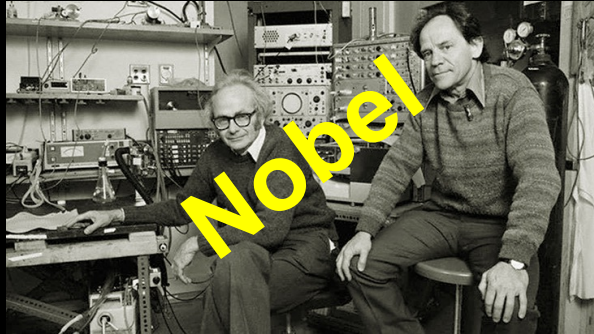
Turing and I had an awful lot in common, and we would talk about that kind of question.

He had already written his famous paper about Turing Machines, so called, as they call them now, Turing Machines. They didn't call them that then.

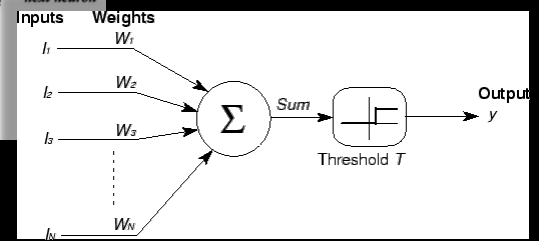
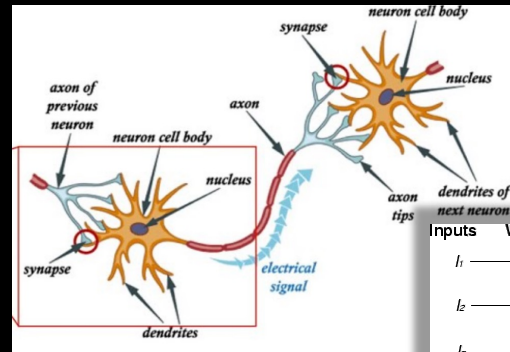
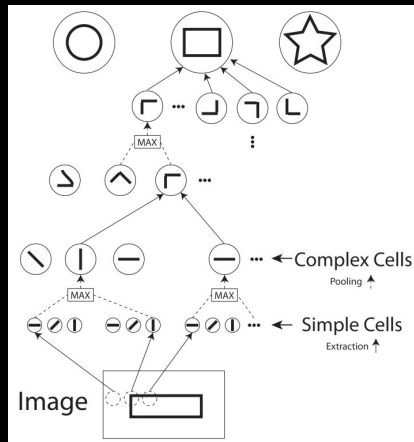
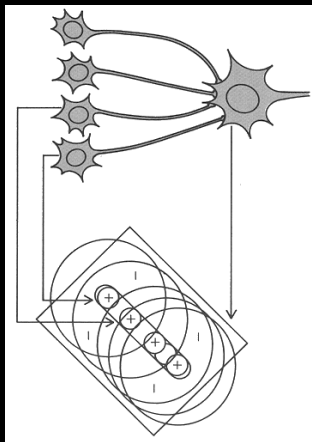
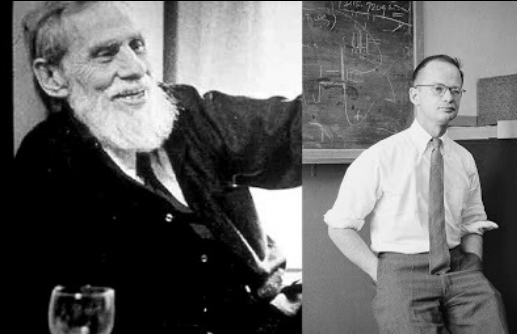
And we spent much time discussing the concepts of what's in the human brain. How the brain is built, how it works and what can be done with machines and whether you can do anything with machines that you can do with the human brain and so on.



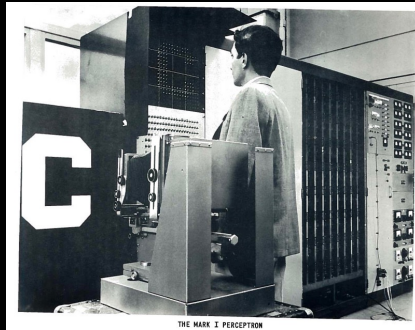
Hubel & Wiesel, **neural basis of vision**, 1959, 1962



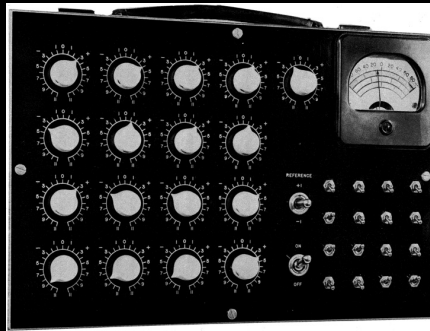
McCulloch & Pitts, **neuron model**, 1943



Early machine learning

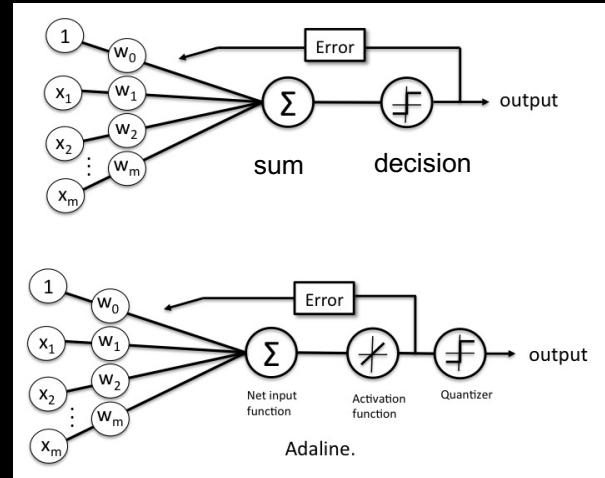


Frank Rosenblatt,
perceptron, 1957



Ted Hoff & Bernard Widrow,
ADALINE, 1960

McCulloch-Pitts neurons, learning via “error feedback”

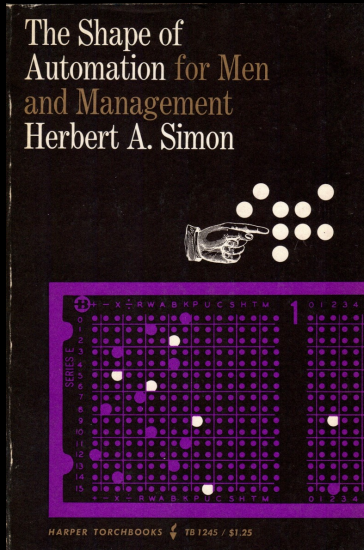


Beginnings of **neural networks**

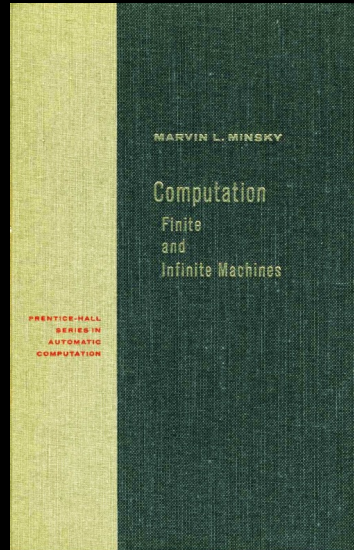
Beginnings of **machine learning**

Error **backpropagation/feedback** is still the core of modern ML

Premature optimism

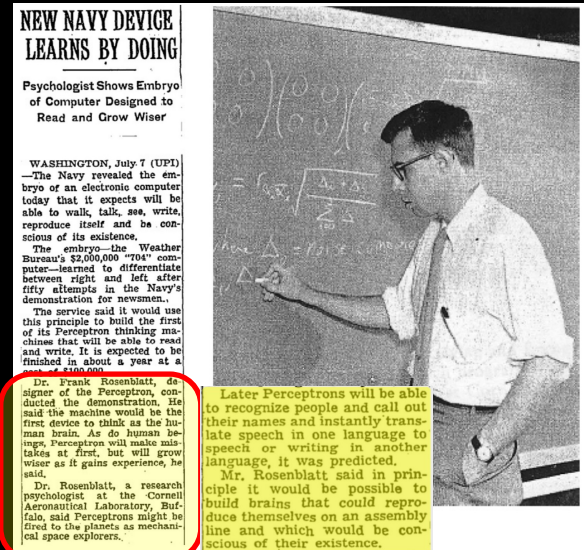


“in 20 years, machines will do any human task” 1965



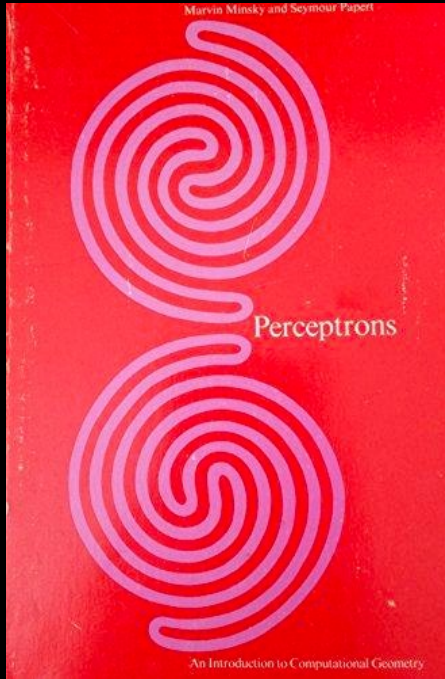
“within a generation (...) the problem of creating AI will be solved” 1967

first artificial neural network: **perceptron**
1957



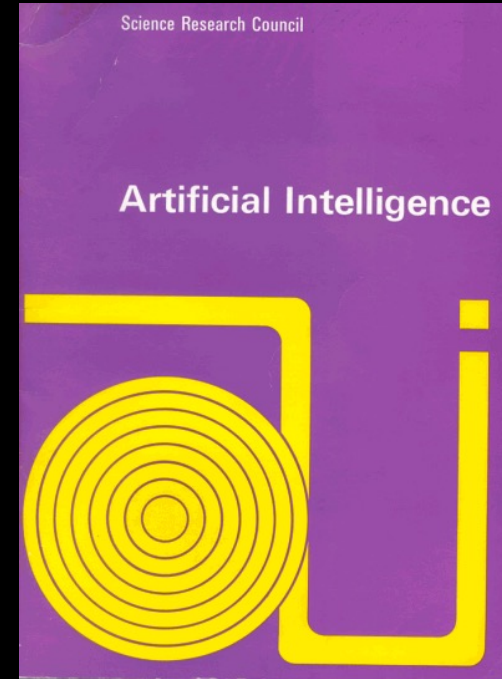
“perceptrons will be fired to the planets as mechanical space explorers” 1958

AI and neural networks winter



Minsky & Papert, 1969

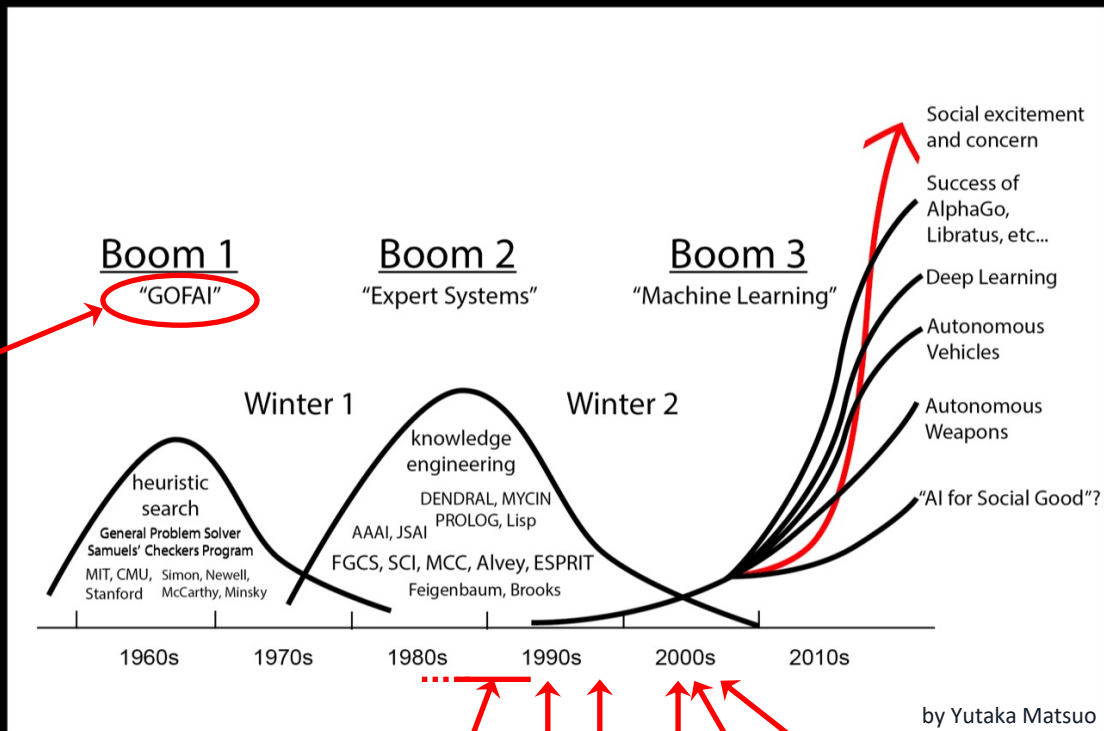
travou a fundo a investigação conexionista, reforçou a vertente “simbólica”



Lighthill report, 1972

“as descobertas feitas até hoje não produziram os impactos prometidos”

AI Winters and Booms

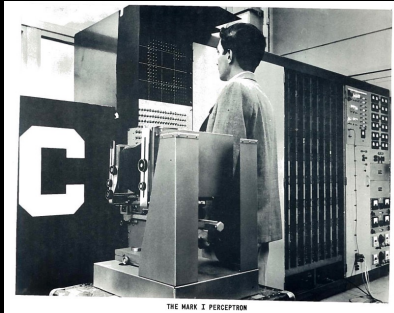


good old-fashioned AI

- Generalization of personal computers
- The Internet was born
- End of the USSR



Neural networks: 3 decades of evolution (1957-1989)



Frank Rosenblatt, **perceptron**, 1957



Hopfield networks, 1982



Rumelhart, Hinton, Williams, **backpropagation**, 1986

Prior work by Linnainmaa (1970, 1976),
Werbos (1974), LeCun (1985)

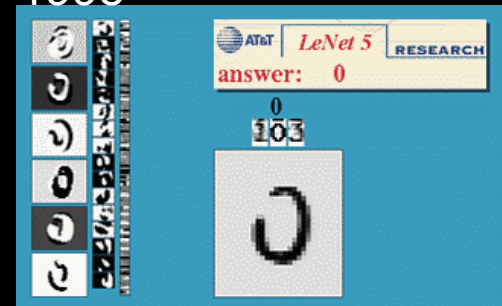


Sejnowski & Hinton, **Boltzman machines**, 1983



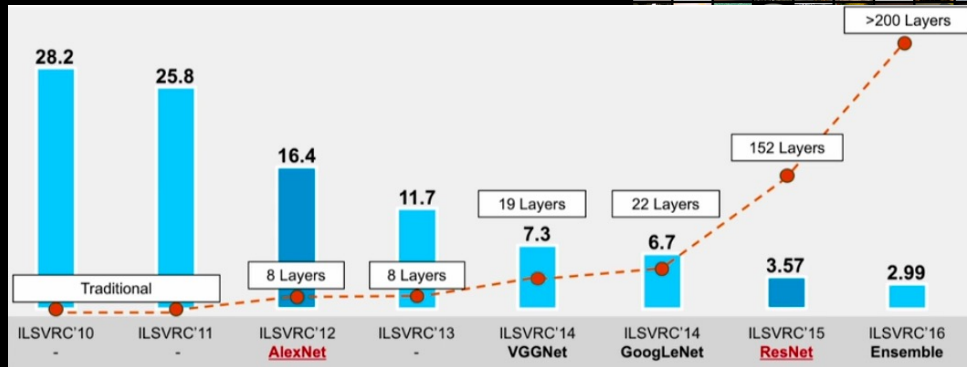
Yann LeCun, **deep convolutional networks**,
1989 (inspired by Hubel & Wiesel)

1998

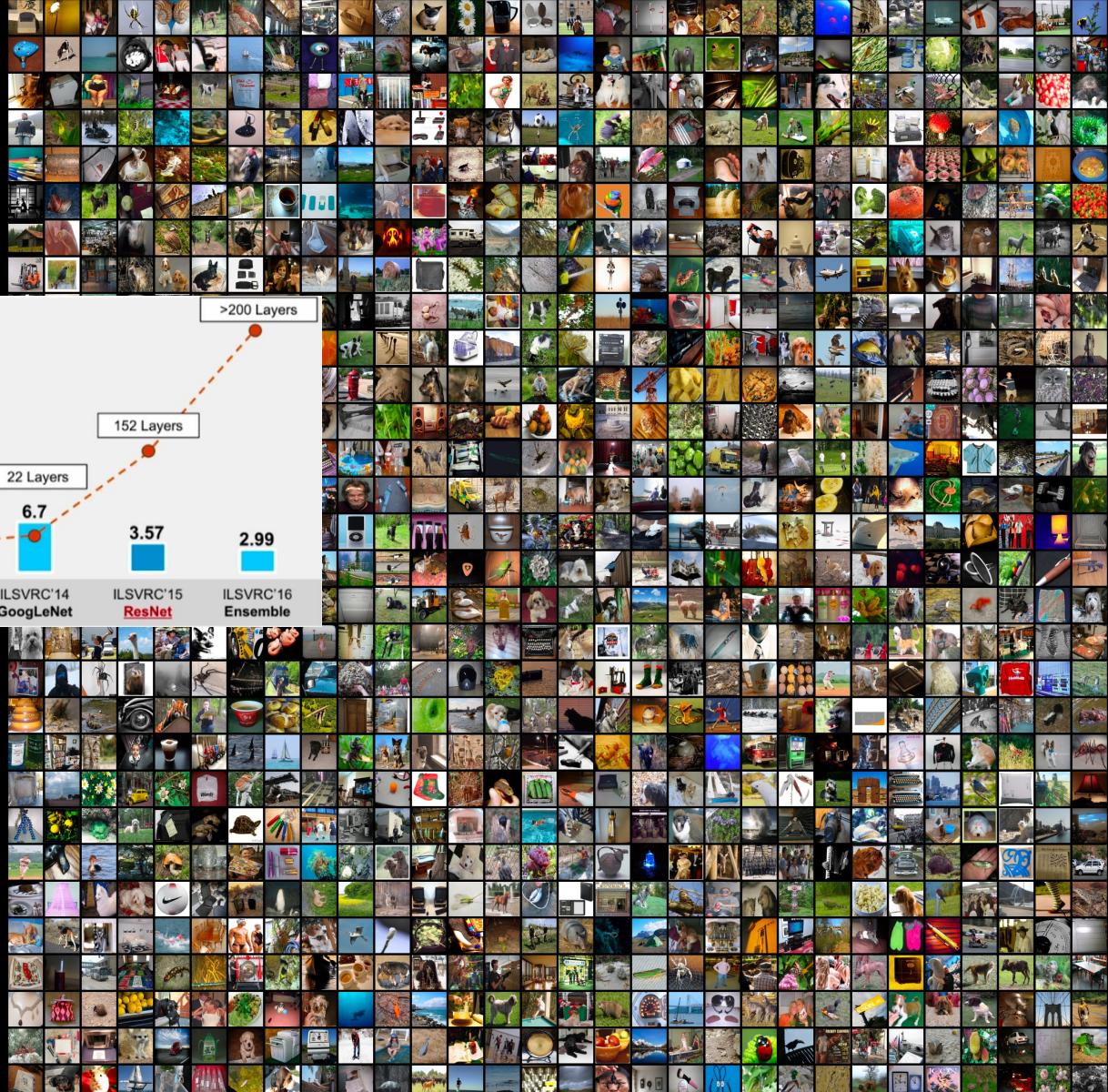


The ImageNet moment 2012

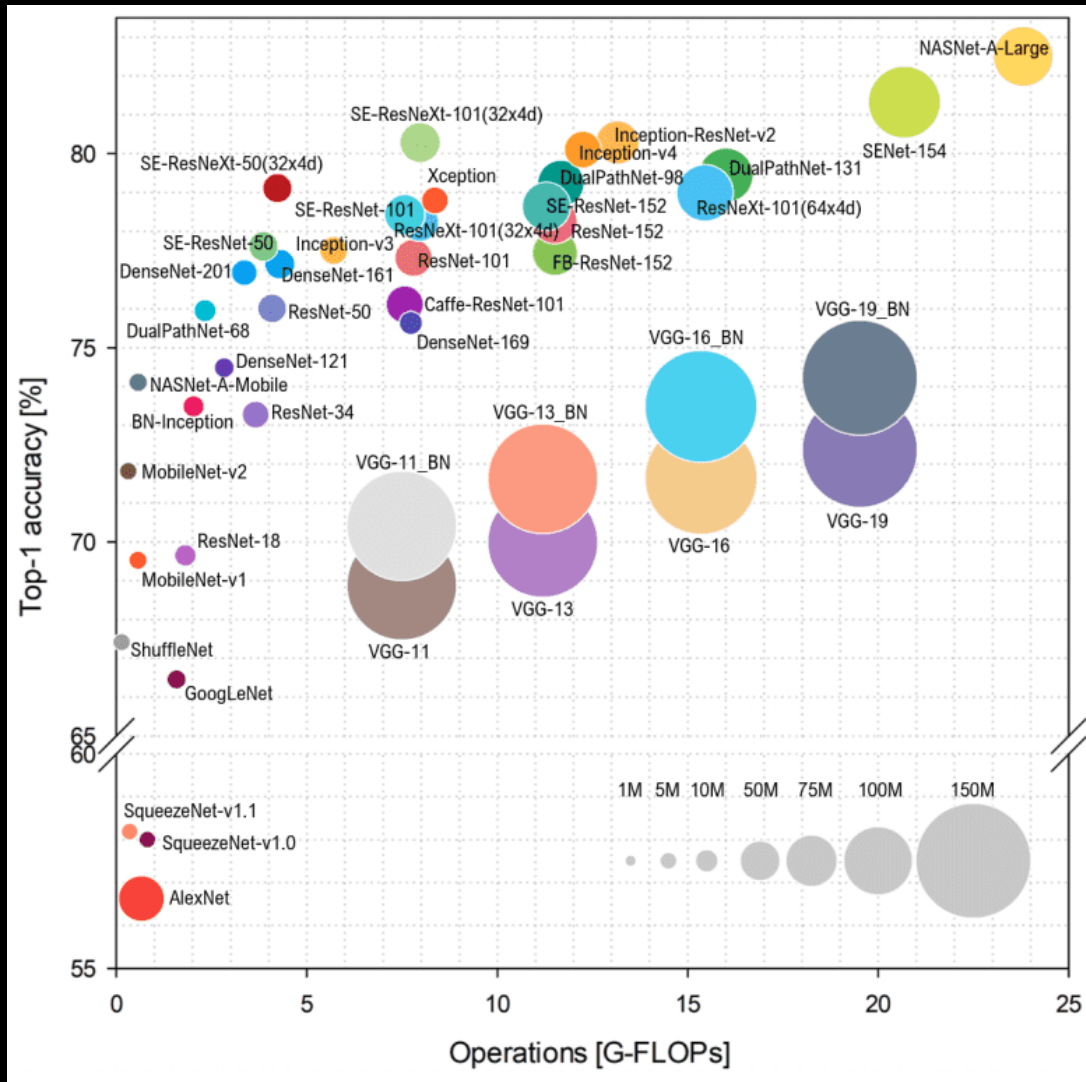
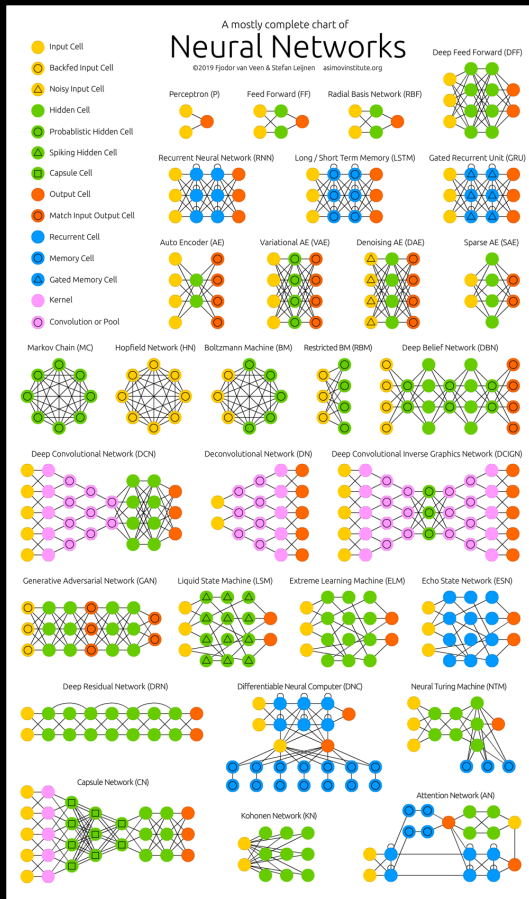
ImageNet (2009): 14 million images,
20000 categories



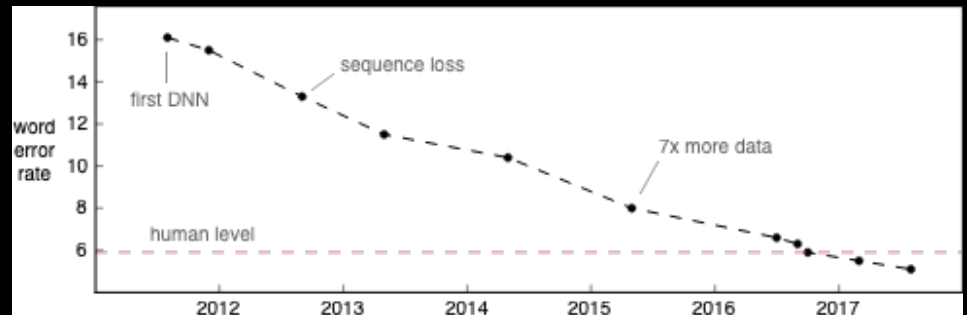
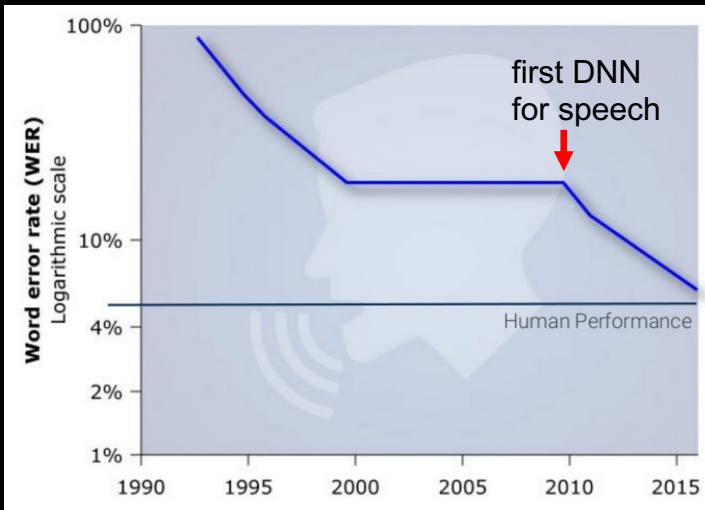
ImageNet Large Scale Visual Recognition Challenge



Zoo of neural networks



Also in speech recognition



Another game falls to an AI player

This time it is one that involves negotiation and double-dealing



Nov 23rd 2022

< St

BACKGAMMON WAS an easy win. Chess, harder. Go, harder still. But for some aficionados it is only now that artificial intelligence (AI) can truly say it has joined the game-playing club—for it has proved it can routinely beat humans at Diplomacy.

Science

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RESEARCH ARTICLE

Human-level play in the game of *Diplomacy* by combining language models with strategic reasoning

META FUNDAMENTAL AI RESEARCH DIPLOMACY TEAM (FAIR)*, ANTON BAKHTIN , NOAM BROWN , EMILY DINAN , GABRIELE FARINA , COLIN FLAHERTY 

DANIEL FRIED , ANDREW GOFF , JONATHAN GRAY , [...], AND MARKUS ZIJLSTRA  +17 authors [Authors Info & Affiliations](#)

SCIENCE • 22 Nov 2022 • First Release • DOI: 10.1126/science.ade9097

Text generation and chatting: GPT-4 and Chat GPT

MA

Please explain Dijkstra's algorithm for shortest path computation, but in a poem written by Shakespeare



O Dijkstra's algorithm, thou art a marvel,
A tool of great utility and skill,
Designed to find the shortest path, noravel,
Between two nodes in a graph, if thou will.

Thou starteth at the source, and then doth roam,
Exploring neighboring nodes along the way,
Selecting always the path that leadeth home,
To the unvisited node with the least to pay.

Thou continueth on until the goal is reached,
At which point thou art done and dost return,
With the shortest path, thy task completed,
And a job well done, for which thou dost earn

Praise and admiration from those who know,
The value of a well-crafted algorithm.

How/why did it happen?



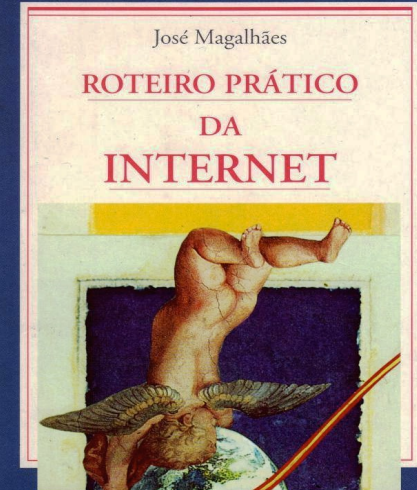
Only 30 years ago...



1994



1995



Internet was **small**:
you could have a “guide”

Technological (r)evolutions

JAN
2022

ESSENTIAL DIGITAL HEADLINES

OVERVIEW OF THE ADOPTION AND USE OF CONNECTED DEVICES AND SERVICES



TOTAL
POPULATION



7.91
BILLION

URBANISATION
57.0%

we
are
social

UNIQUE MOBILE
PHONE USERS



5.31
BILLION

vs. POPULATION
67.1%



INTERNET
USERS

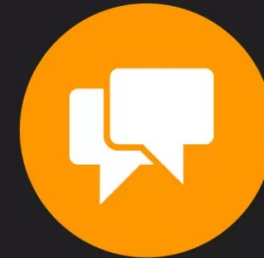


4.95
BILLION

vs. POPULATION
62.5%



ACTIVE SOCIAL
MEDIA USERS



4.62
BILLION

vs. POPULATION
58.4%

9

SOURCES: UNITED NATIONS; U.S. CENSUS BUREAU; GOVERNMENT BODIES; GSMA INTELLIGENCE; ITU; GWI; EUROSTAT; CNNIC; APJII; CIA WORLD FACTBOOK; COMPANY ADVERTISING RESOURCES AND EARNINGS REPORTS; OCDH; TECHRASA; KEPIOS ANALYSIS. ADVISORY: SOCIAL MEDIA USERS MAY NOT REPRESENT UNIQUE INDIVIDUALS. COMPARABILITY: SOURCE AND BASE CHANGES.

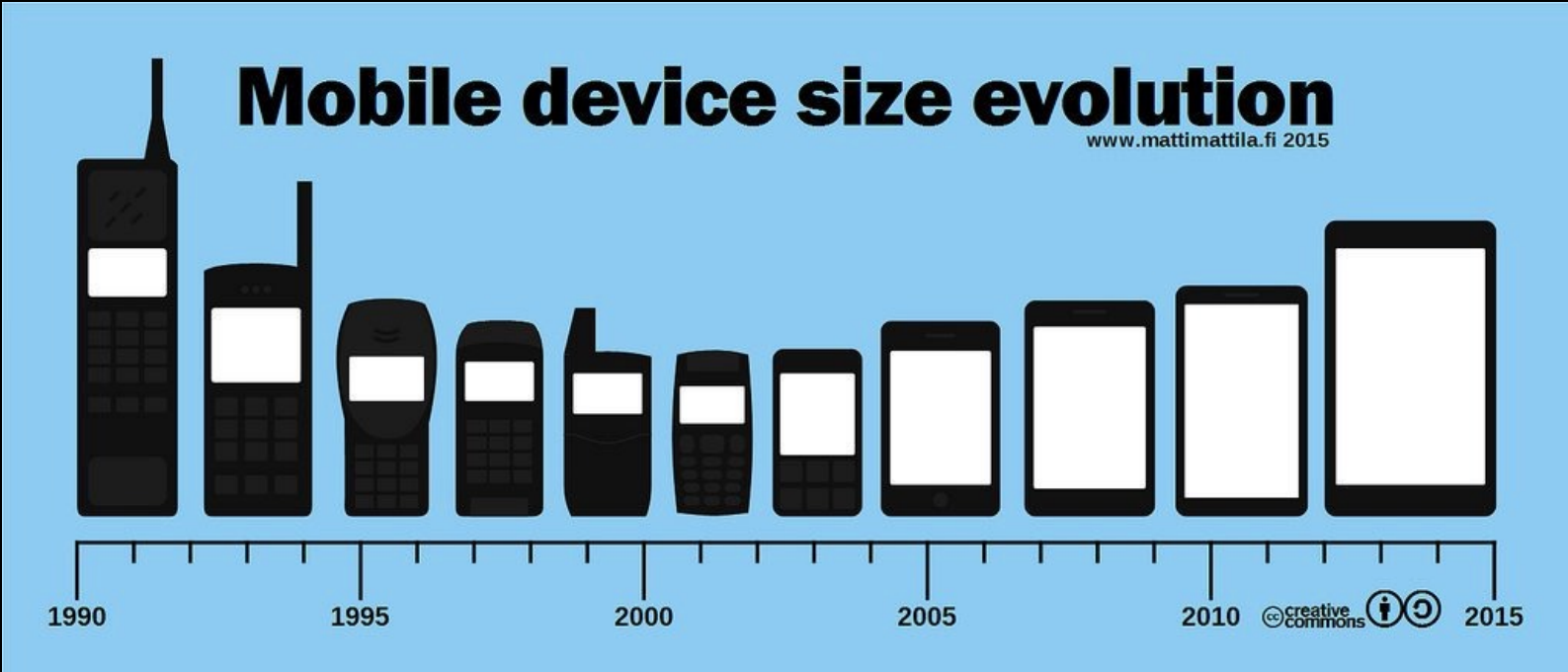
we
are
social



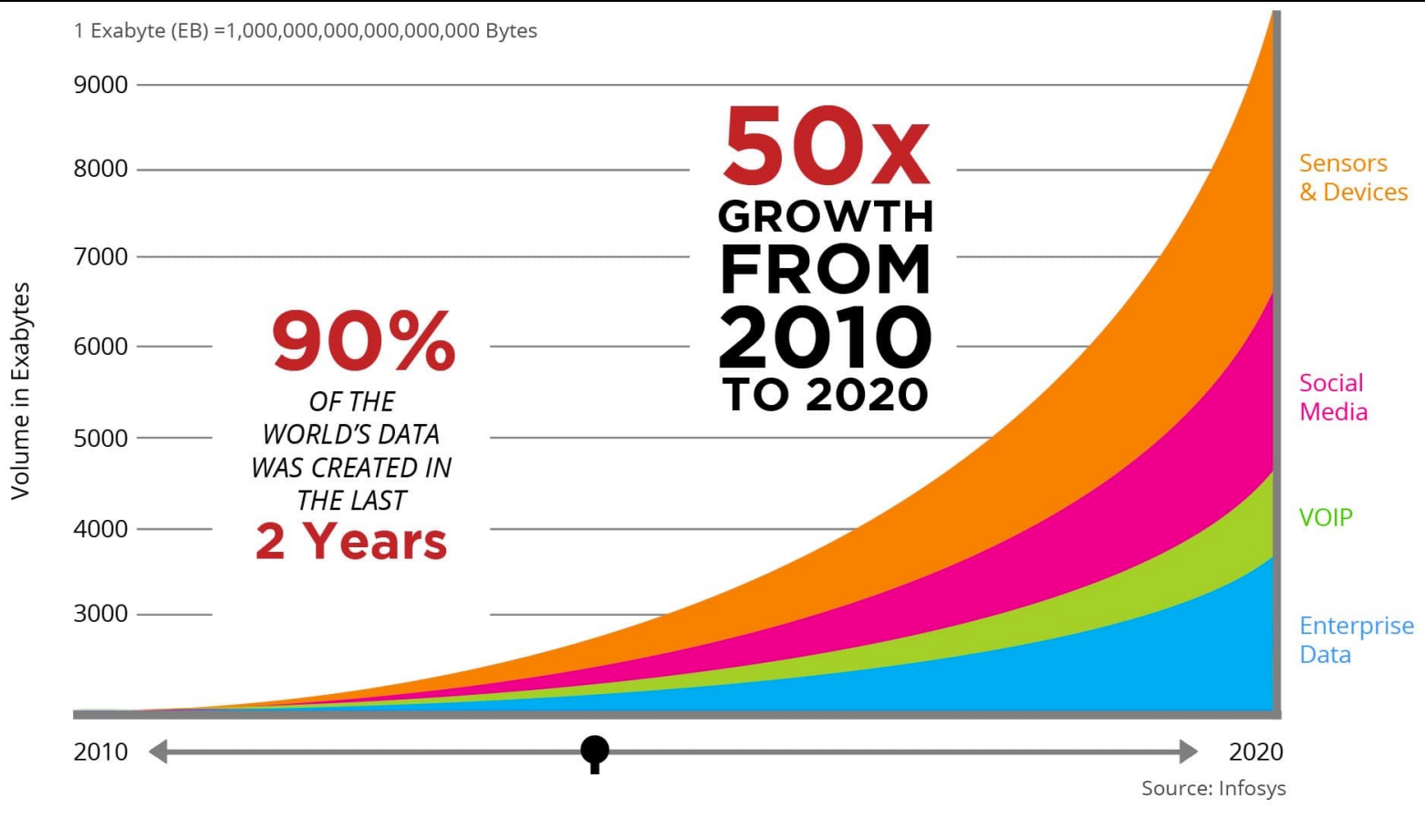
Hootsuite®

access to (and production of) data in huge scale
video, photos, location, purchases, social networks, medical/health, science, ...

Technological (r)evolutions



Technological (r)evolutions

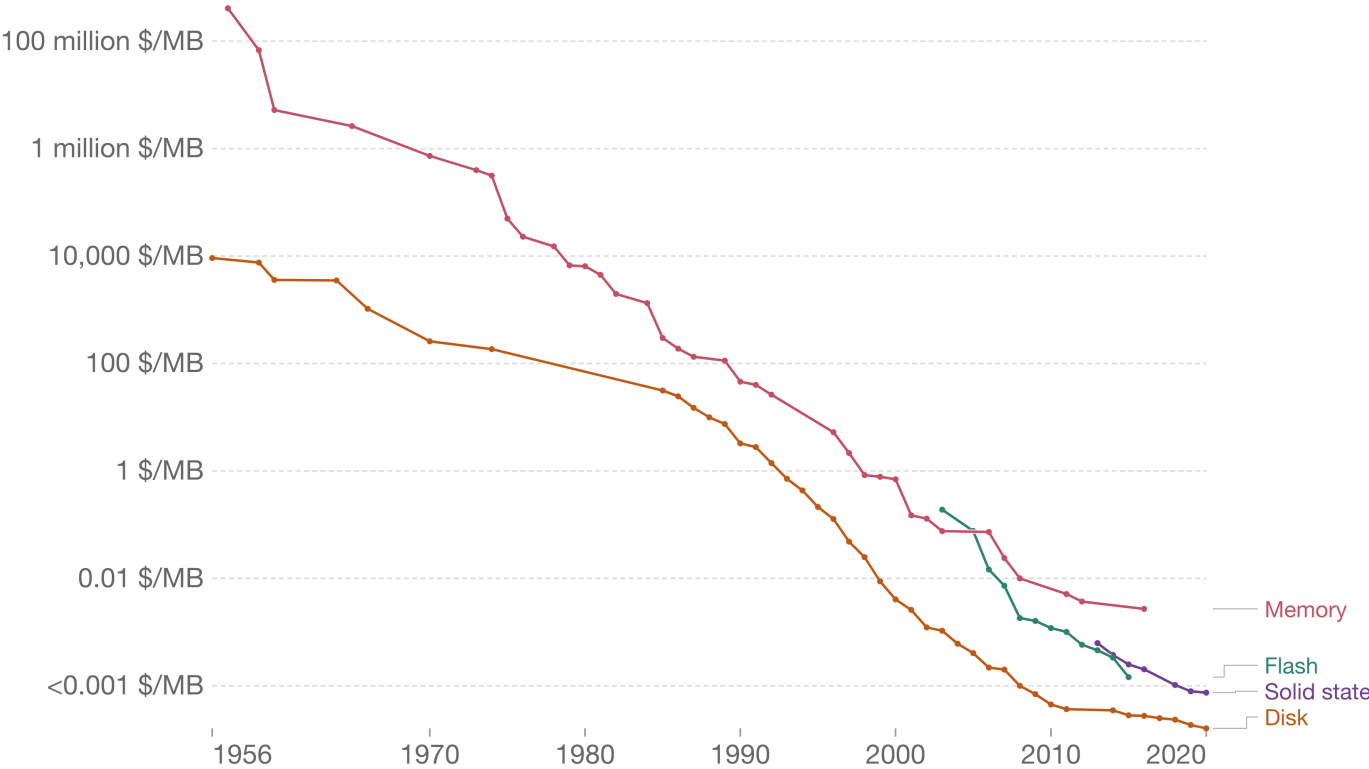


Technological (r)evolutions

Historical cost of computer memory and storage



Measured in US dollars per megabyte.

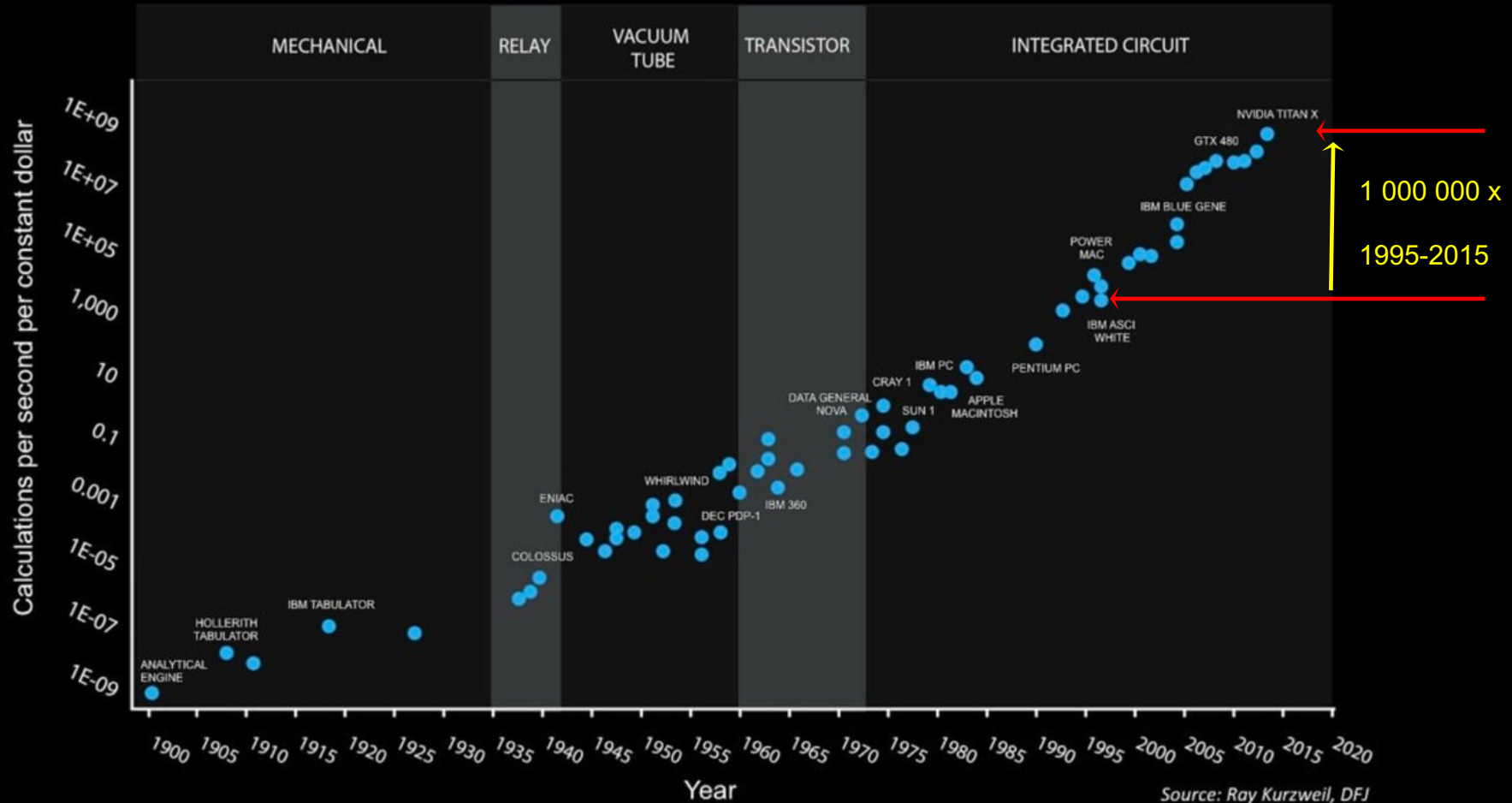


Source: John C. McCallum (2022)

OurWorldInData.org/technological-change • CC BY






Note: For each year the time series shows the cheapest historical price recorded until that year.

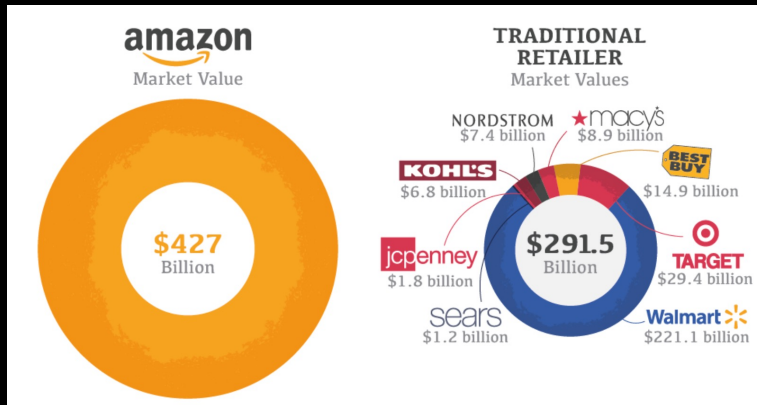
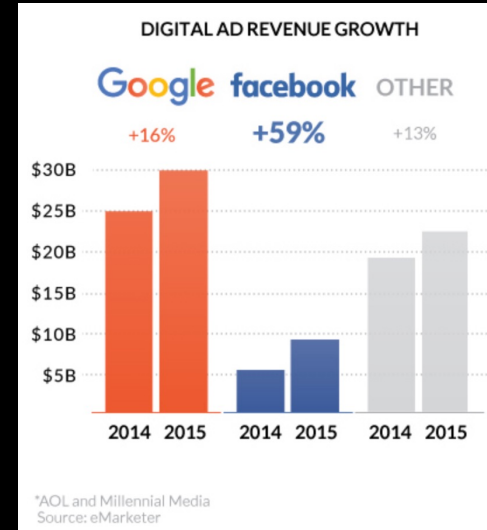
120 Years of Moore's Law



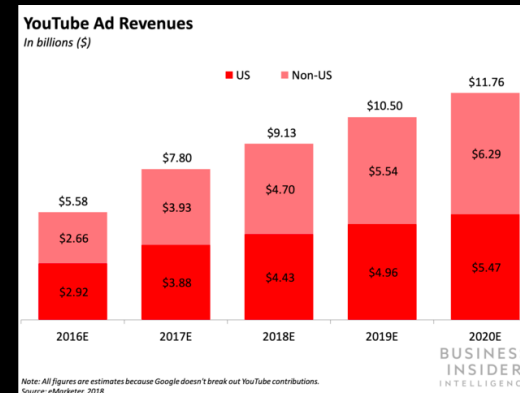
Source: Ray Kurzweil, DFJ

Pushed by a business paradigm shift

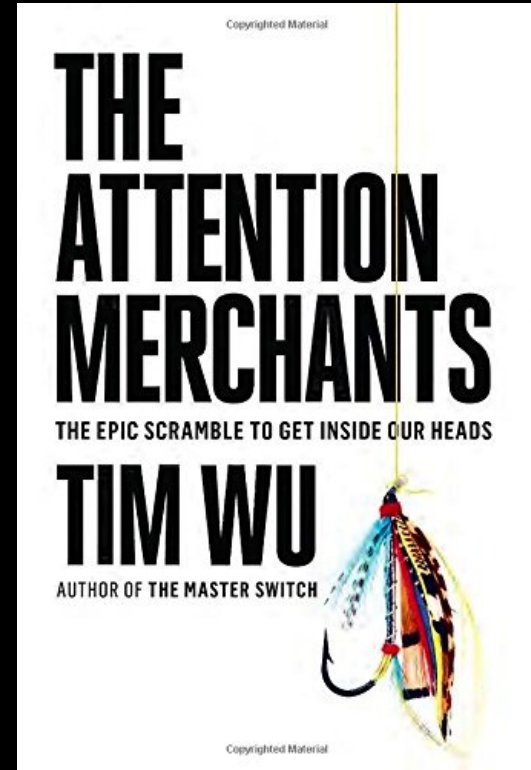
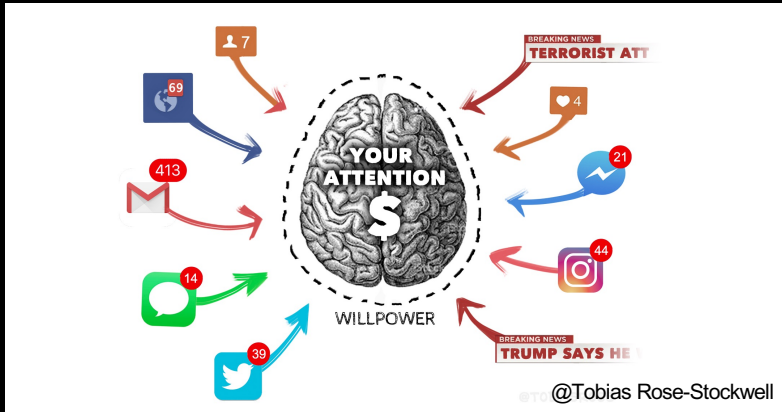
- super-abundant contents: **loss of value**
- super-abundant contents: **search becomes crucial**
- how to monetize search? **publicity!** 
- how to monetize social networks? **publicity!**   
- online commerce: **recommendation** 



ML plays a central role!



Business paradigma change



Mobile phones are user-data harvesting devices

ios

ios

Commercial logo as used by Apple, since 2017



2:08

Album # 76° 15

Thunderstorms 107°-149°

No events today

Weather Calendar Photos Camera

FaceTime Mail Messages App Store

TV Podcasts App Store

Maps Health Wallet Settings


Search

Phone Safari Messages Music

Developer Apple Inc.

Android

Android



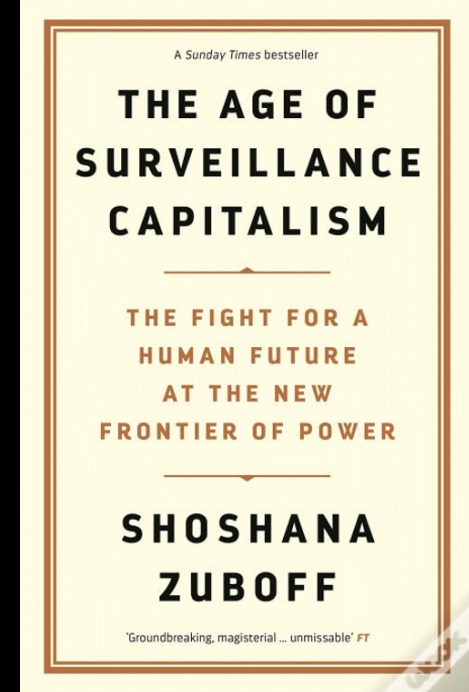
Wordmark and logo used since 2023

Developer Various (mostly Google)



- Business model behind Facebook, Google, Amazon, Twitter, ...
- Massive gathering and AI-based analysis of user information.
- Product: behavioral “futures”.
- “If you’re using the service for free, you’re the product.”
- Implications: privacy, addiction, behavior manipulation, threat to democracy, ...

- Solutions: regulation, awareness, education, literacy, ...



Historic R&D spend (\$m)



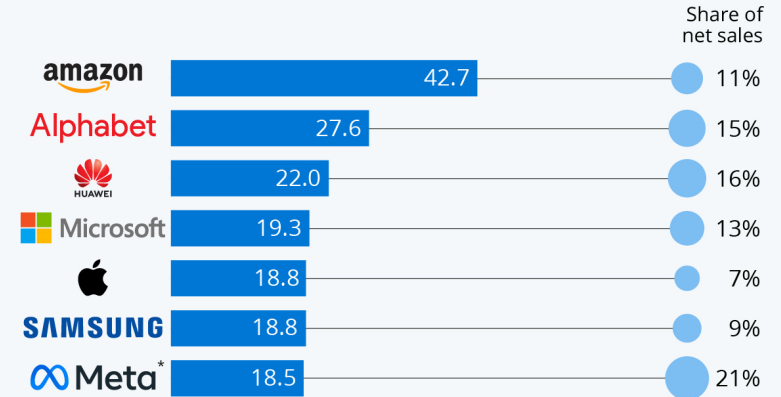
Source: Bloomberg, April 2018

The Equities Forum

M&G INVESTMENTS

The World's Biggest R&D Spenders

Companies with the highest R&D investment expenditure in 2020 (in billion U.S. dollars)

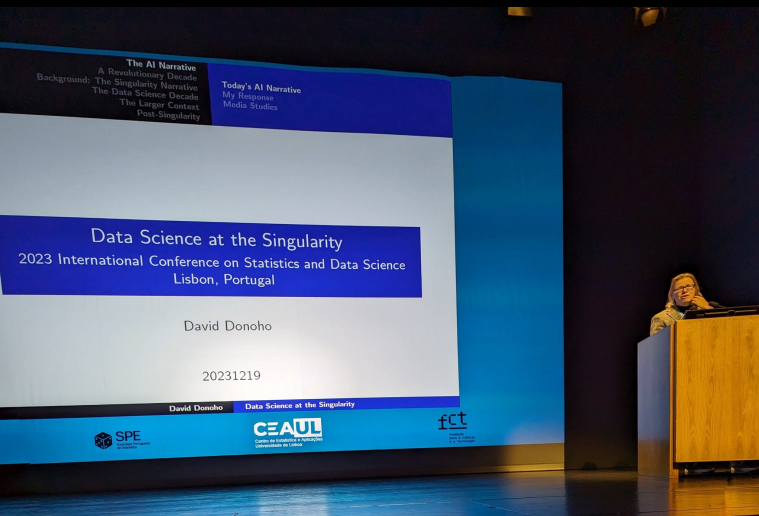


* formerly Facebook (until Oct 2021)

Sources: Nasdaq.com, corporate reports



statista



Data Science at the Singularity

David Donoho

Frictionless reproducibility

[FR-1: Data] datafication of everything, with a culture of research data sharing. One can now find datasets publicly available online on a bewildering variety of topics, from chest x-rays to cosmic microwave background measurements to uber routes to geospatial crop identifications.

[FR-2: Re-execution] research code sharing including the ability to exactly re-execute the same complete workflow by different researchers.

[FR-3: Challenges] adopting challenge problems as a new paradigm powering scientific research. The paradigm includes: a shared public dataset, a prescribed and quantified task performance metric, a set of enrolled competitors seeking to outperform each other on the task, and a public leaderboard. Thousands of such challenges with millions of entries have now taken place, across many fields.

Classical paradigm: supervised learning

Fundamental **bottlenecks**:

- data scarcity
- label scarcity (human expertise is very expensive)

Several approaches:

- data augmentation
 - synthetic data
 - transfer learning
- } still supervised learning
- **New paradigm: self-supervised learning**

Recent paradigm shift...

Foundation models: pretrain on raw data
(maybe) adapt (fine-tune) to various downstream applications

Self-supervised pretraining: surrogate task, e.g., masked/next word prediction
key advantage: no human intervention!

A Pretraining



Large corpus
(unlabeled text)

"Would you tell me, please, which way I ought to go from here?"
"That depends a good deal on where you want to get to," said the Cat.
"I don't much care where—" said Alice.
"Then it doesn't matter which way you go," said the Cat.
"—so long as I get *somewhere*," Alice added as an explanation.
"Oh, you're sure to do that," said the Cat, "if you only walk long enough."

Original text

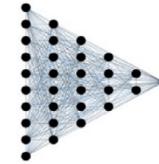
Masking



"Would you tell me, [REDACTED], which way I [REDACTED] to go from here?"
"That [REDACTED] a [REDACTED] deal on where you want to get to," said the Cat.
"I [REDACTED] much care where—" [REDACTED] Alice.
"Then it doesn't matter [REDACTED] you go," said the Cat.
"—so long as I get *somewhere*," Alice [REDACTED] as an explanation.
"Oh, [REDACTED] to do that," said the Cat, "if [REDACTED] only [REDACTED] long enough."

Masked text

Language model



"Would you tell me, *sir*, which way I *need* to go from here?"
"That *depends* a *good* deal on where you want to get to," said the Cat.
"I *don't* much care where—" *said* Alice.
"Then it doesn't matter *which way* you go," said the Cat.
"—so long as I get *somewhere*," Alice *added* as an explanation.
"Oh, *no need* to do that," said the Cat, "if *one* only *waits* long enough."

Predicted text

Loss

B Fine-tuning

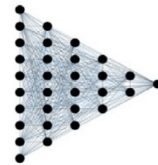


Small labeled
dataset

We wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

Text

Fine-tuned model



Topic: Biology (97%)

Prediction

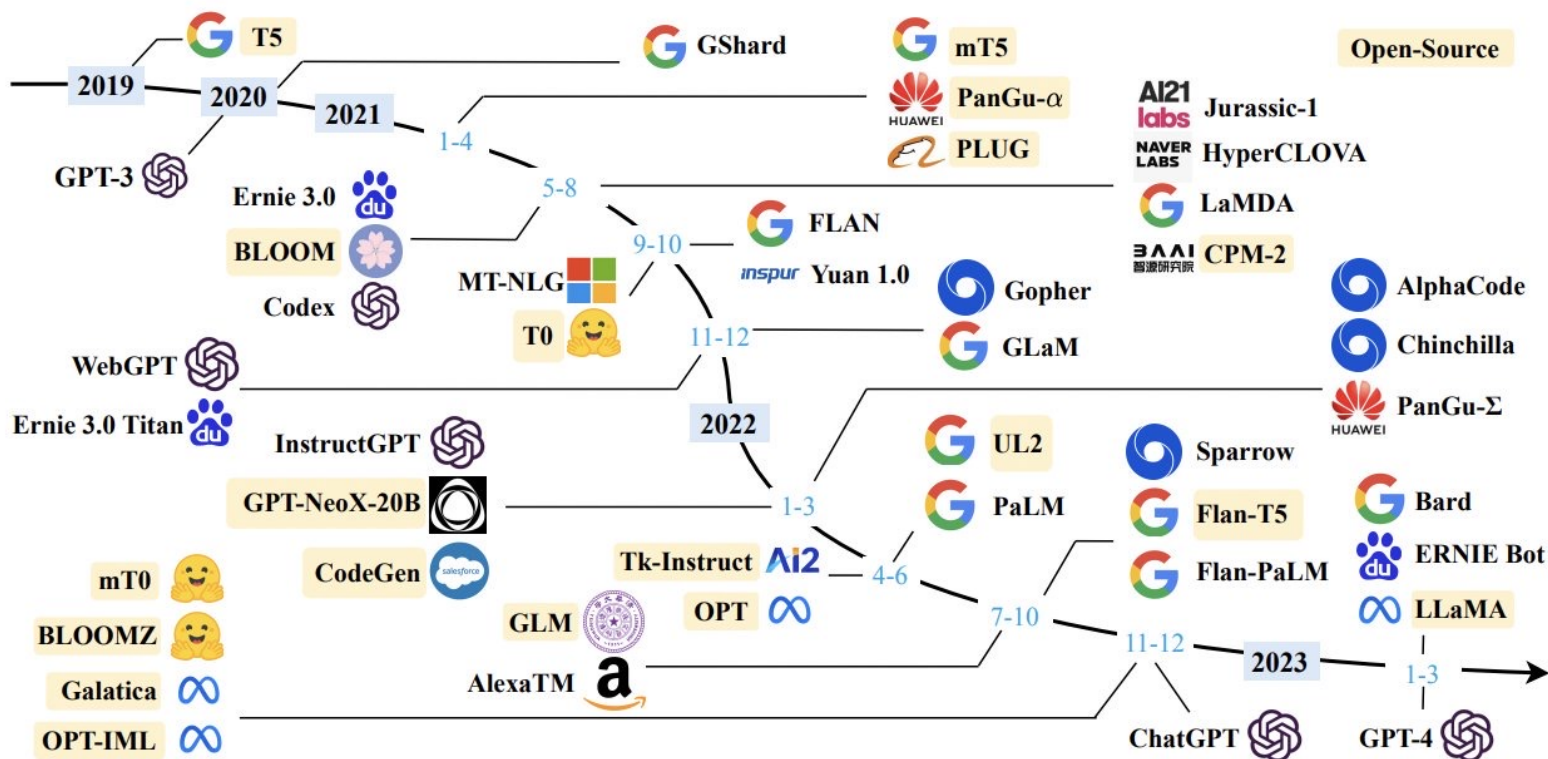
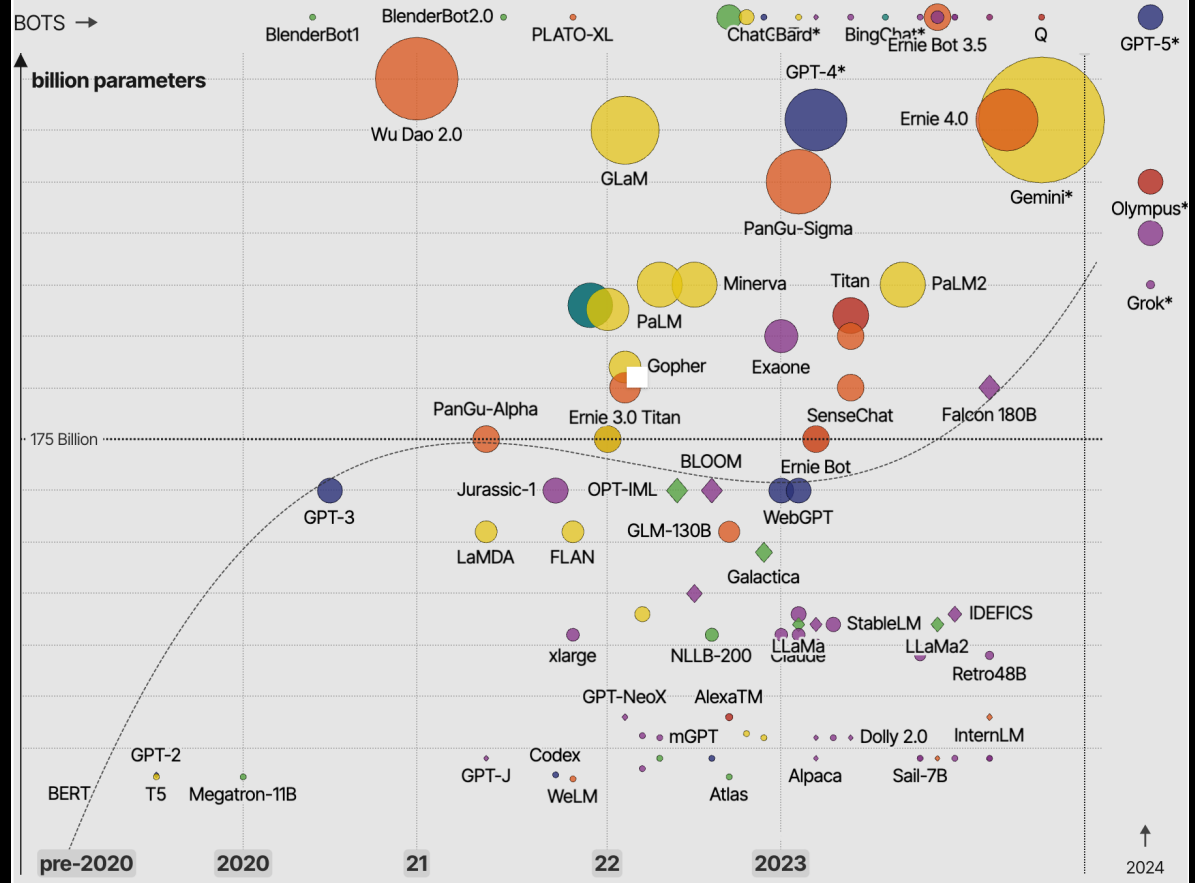


Fig. 1. A timeline of existing large language models (having a size larger than 10B) in recent years. We mark the open-source LLMs in yellow color.

The Rise and Rise of A.I. Large Language Models (LLMs) & their associated bots like ChatGPT

○ size = no. of parameters ◊ open-access

● Amazon-owned ● Chinese ● Google ● Meta / Facebook ● Microsoft ● OpenAI ● Other



David McCandless, Tom Evans, Paul Barton
 Information is Beautiful // UPDATED 6th Dec 23

source: news reports, [LifeArchitecture.ai](#)
 * = parameters undisclosed // see [the data](#)



On the Opportunities and Risks of Foundation Models

Rishi Bommasani* Drew A. Hudson Ehsan Adeli Russ Altman Simran Arora
Sydney von Arx Michael S. Bernstein Jeannette Bohg Antoine Bosselut Emma Brunskill
Erik Brynjolfsson Shyamal Buch Dallas Card Rodrigo Castellon Niladri Chatterji
Annie Chen Kathleen Creel Jared Quincy Davis Dorottya Demszky Chris Donahue
Moussa Doumbouya Esin Durmus Stefano Ermon John Etchemendy Kawin Ethayarajh
Li Fei-Fei Chelsea Finn Trevor Gale Lauren Gillespie Karan Goel Noah Goodman
Shelby Grossman Neel Guha Tatsunori Hashimoto Peter Henderson John Hewitt
Daniel E. Ho Jenny Hong Kyle Hsu Jing Huang Thomas Icard Saahil Jain
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Emergence of...

Homogenization of...

Machine Learning



"how"

learning algorithms

Deep Learning



features

architectures

Foundation Models

functionalities

models



Bommasani et al, 2022

Not AGI, but GAI!

blog.research.google

QUESTION ANSWERING

SEMANTIC PARSING

PROVERBS

ARITHMETIC

CODE COMPLETION

GENERAL KNOWLEDGE

READING COMPREHENSION

SUMMARIZATION



LOGICAL INFERENCE CHAINS

COMMON-SENSE REASONING

PATTERN RECOGNITION

TRANSLATION

DIALOGUE

JOKE EXPLANATIONS

PHYSICS QA

LANGUAGE UNDERSTANDING

ChatGPT: A Meta-Analysis after 2.5 Months

Christoph Leiter and Ran Zhang and Yanran Chen

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Natural Language Learning Group (NLLG)

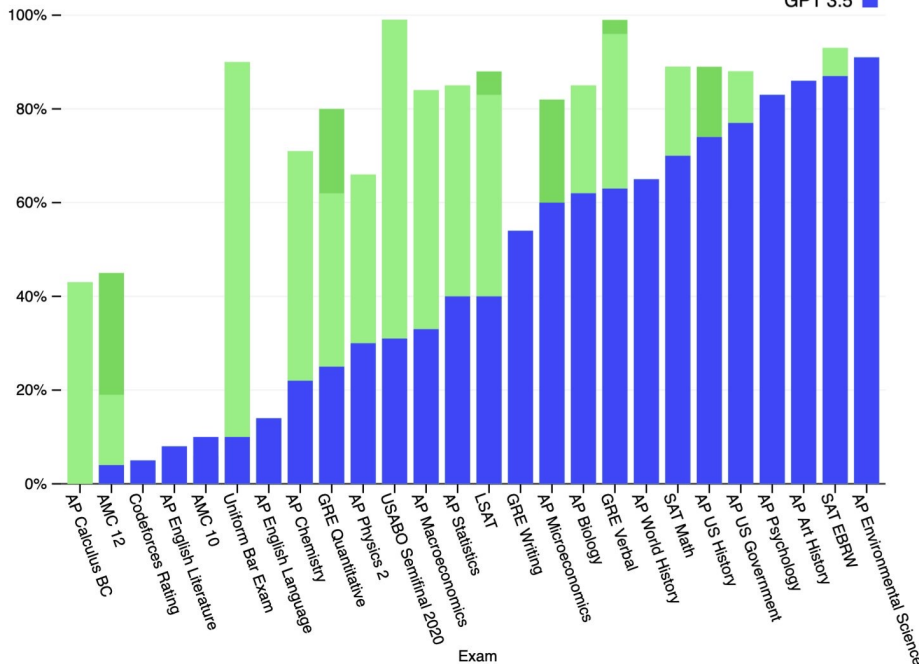
Faculty of Technology, Bielefeld University

Abstract

ChatGPT, a chatbot developed by OpenAI, has gained widespread popularity and media attention since its release in November 2022. However, little hard evidence is available regarding its perception in various sources. In this paper, we analyze over 300,000 tweets and more than 150 scientific papers to investigate how ChatGPT is perceived and discussed. Our findings show that ChatGPT is generally viewed as of high quality, with positive sentiment and emotions of joy dominating in social media. Its perception has slightly decreased since its debut, however, with joy decreasing and (negative) surprise on the rise, and it is perceived more negatively in languages other than English. In recent scientific papers, ChatGPT is characterized as a great opportunity across various fields including the medical domain, but also as a threat concerning ethics and receives mixed assessments for education. Our comprehensive meta-analysis of ChatGPT's current perception after 2.5 months since its release can contribute to shaping the public debate and informing its future development. We make our data available.¹

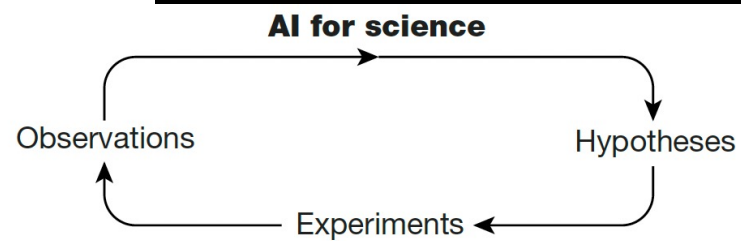
Exam results (ordered by GPT 3.5 performance)














Estimated percentile lower bound (among test takers)

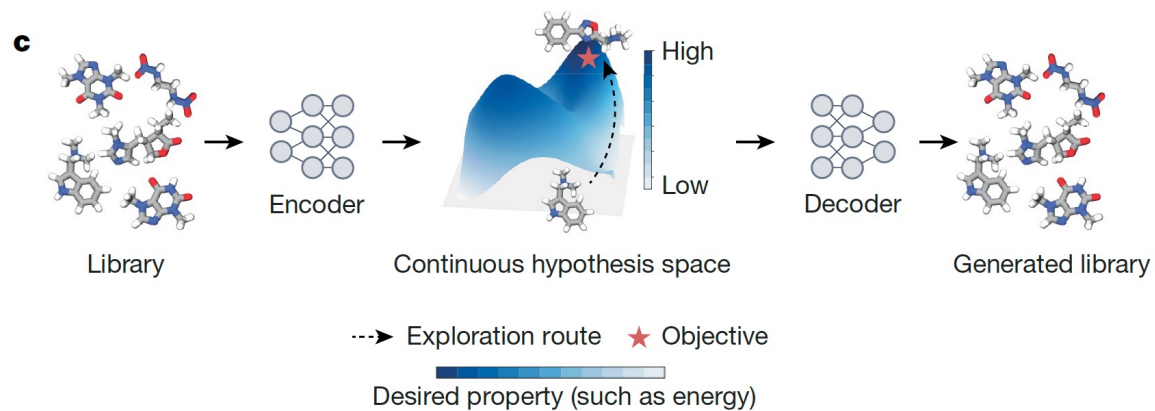
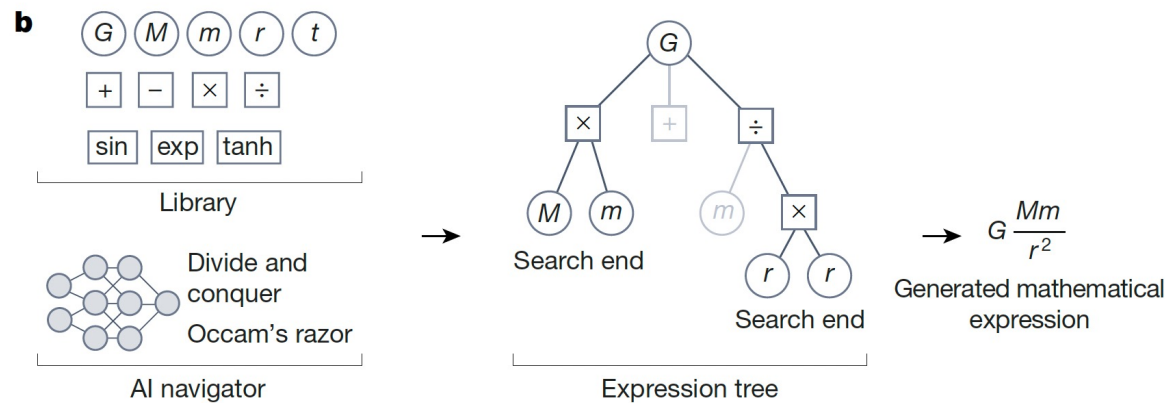
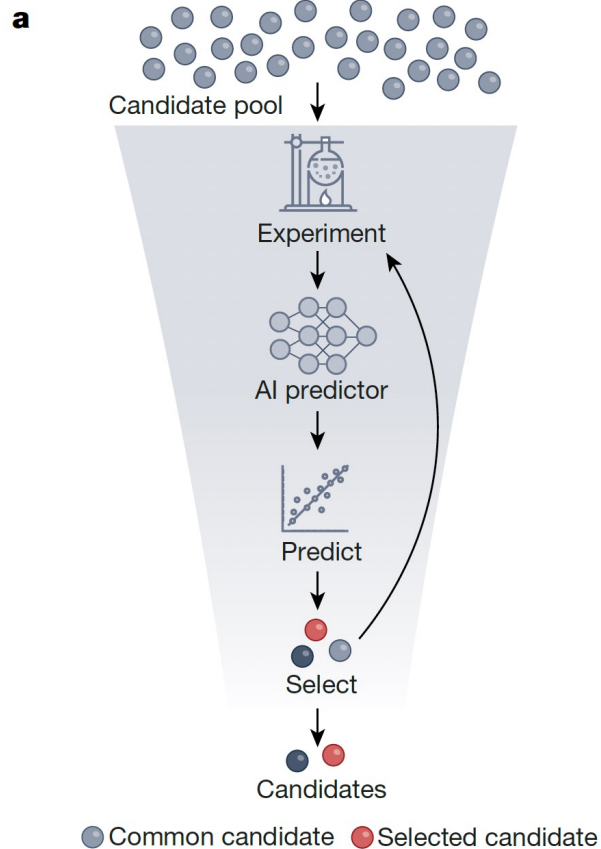


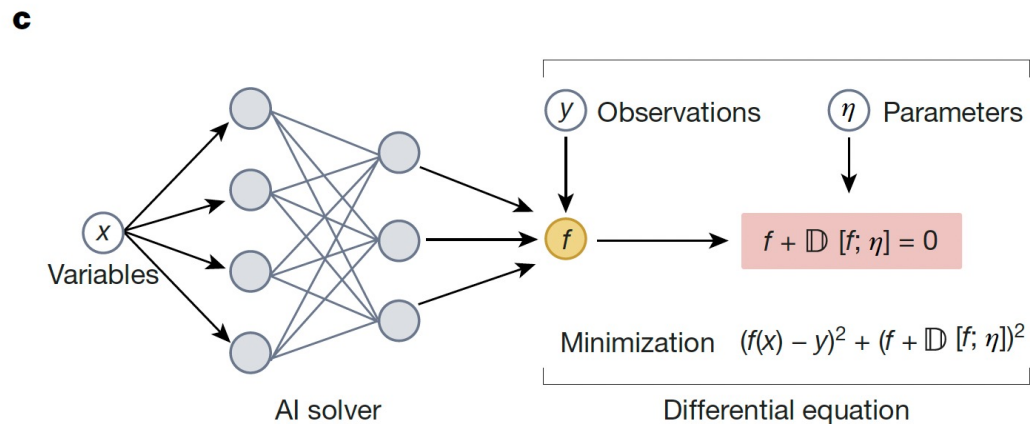
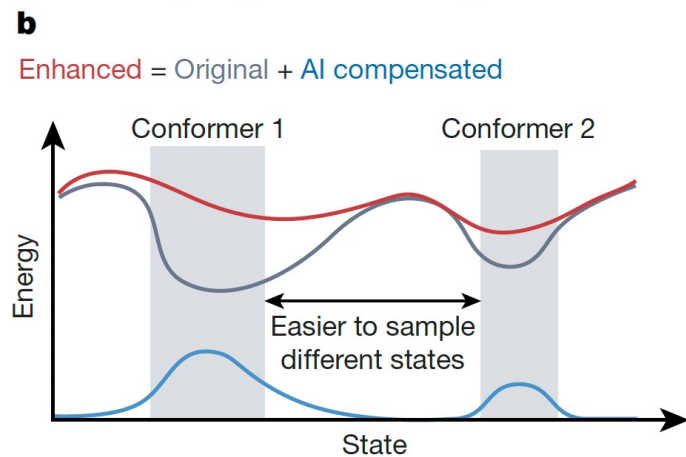
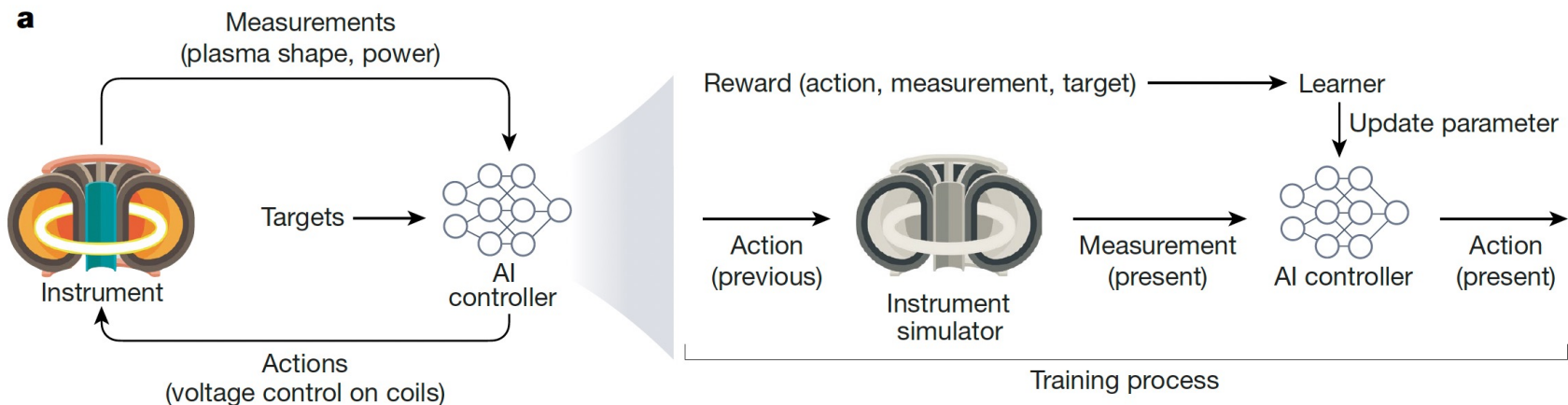
Scientific discovery in the age of artificial intelligence

Nature | Vol 620 | 3 August 2023 |



-  Weather forecasting
-  Battery design optimization
-  Magnetic control of nuclear fusion reactors
-  Planning chemical synthesis pathway
-  Neural solvers of differential equations
-  Hydropower station location planning
-  Synthetic electronic health record generation
-  Rare event selection in particle collisions
-  Language modelling for biomedical sequences
-  High-throughput virtual screening
-  Navigation in the hypothesis space
-  Super-resolution 3D live-cell imaging
-  Symbolic regression







You

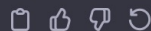
Let's discuss modern applications of AI in the field of mobile communications, including in mobile communication research, development, and engineering.



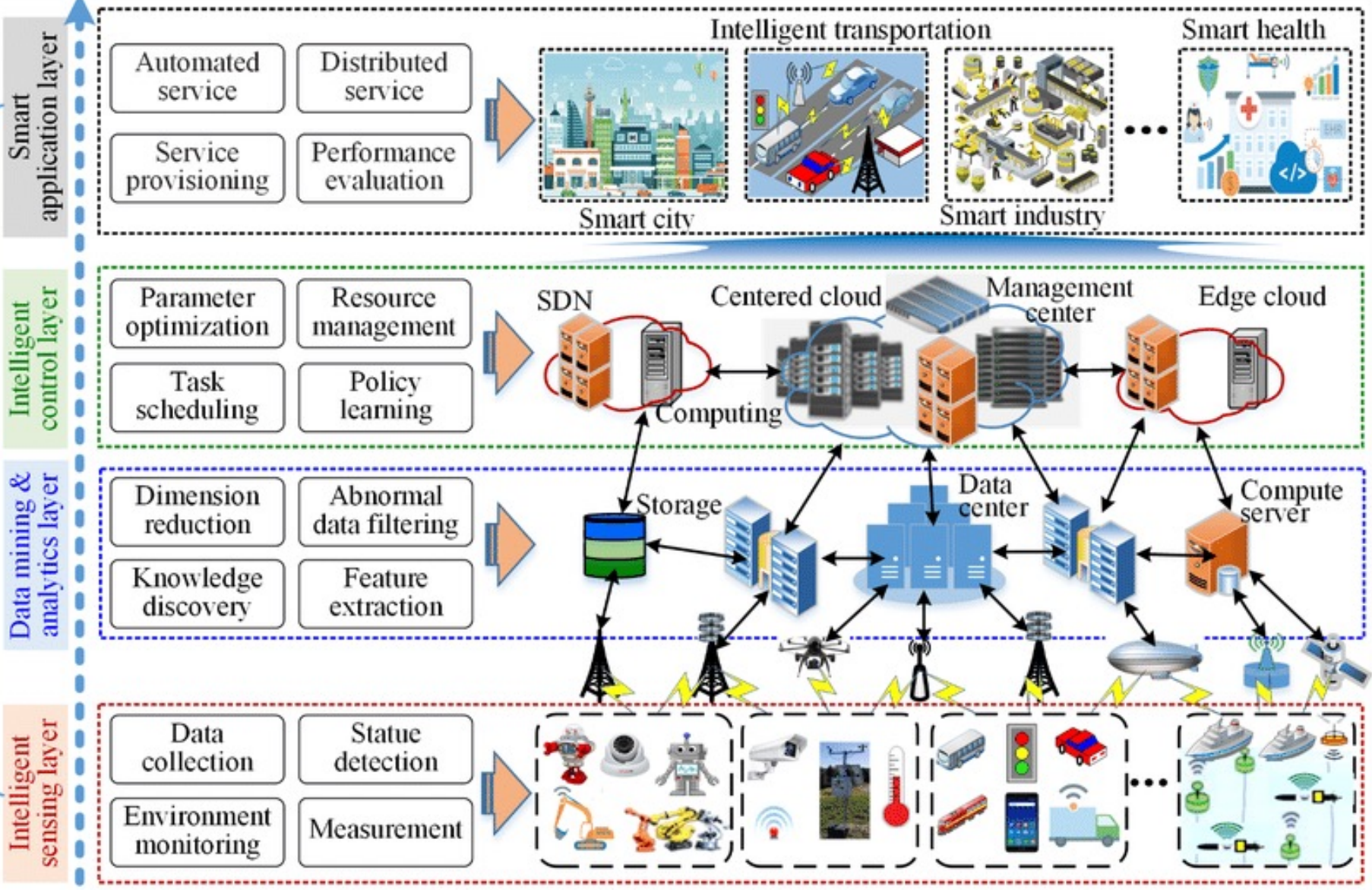
ChatGPT

Certainly! Here's a condensed version of each point:

1. **Network Optimization:** AI improves traffic management, reduces costs, and enhances efficiency in network operations.
2. **5G and Beyond:** AI dynamically manages complex networks, ensuring higher data rates and lower latency.
3. **Signal Processing:** AI aids in real-time adaptation for better signal quality and efficient data transmission.
4. **User Experience:** AI personalizes mobile device experiences with intelligent assistants and context-aware services.
5. **Security:** AI detects anomalies and threats in network security, protecting user data.
6. **Energy Efficiency:** AI reduces the energy consumption of mobile networks through intelligent resource management.
7. **R&D Acceleration:** AI speeds up testing and development of new mobile technologies and protocols.
8. **Customer Service:** AI-driven chatbots provide quick, automated customer support.
9. **Edge Computing & IoT:** AI processes data in real-time at the edge, crucial for IoT devices.
10. **Market Analytics:** AI analyzes trends and customer behavior for targeted marketing and product development.



AI-enabled functions



Data Flow: Mobile networks feed AI with essential data.

AI Access: Connectivity enables AI services on-the-go.

Instant AI: Real-time communication powers immediate AI responses.

Cloud Link: Networks connect devices to AI in the cloud.

Global Insights: Communication enables AI's worldwide data analysis.

Data Transfer: Essential for AI's data needs.

Edge AI: Networks support fast, local AI processing.

IoT: Communications link AI with IoT devices for smart automation.

AI and mobile communications are deeply intertwined!

THANK YOU!