



CEARÁ
GOVERNO DO ESTADO

SECRETARIA DA EDUCAÇÃO

Centro de Formação e Desenvolvimento para Profissionais
de Educação do Estado do Ceará Profª. Maria Neli
Sobreiras de Oliveira (**FormaCE**)

IA & Educação

Aplicações de Modelos de Linguagem

Michael Souza (UFC)

Da Curiosidade à Necessidade

“IA é o avanço tecnológico mais significativo desde a interface gráfica.

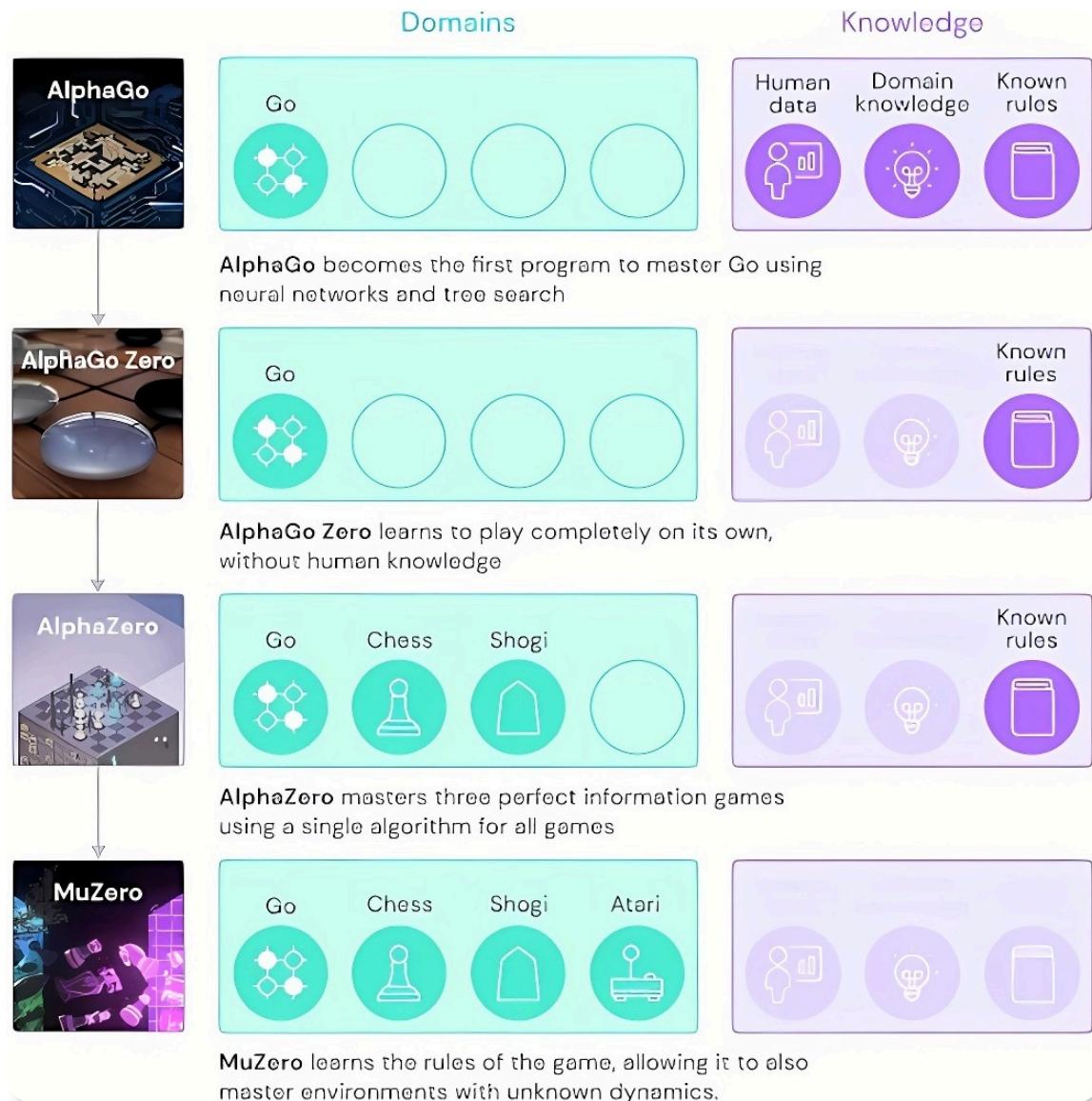
Assim como o microprocessador e a Internet, ela transformará a maneira como trabalhamos, aprendemos, viajamos e nos comunicamos.”

Bill Gates
Microsoft



The Age of AI has begun [Bill Gates, 2023]

Jan, 2016



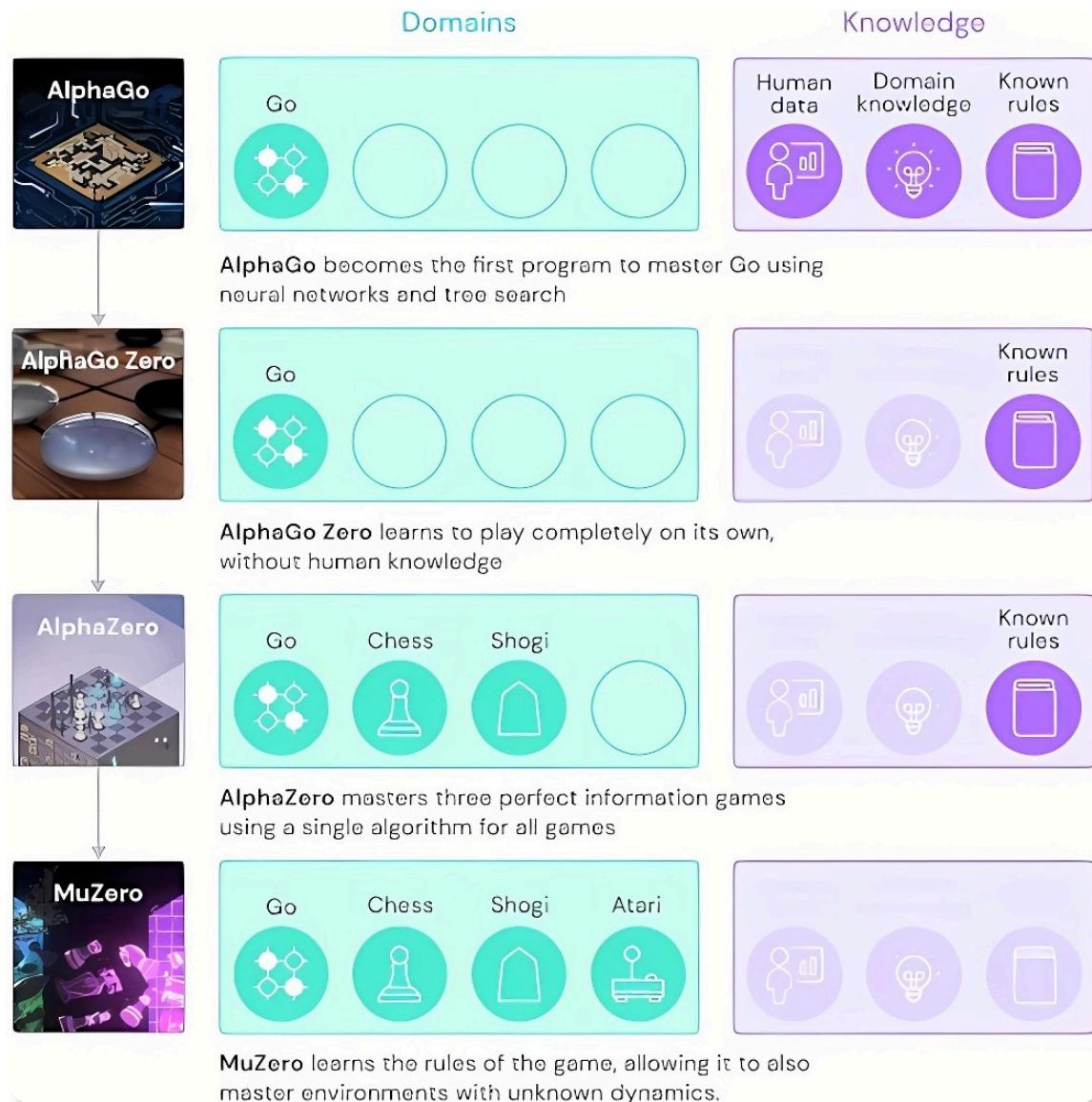
Out, 2017

Dec, 2018

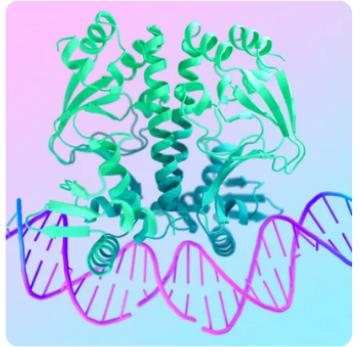
Dec, 2020

MuZero: Mastering Go, chess, shogi and Atari without rules [DeepMind, 2020]

Jan, 2016



AlphaFold

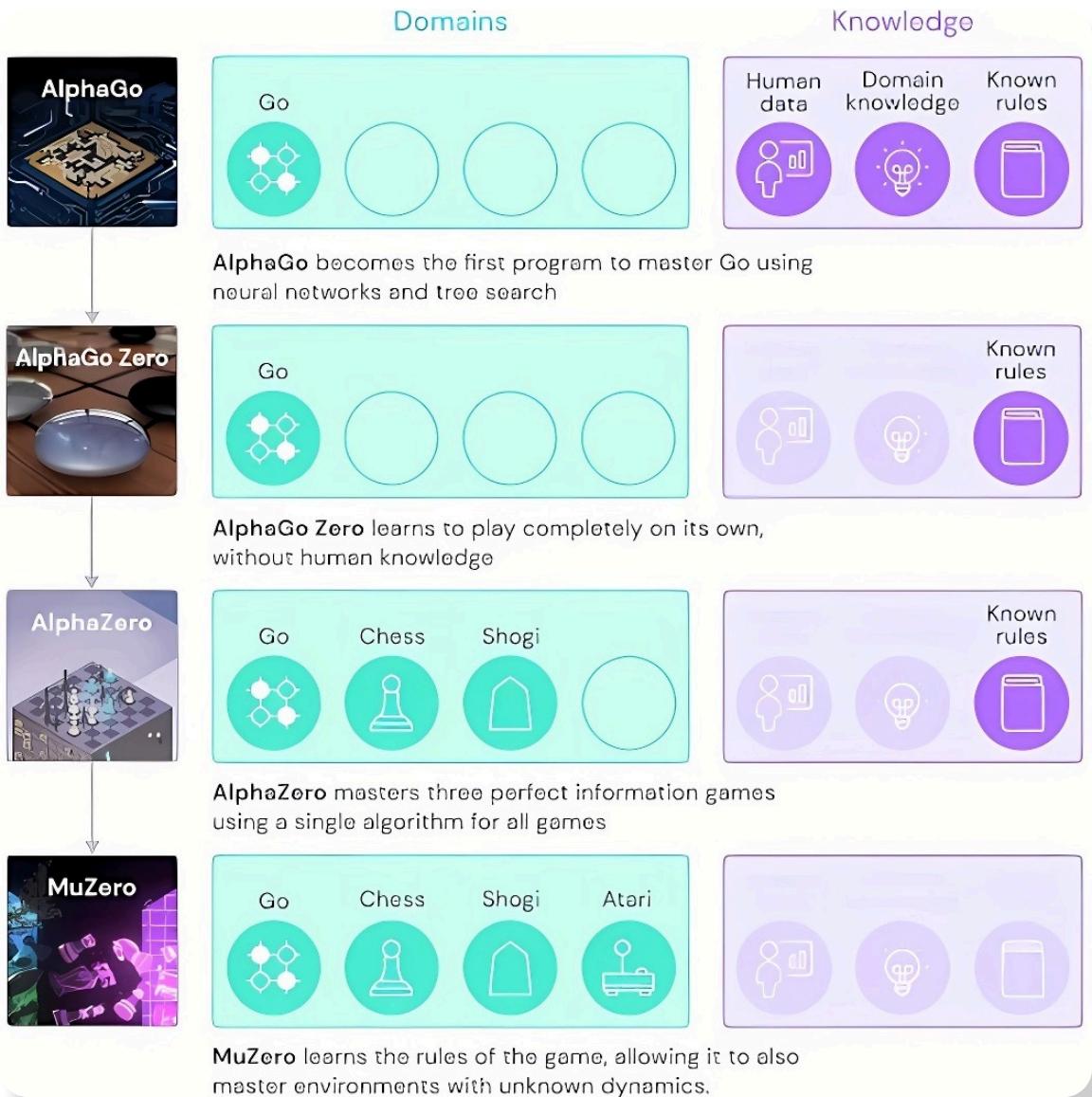


Nov, 2020

"O que nos levou **meses e anos** para fazer, o AlphaFold conseguiu fazer em um **fim de semana**."
McGeehan, Univ. Portsmouth

'It will change everything': DeepMind's AI makes gigantic leap in solving ... [Callaway, 2020]

Jan, 2016



Nobel, 2024

Geoffrey Hinton
 (esquerda) e **Demis Hassabis** (direita)
 ganhadores de Nobel de
 Física e Química
 contribuições em IA.

'Is AI physics or chemistry? Nobel Prize wins spark debate about tech's role in science [Davies, 2024]'



Fev, 2022



Abr, 2022



Jul, 2022

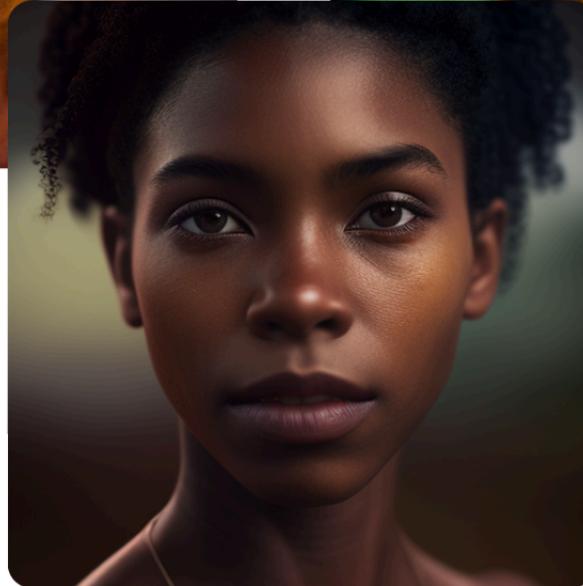
[Midjourney, 2022-2023]



Fev, 2022

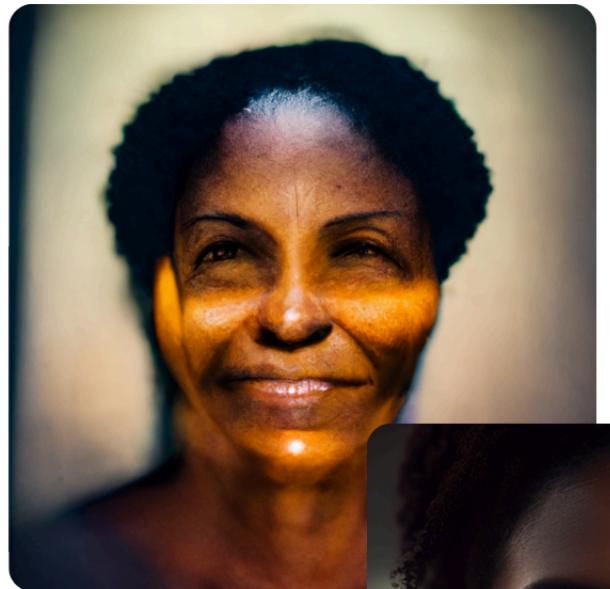


Jul, 2022



Nov, 2022

[Midjourney, 2022-2023]



Fev, 2022



Nov, 2022



Mai, 2023

[Midjourney, 2022-2023]

2024



[Runway, 2024]



**"She's like me,
without the jetlag"**

- Mathilda

Mathilda Gvariani / NEXT New York

Digital Twin

H&M Knows Its AI Models Will Be Controversial [Bain, 2025]

The Cybernetic Teammate: A Field Experiment on Generative AI Reshaping Teamwork and Expertise

Fabrizio Dell'Acqua
 Charles Ayoubi
 Hila Lifshitz
 Raffaella Sadun
 Ethan Mollick
 Lilach Mollick

Yi Han
 Jeff Goldman
 Hari Nair
 Stew Taub
 Karim R. Lakhani

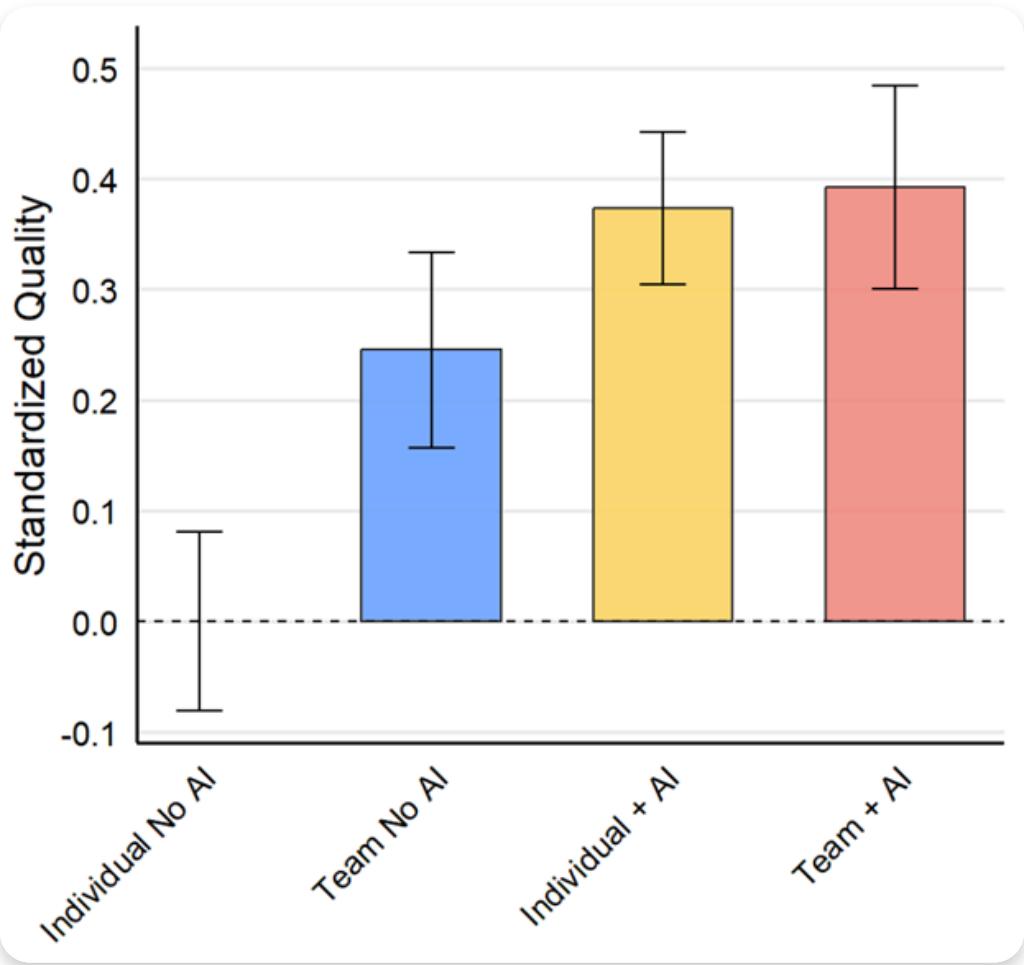
Abstract

We examine how artificial intelligence transforms the core pillars of collaboration—performance, expertise sharing, and social engagement—through a pre-registered field experiment with 776 professionals at Procter & Gamble, a global consumer packaged goods company. Working on real product innovation challenges, professionals were randomly assigned to work either with or without AI, and either individually or with another professional in new product development teams. Our findings reveal that AI significantly enhances performance: individuals with AI matched the performance of teams without AI, demonstrating that AI can effectively replicate certain benefits of human collaboration. Moreover, AI enhanced the quality of solutions generated by R&D professionals to suggest more technical solutions, while Commercial professionals leaned towards commercially-oriented proposals. Professionals using AI produced balanced solutions, regardless of their professional background. Finally, AI's language-based interface prompted more positive self-reported emotional responses among participants, suggesting it can fulfill part of the social and motivational role traditionally offered by human teammates. Our results suggest that AI adoption at scale in knowledge work reshapes not only performance but also how expertise and social connectivity manifest within teams, compelling organizations to rethink the very structure of collaborative work.

Keywords: Artificial intelligence, Teamwork, Human-machine interaction, Productivity, Skills, Innovation, Field experiment.

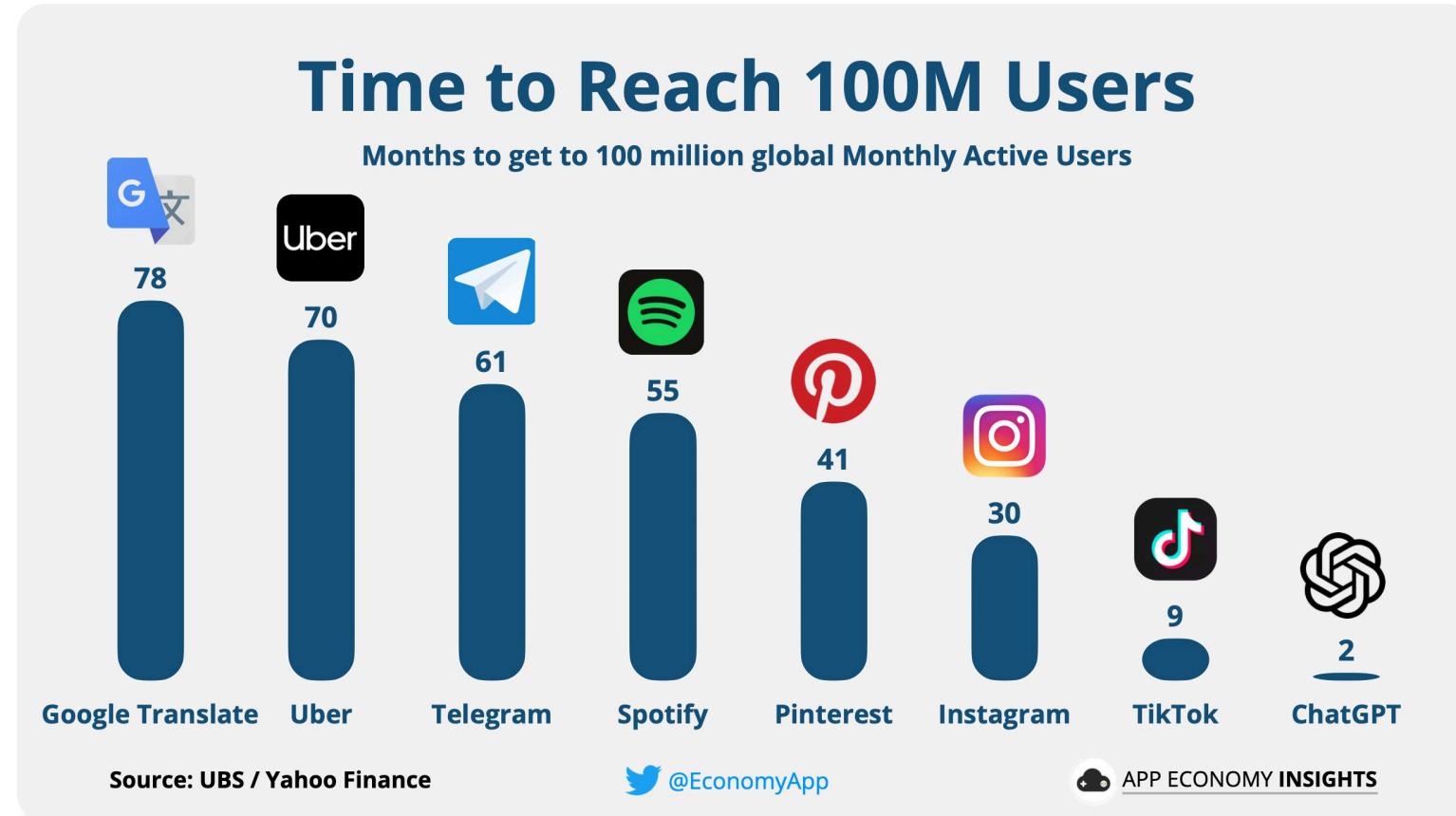


Harvard
Business
School



The Cybernetic Teammate: A Field Experiment on Generative AI Reshaping Teamwork and Expertise
 [Dell'Acqua et. al, 2025]

Tempo para alcançar 100 milhões de usuários



Threads becomes fastest-ever app to surge past 150 MILLION ... [Daily Mail, 2023]



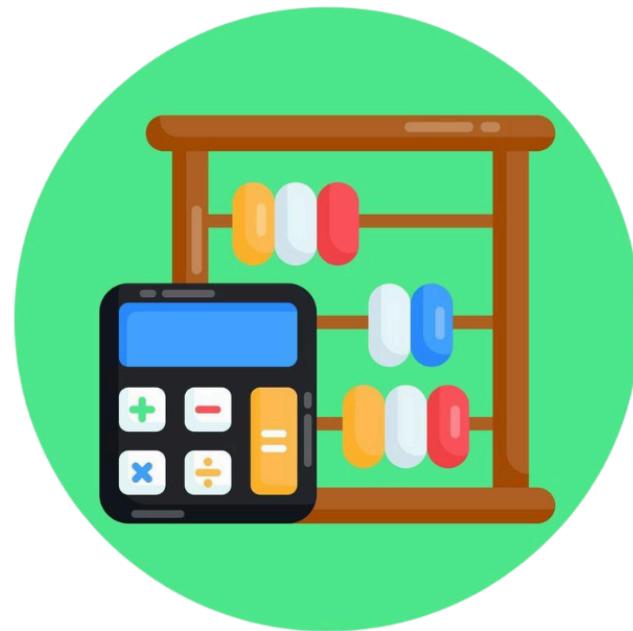
Um mundo pixelado

Os riscos da IA na educação

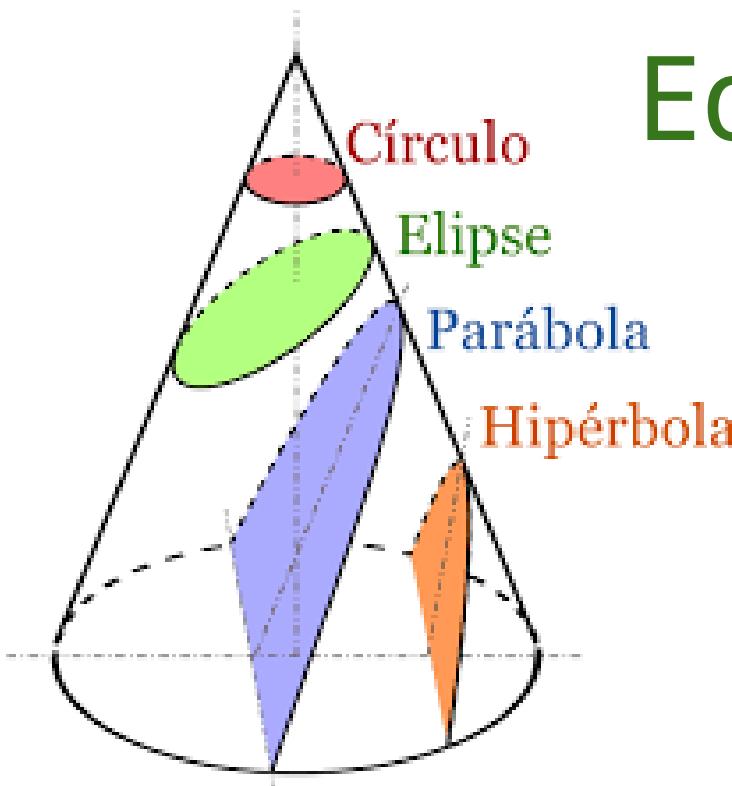
- Redução do pensamento crítico
- Dependência tecnológica
- Imprecisão e viés
- Impactos sociais e tecnológicos

Socrates on the Forgetfulness that Comes with Writing [Plato, 370 a.C.]

Melhoria vs Transformação



... What the Success of Chalkboards Tells Us About the Future of Computers ... [Krause, 2000]



Educação: Conteúdo e Forma

- Em 1825, o quadro negro foi adotado na universidade de Yale.
- Em 1830, os alunos passaram a ser obrigados a reproduzir de memória partes dos livros nos quadros.

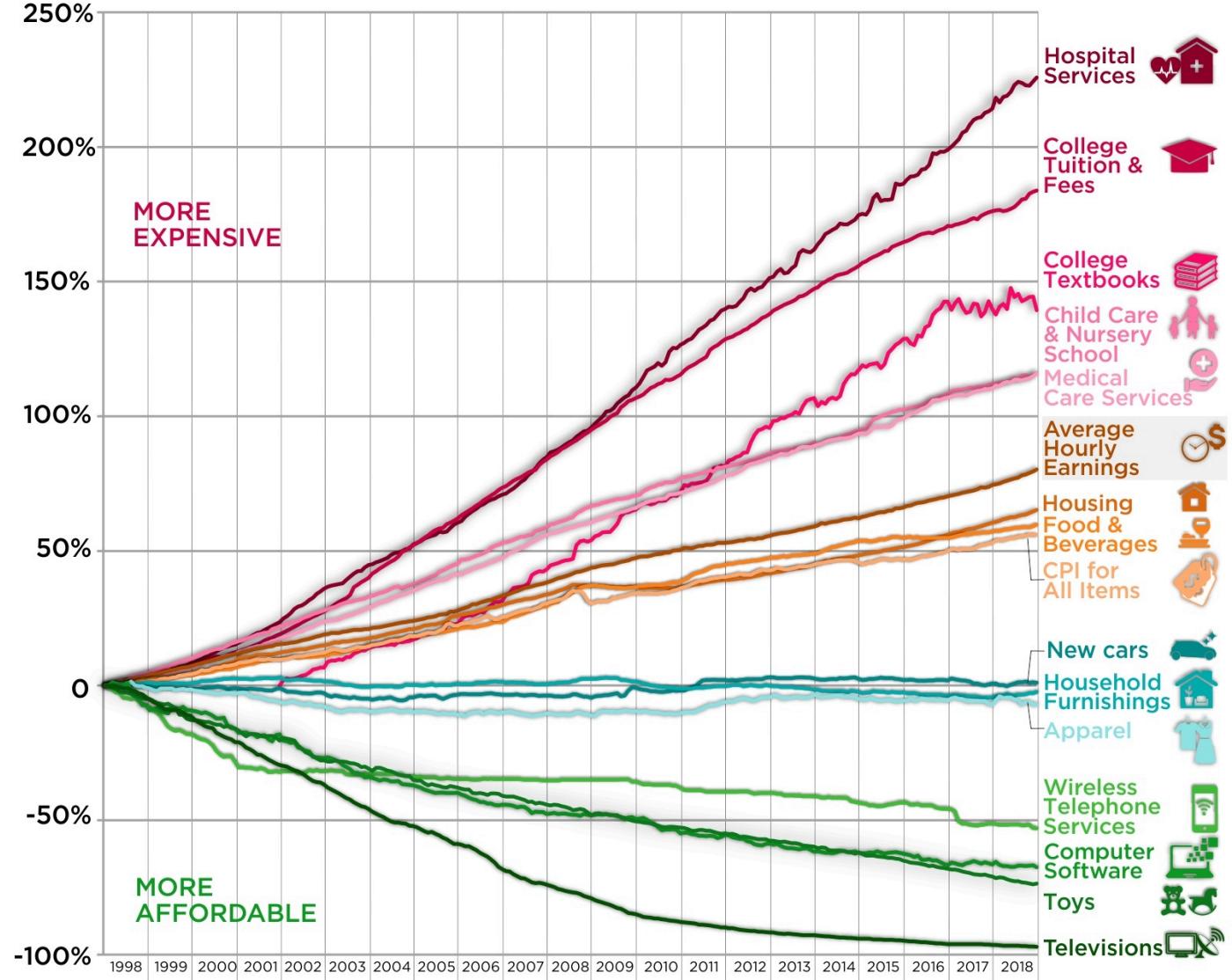


Universalizar vs. Pasteurizar

- *Descentralização Curricular*
- *Educação Inclusiva*
- *Avaliações Personalizadas*
- *Feedbacks Contínuos*

20 Years of Price Changes in The United States

Selected Consumer Goods & Services, Wages (January 1998 to December 2018)



Article & Sources:

<https://howmuch.net/articles/price-changes-in-usa-in-past-20-years>

CPI and other price indices - Bureau of Labor Statistics - <https://data.bls.gov/PDQWeb/cu>

Average hourly earnings - Bureau of Labor Statistics - <https://data.bls.gov/timeseries/CES0500000008>

Efeito Baumol

- *Custos crescentes sem ganhos de produtividade*
- *Impacto na oferta de serviços essenciais*

William Baumol, whose ... [Lee, 2017]



IA na Educação (GPT4-o, Sal & Imran Khan)

GPT-4o (Omni) math tutoring demo on Khan Academy





KHANMIGO
by Khan Academy

Get Khanmigo

Khanmigo is your always-available debate pa

For teachers
Knock something off your to-do list in minutes.

For learners
Prep for tests without breaking a sweat.

For parents
On-demand help makes homework time a breeze.

Can you help me solve this?
I need a grading rubric

"Os educadores podem acessar um **banco de dados de exercícios** recomendados para os alunos, **analisar tendências** da turma e **simplificar tarefas** administrativas."

Sal Khan (CEO Khan Academy)

First Avenue School

- 1.081 alunos
- 98% minorias, 86% econ. desfavorecidos
- Relação aluno-professor: 15:1
- Atende do PK (4 anos) ao 8º ano
- Proficiência 21% matemática, 36% leitura



First Avenue School Makes U.S. News Rankings for 2024 [NPS, 2024]

Limitações

- Erros na resolução de problemas
- Ajuda excessiva durante as avaliações
- Alinhamento pedagógico
- Mais treinamento para professores



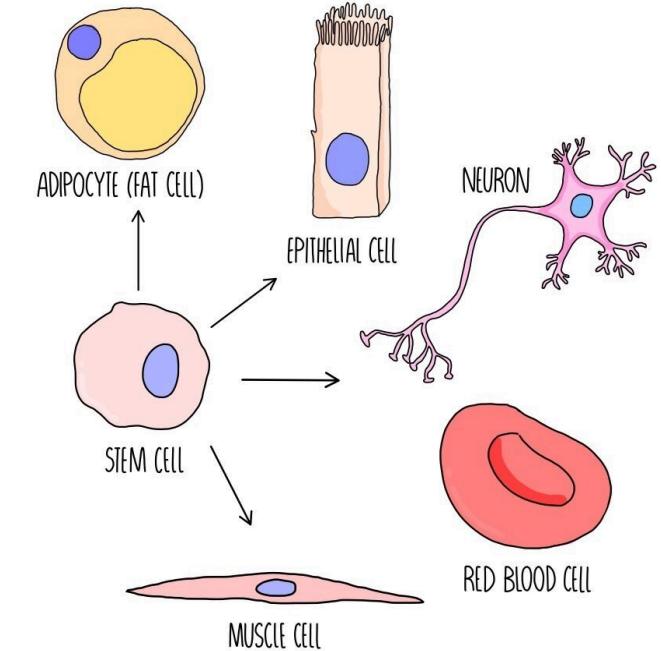
Newark Public Schools Among 1st in US to Pilot New AI Tutor [Mosaic, 2024]



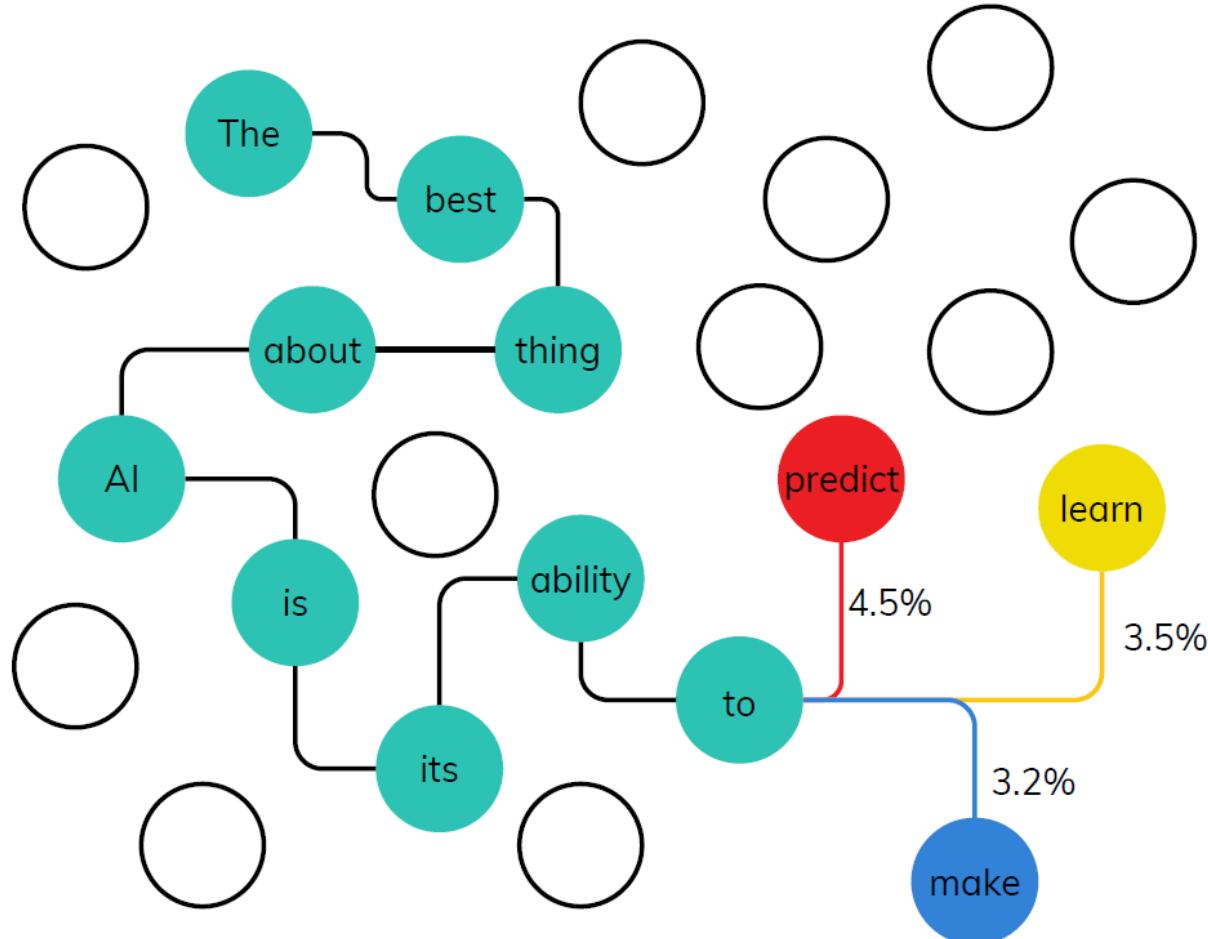
PNL: Problema Fundamental

- Tradução de texto
- Correção gramatical
- Sumarização de texto
- Extração de informações

A abordagem tradicional é treinar uma rede neural para cada tarefa específica, utilizando grandes bancos de dados.



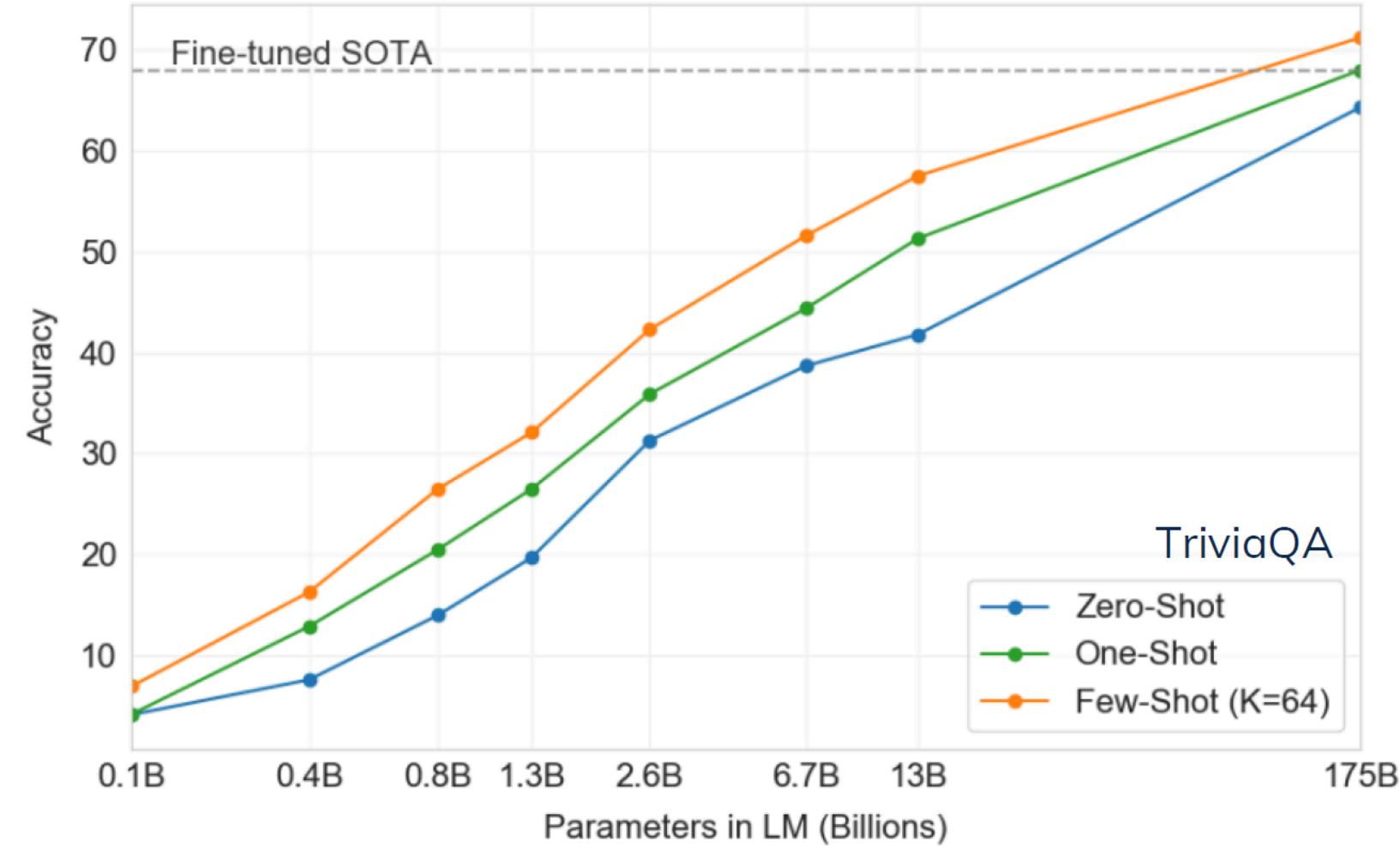
The best thing about AI is its ability to _____



A próxima
palavra é?

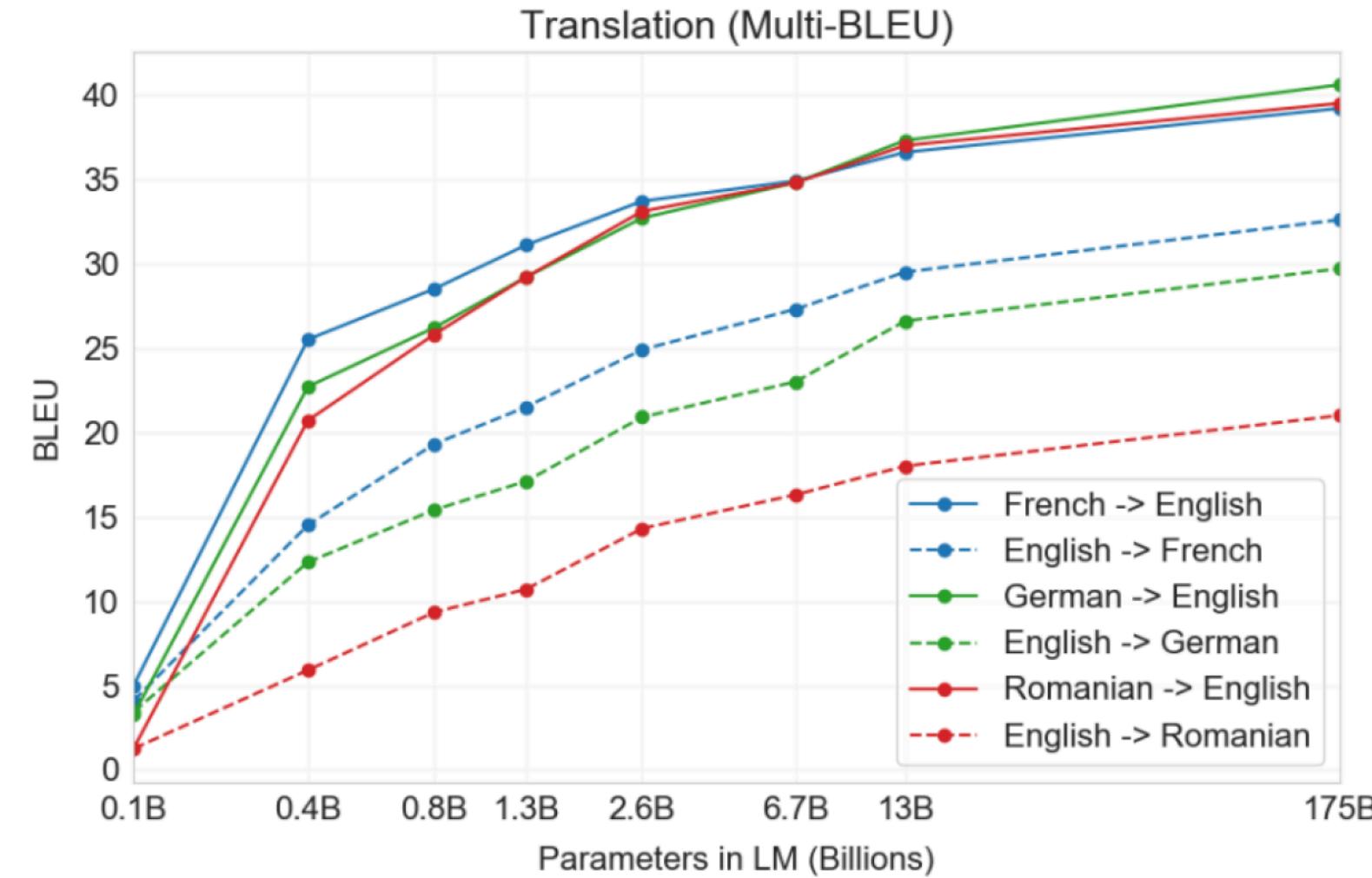
What Is ChatGPT Doing ... and Why Does It Work? [Stephen Wolfram, 2023]

PNL: QA



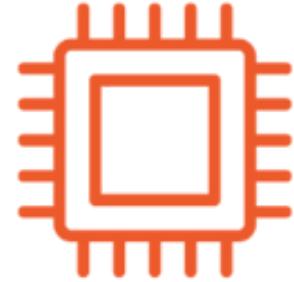
Language Models are Few-Shot Learners [Brown et al., 2020]

PNL: Tradução



Language Models are Few-Shot Learners [Brown et al., 2020]

Por que agora?



Hardware



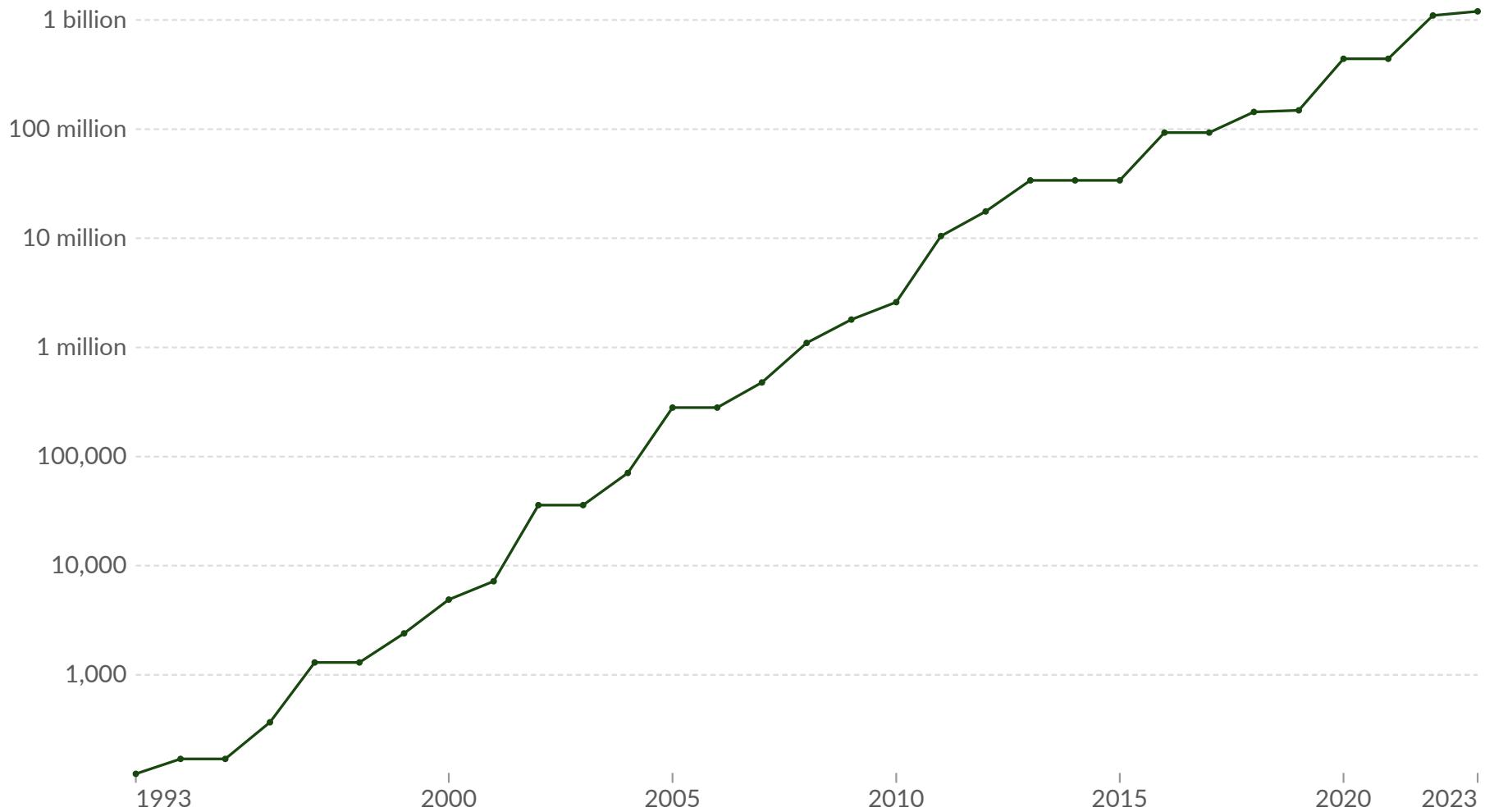
Dados



Algoritmos

Computational capacity of the fastest supercomputers

The number of floating-point operations¹ carried out per second by the fastest supercomputer in any given year. This is expressed in gigaFLOPS, equivalent to 10^9 floating-point operations per second.



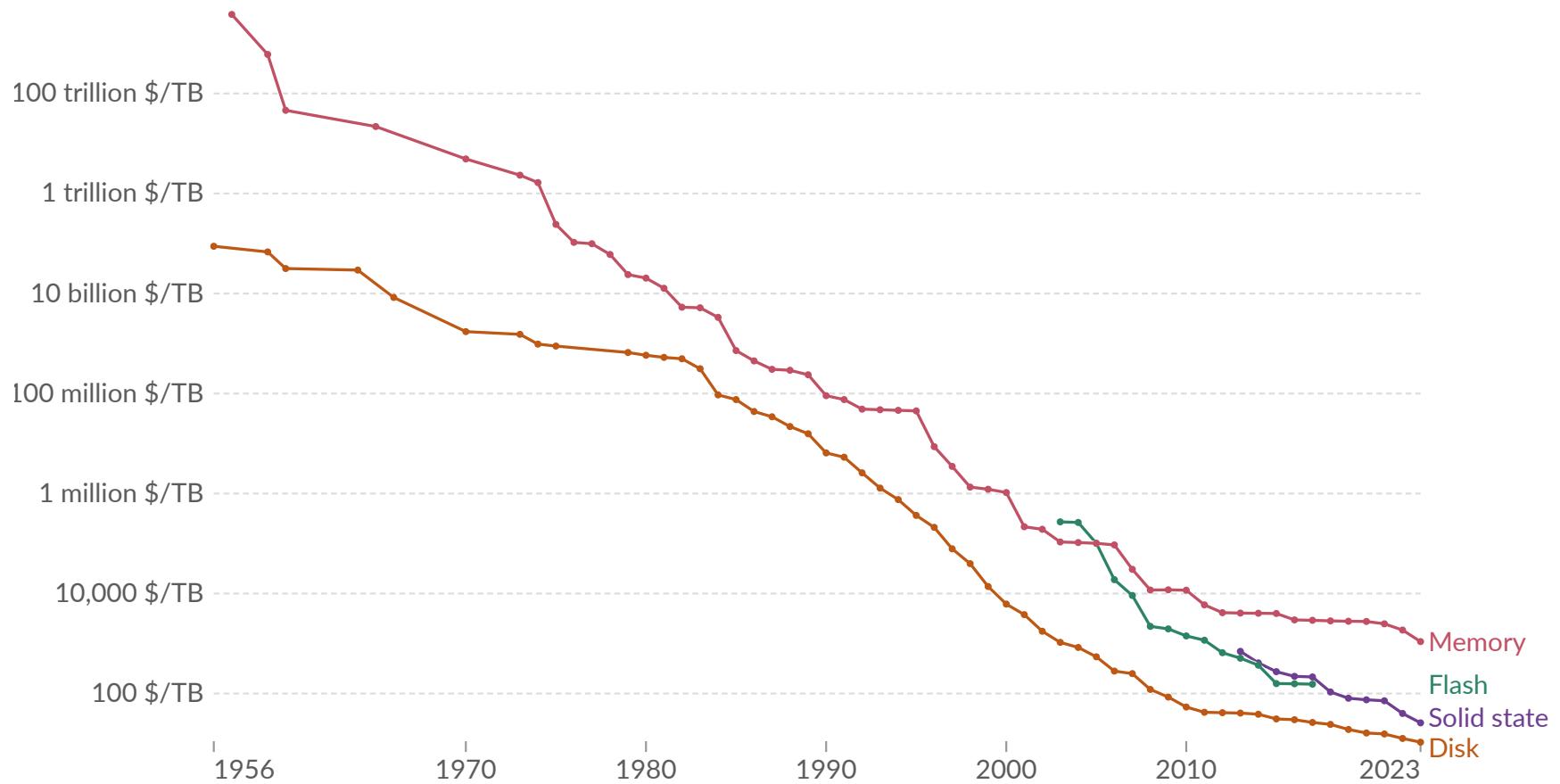
Data source: Dongarra et al. (2023)

OurWorldInData.org/technological-change | CC BY

Moore's Law [Roser et. al, 2023]

Historical price of computer memory and storage

This data is expressed in US dollars per terabyte (TB), adjusted for inflation. "Memory" refers to random access memory (RAM), "disk" to magnetic storage, "flash" to special memory used for rapid data access and rewriting, and "solid state" to solid-state drives (SSDs).



Moore's Law [Roser et. al, 2023]

Explosão de Dados

Dados por minuto

 **41,666,667**

messages shared
by WhatsApp users

 **347,222**

stories posted by Instagram users

 **1,388,889**

video / voice calls made
by people worldwide

 **150,000**

messages shared by Facebook users

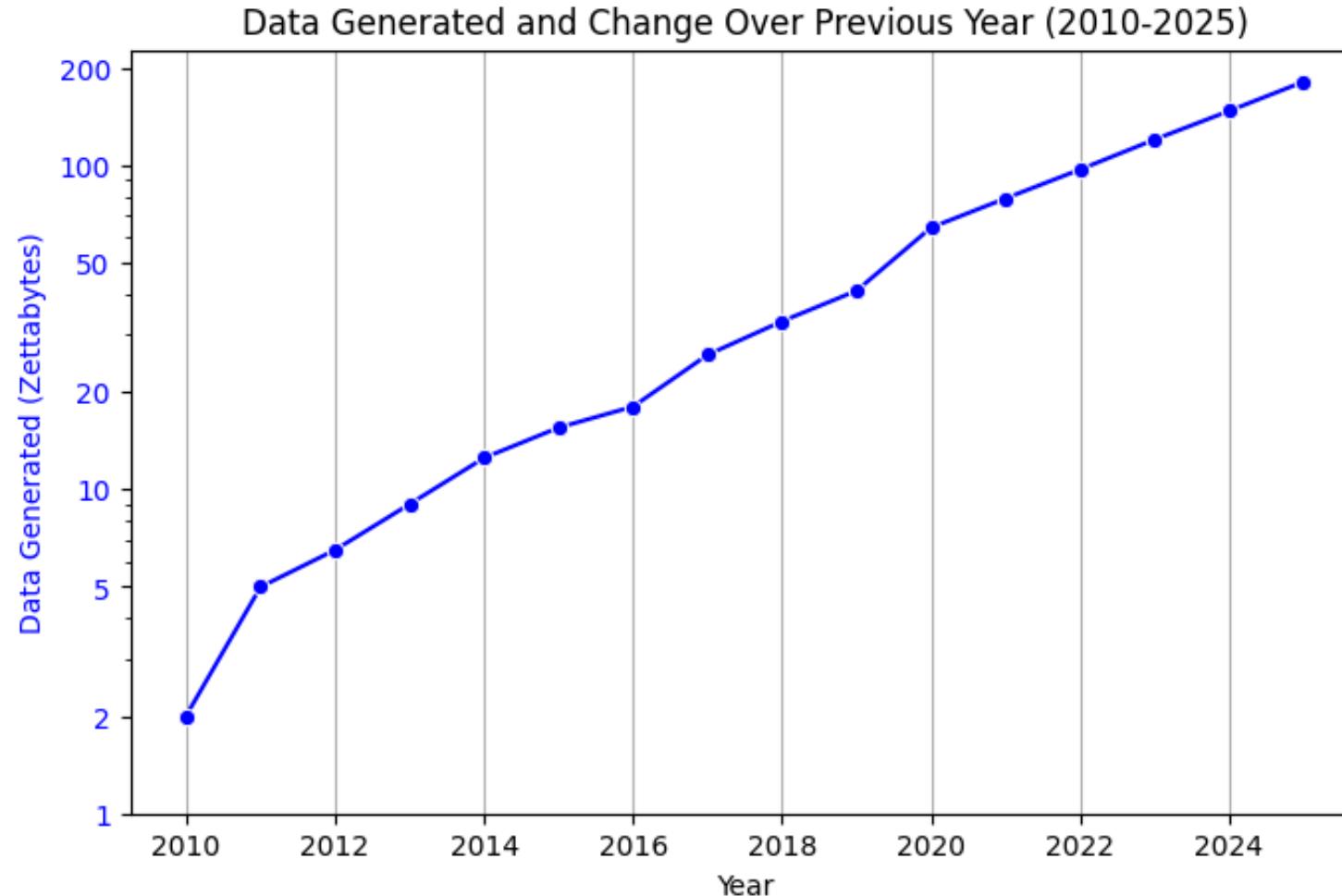
 **404,444**

hours of video streamed
by Netflix users

 **147,000**

photos shared by Facebook users

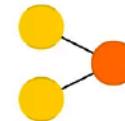
Explosão de Dados



Volume of data/information created, captured, copied, and consumed ... [Statista, 2024]

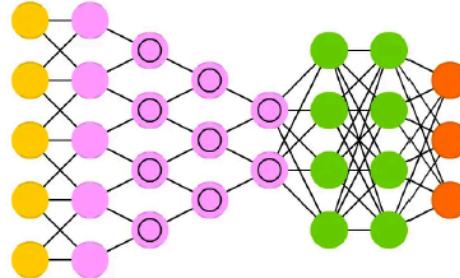
McCulloch '43

Perceptron (P)



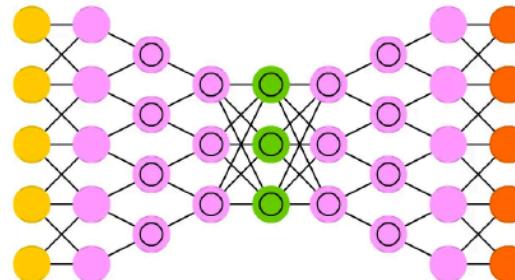
Cun'80

Deep Convolutional Network (DCN)



Kulkarni'15

Deep Convolutional Inverse Graphics Network (DCIGN)

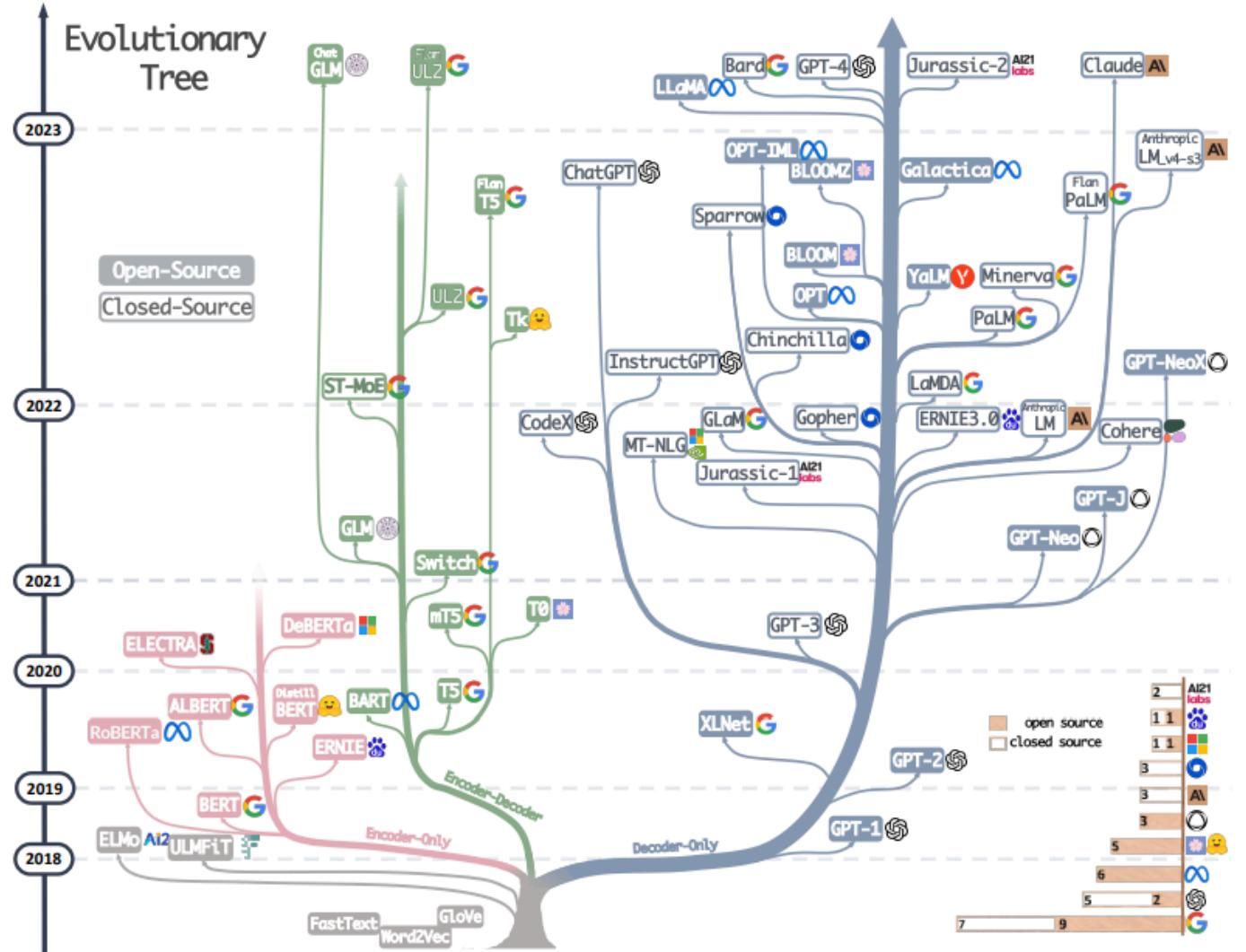


Redes Neurais

Rank	Citations	Title	Year
1	305,148	Protein measurement with the folin phenol reagent	1951
2	213,005	Cleavage of structural proteins during the assembly of the head of bacteriophage T4	1970
3	173,883	Attention is all you need	2017

Attention is All You Need [Vaswani et al., 2017]

Explosão de Modelos de Linguagem



Harnessing the Power of LLMs in Practice: A Survey on ChatGPT and Beyond [Yang et. al, 2023]

Rank* (UB)	Model	Arena Score	Votes ▲	Organization	License
1	Gemini-2.5-Pro-Exp-03-25	1443	3474	Google	Proprietary
2	ChatGPT-4o-latest_(2025-03-26)	1408	2676	OpenAI	Proprietary
2	Grok-3-Preview-02-24	1404	10397	xAI	Proprietary
2	GPT-4.5-Preview	1398	10907	OpenAI	Proprietary
5	Gemini-2.0-Flash-Thinking-Exp-01-21	1381	22987	Google	Proprietary
5	Gemini-2.0-Pro-Exp-02-05	1380	20289	Google	Proprietary
7	DeepSeek-R1	1360	13074	DeepSeek	MIT
7	Gemini-2.0-Flash-001	1355	18650	Google	Proprietary
7	o1-2024-12-17	1351	25363	OpenAI	Proprietary
10	Qwen2.5-Max	1340	17452	Alibaba	Proprietary
10	Gemma-3-27B-it	1339	7238	Google	Gemma
10	o1-preview	1335	33188	OpenAI	Proprietary

LLM Arena # Leaderboard, 31/03/2025

Palavras vs. Números

Redes neurais lidam com números, não com palavras.

Desejamos uma representação que seja

útil = semântica + aritmética



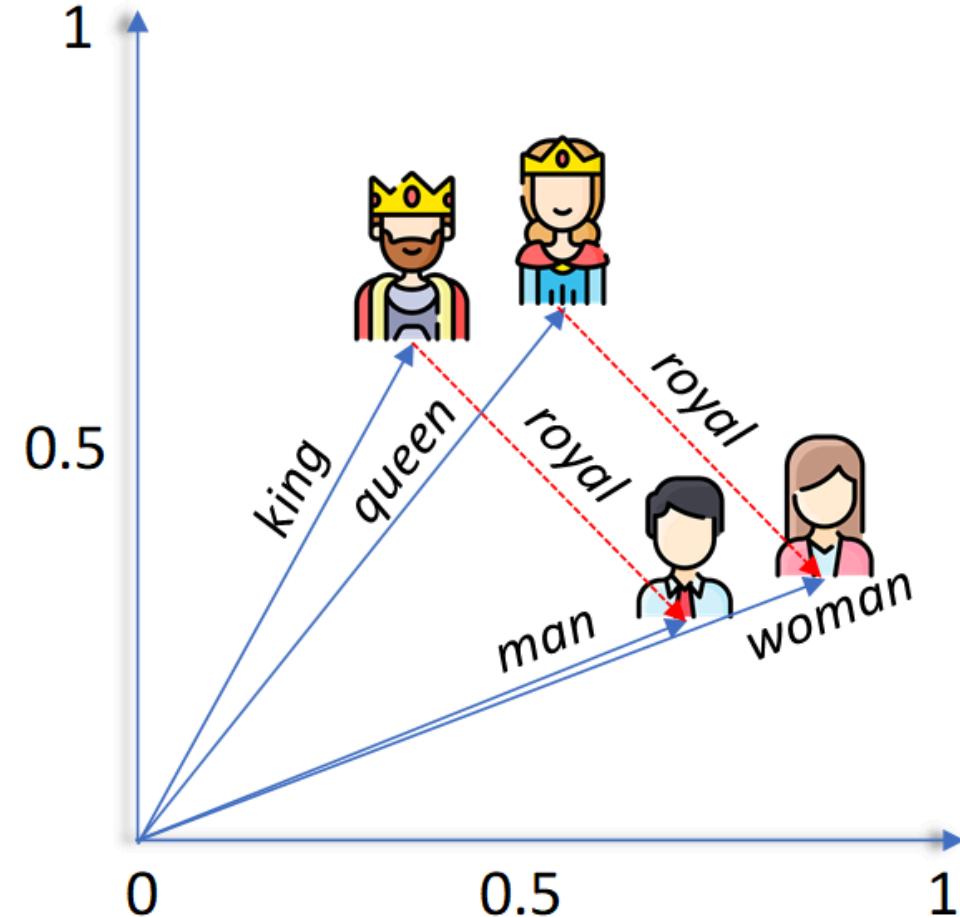
Über formal unentscheidbare Sätze der Principia Mathematica und verwandter .. [Kurt Gödel, 1931]

Word Embedding

Redes neurais lidam com números, não com palavras.

Desejamos uma representação que seja

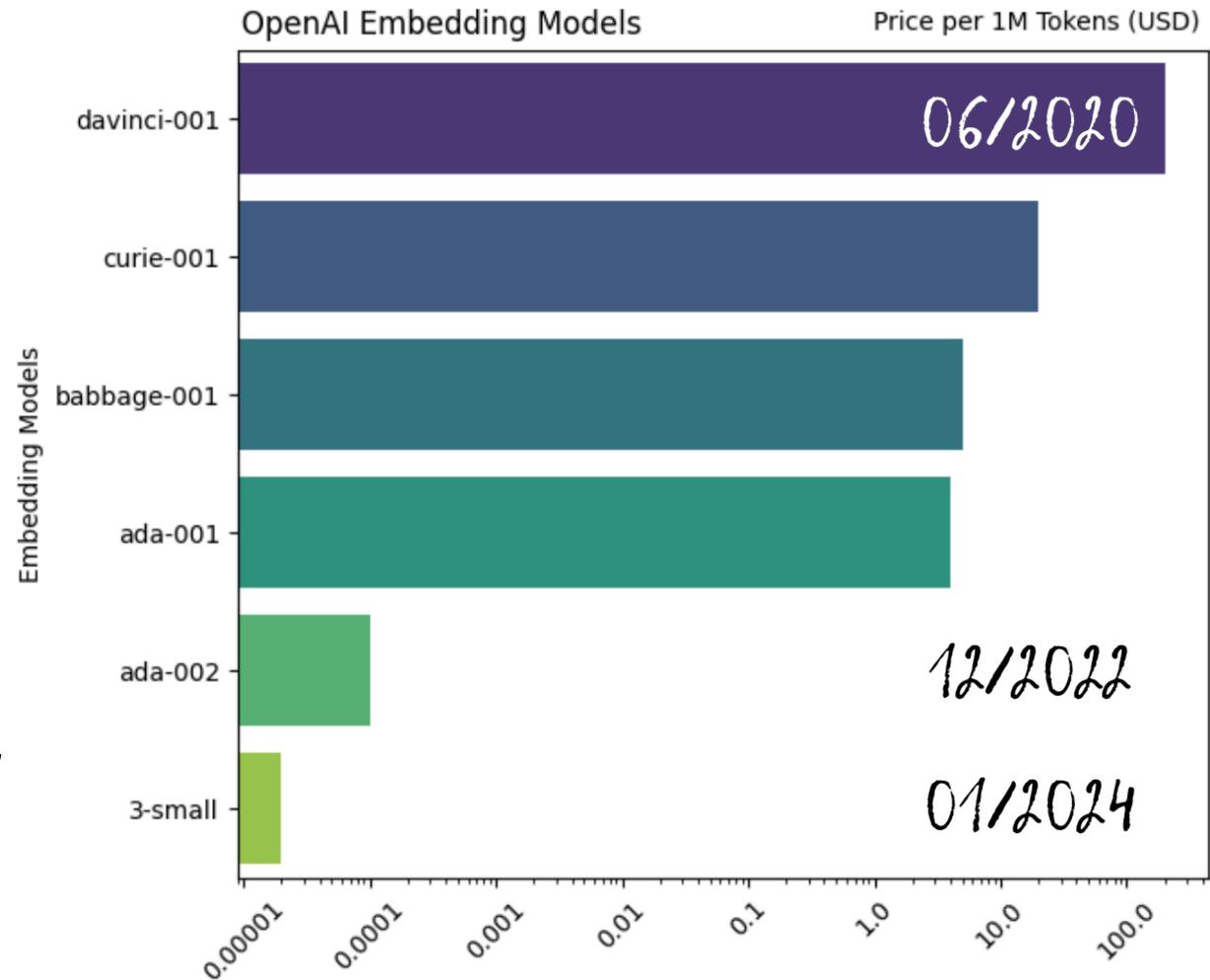
útil = semântica + aritmética



Word Embedding

Redes neurais lidam com
números, não com palavras.

Desejamos uma
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útil = semântica + aritmética



<https://openai.com/research/>

Word Embeddings

Tokenização

gpt-4 / gpt-3.5-turbo / text-embedding-ada-002

Um triângulo retângulo, em geometria, é um triângulo em que um dos ângulos é reto (ou seja, um ângulo de 90 graus). A relação entre os lados e os ângulos de um triângulo retângulo é a base da trigonometria.

TOKENS CHARACTERS
74 206

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A right triangle, in geometry, is a triangle in which one of the angles is right (i.e., a 90-degree angle). The relationship between the sides and angles of a right triangle is the basis of trigonometry.

TOKENS CHARACTERS
47 203

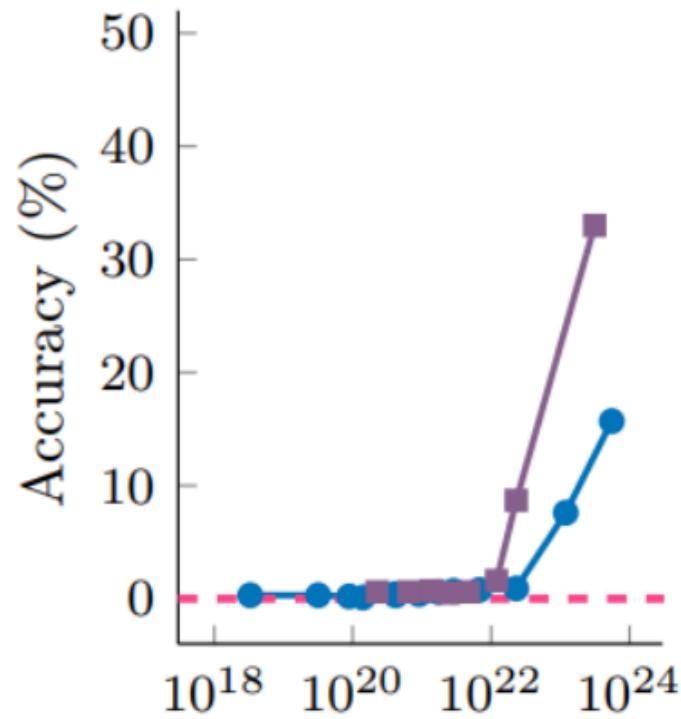
A right triangle, in geometry, is a triangle in which one of the angles is right (i.e., a 90-degree angle). The relationship between the sides and angles of a right triangle is the basis of trigonometry.

Habilidades Emergentes

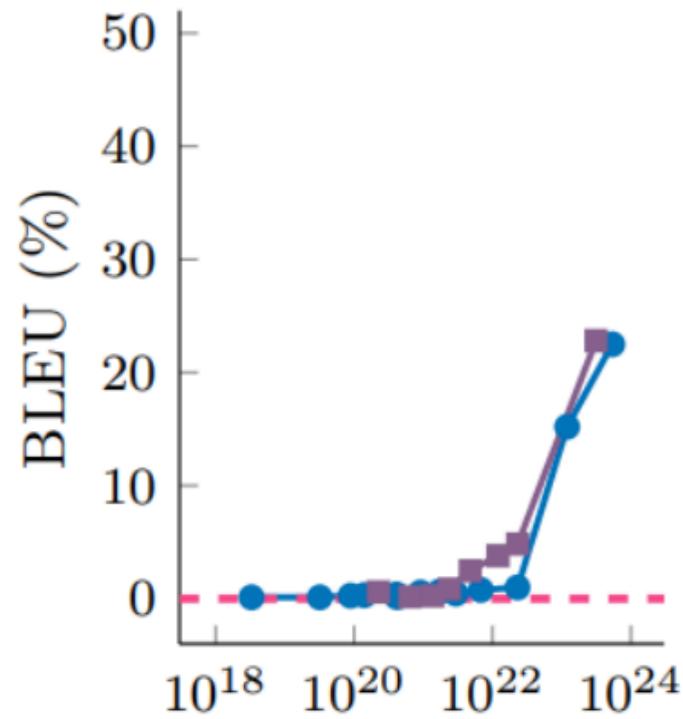
● LaMDA ■ GPT-3

- - - Random

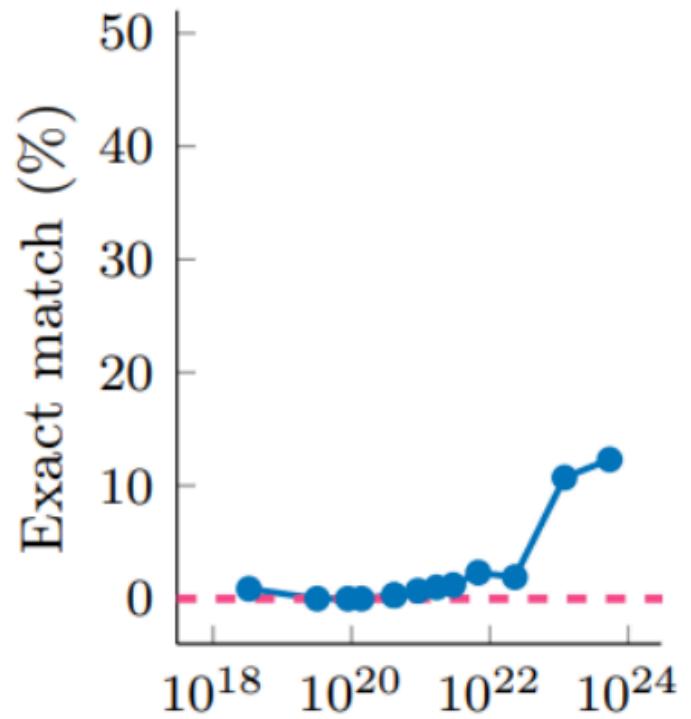
(A) Mod. arithmetic



(B) IPA transliterate



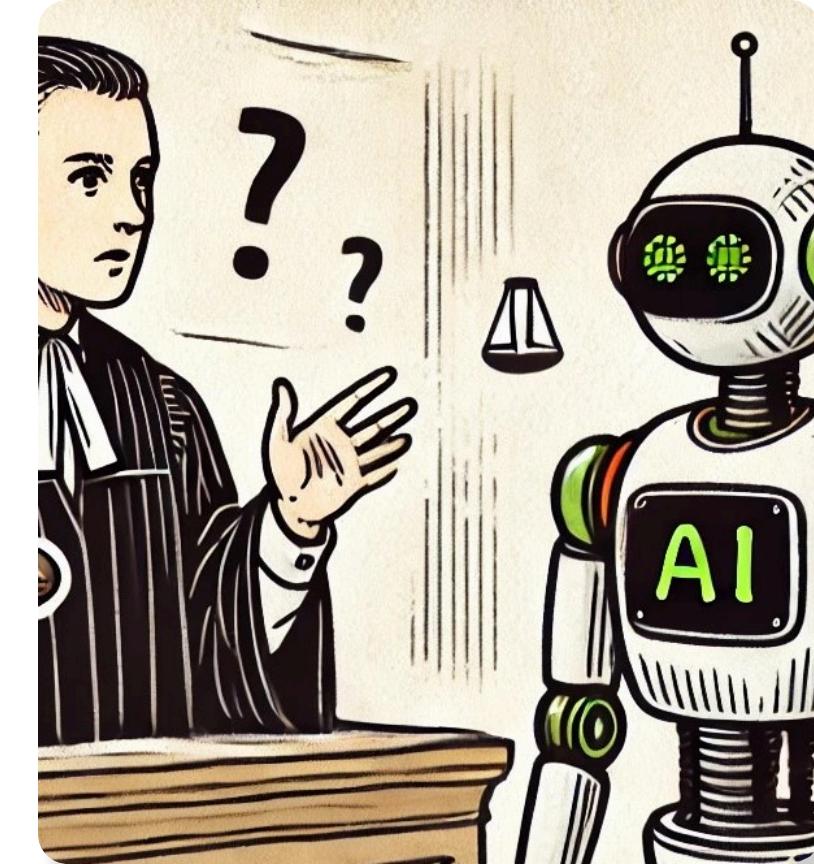
(C) Word unscramble



Emergent Abilities in Large Language Models [Wei et. al, 2022]

Regulação Jurídica

- Qual é o limite de uso de uma obra?
- Dados abertos e democratização
- Modelos compensatórios
- O que é a autoria?

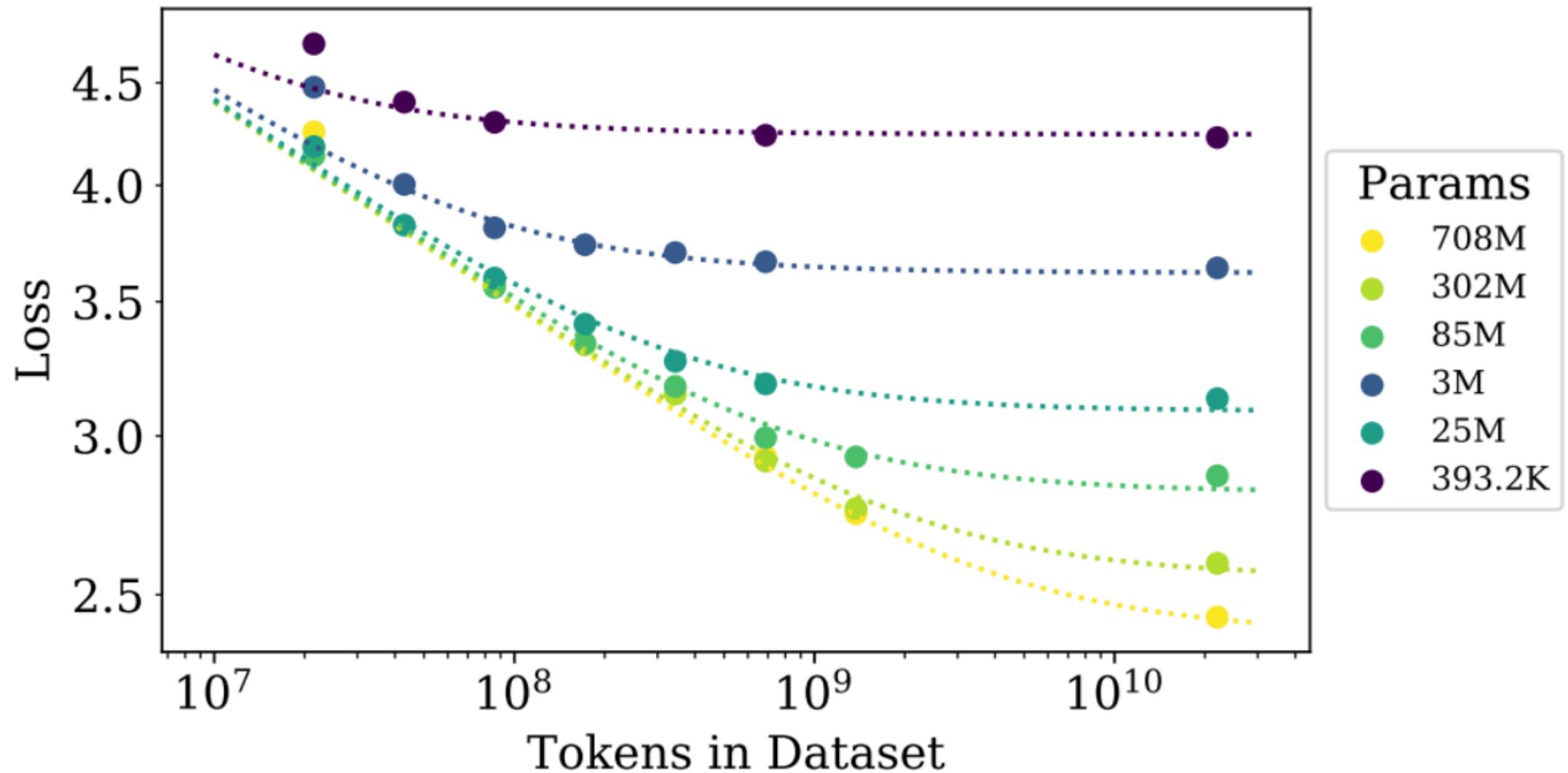


ChatGPT: A Case Study on Copyright Challenges for Generative Artificial Intelligence ... [Lucchi, 2023]



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Loss vs Model and Dataset Size

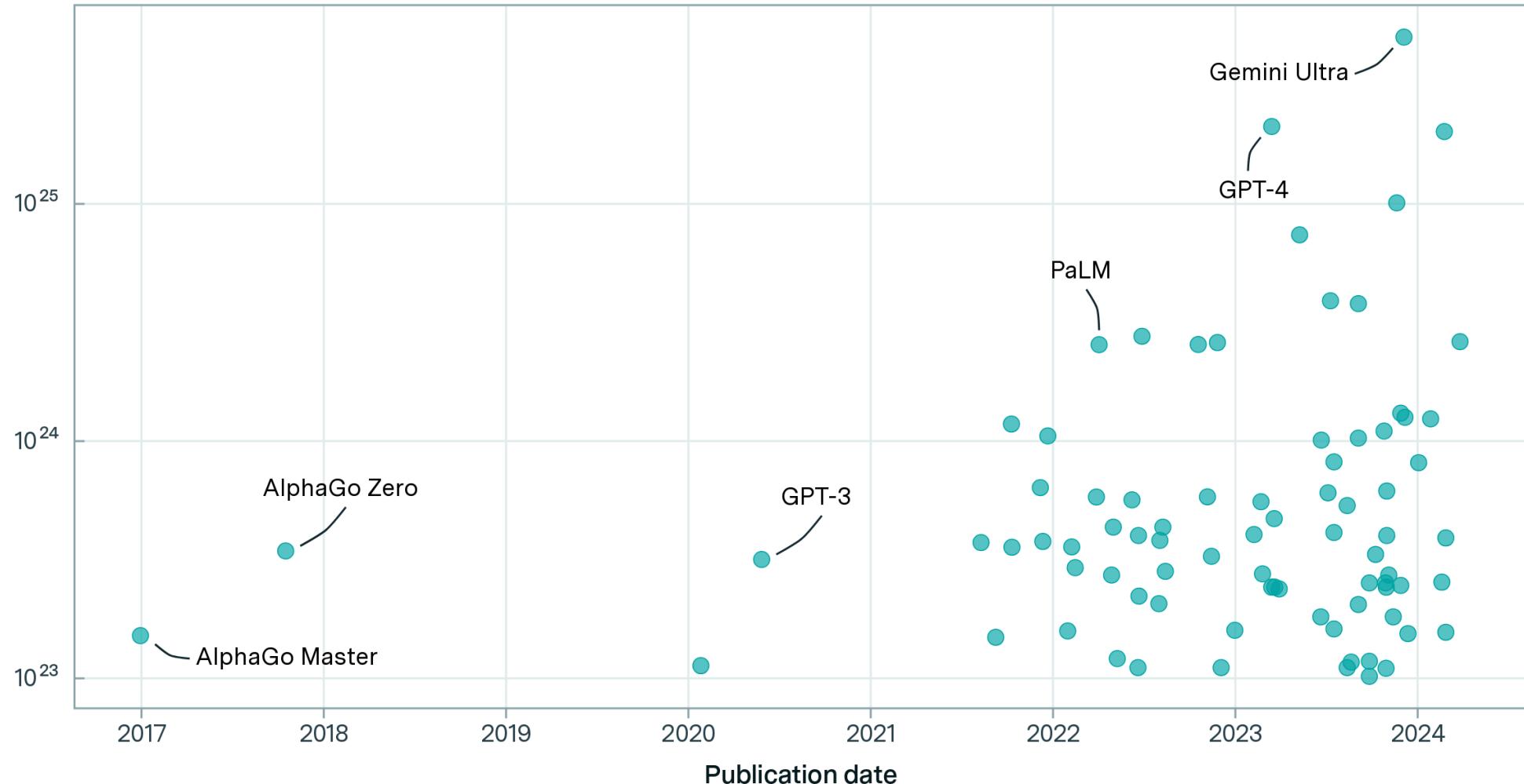


Emergent Abilities in Large Language Models [Wei et. al, 2022]

Large-scale models

EPOCH AI

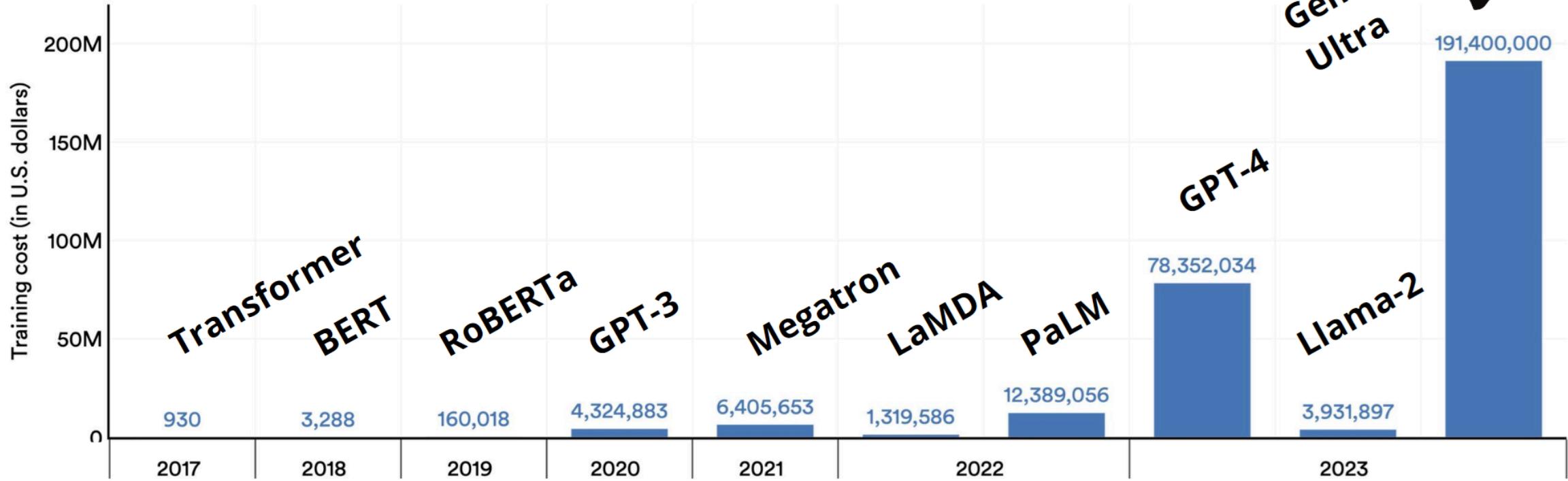
Training compute (FLOP)



Tracking Large-Scale AI Models [Raman et al., 2024]

Estimated training cost of select AI models, 2017–23

Source: Epoch, 2023 | Chart: 2024 AI Index report



Artificial Intelligence Index Report 2024 [Stanford, 2024]