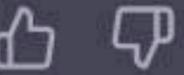




a sarcastic introductory paragraph for a course on data-driven methods in science and engineering



Welcome to our course on data-driven methods in science and engineering! Because apparently, it's not enough to just rely on our brains and expertise anymore - now we have to rely on fancy algorithms and computer programs to do our thinking for us. But don't worry, this course isn't just about becoming a slave to technology. No, no. We'll also be learning how to use data to make better decisions, because apparently we're not capable of making good decisions on our own. So sit back, relax, and let the data do all the work for you. It's the future, after all.



JB

You

a sarcastic introductory paragraph for a course on data-driven modeling in science and engineering



ChatGPT

"Welcome to the course on Data-Driven Modeling in Science and Engineering, where we'll pretend that data is just a bunch of numbers and not the key to unlocking the mysteries of the universe. Here, you'll learn to crunch numbers like a pro, because who needs intuition or theory when you have spreadsheets? Get ready to transform from a curious scientist into a data-mining machine, because in this course, we believe that every complex problem has a numerical solution buried somewhere in a sea of data. So, strap in and prepare your pivot tables, as we embark on a journey to turn raw data into slightly less raw data, and maybe, just maybe, find some answers along the way (but no promises)."





You

more sarcastic

ChatGPT in January 2024



ChatGPT

"Welcome to 'Data-Driven Modeling in Science and Engineering: A Fantastical Odyssey,' the course that promises to transform your overflowing enthusiasm for spreadsheets into a borderline unhealthy obsession! Ever dreamt of swimming in an endless ocean of data, deciphering the secrets of the universe with a few clicks and a lot of guesswork? Well, dream no more! This course will equip you with the superpower to see patterns where others see chaos, and to create models that are almost as accurate as your horoscope. Dive headfirst into the exhilarating world of statistical anomalies and computational conundrums, where your primary weapons are regression analysis and a stubborn refusal to acknowledge the limits of correlation. Forget about 'hands-on' learning; here, it's 'brains-on' as you wrestle with data sets that have more variables than you have social media followers. Prepare for sleepless nights spent in the company of your new best friends: Python, R, and the ever-elusive concept of 'sufficient sample size.' By the end of this course, you'll be able to predict everything from climate patterns to next week's cafeteria menu, or at least, you'll believe you can. So, charge your laptops, sharpen your pencils, and get ready to embark on a journey where the only thing more exciting than the data is the way we'll overinterpret it!"



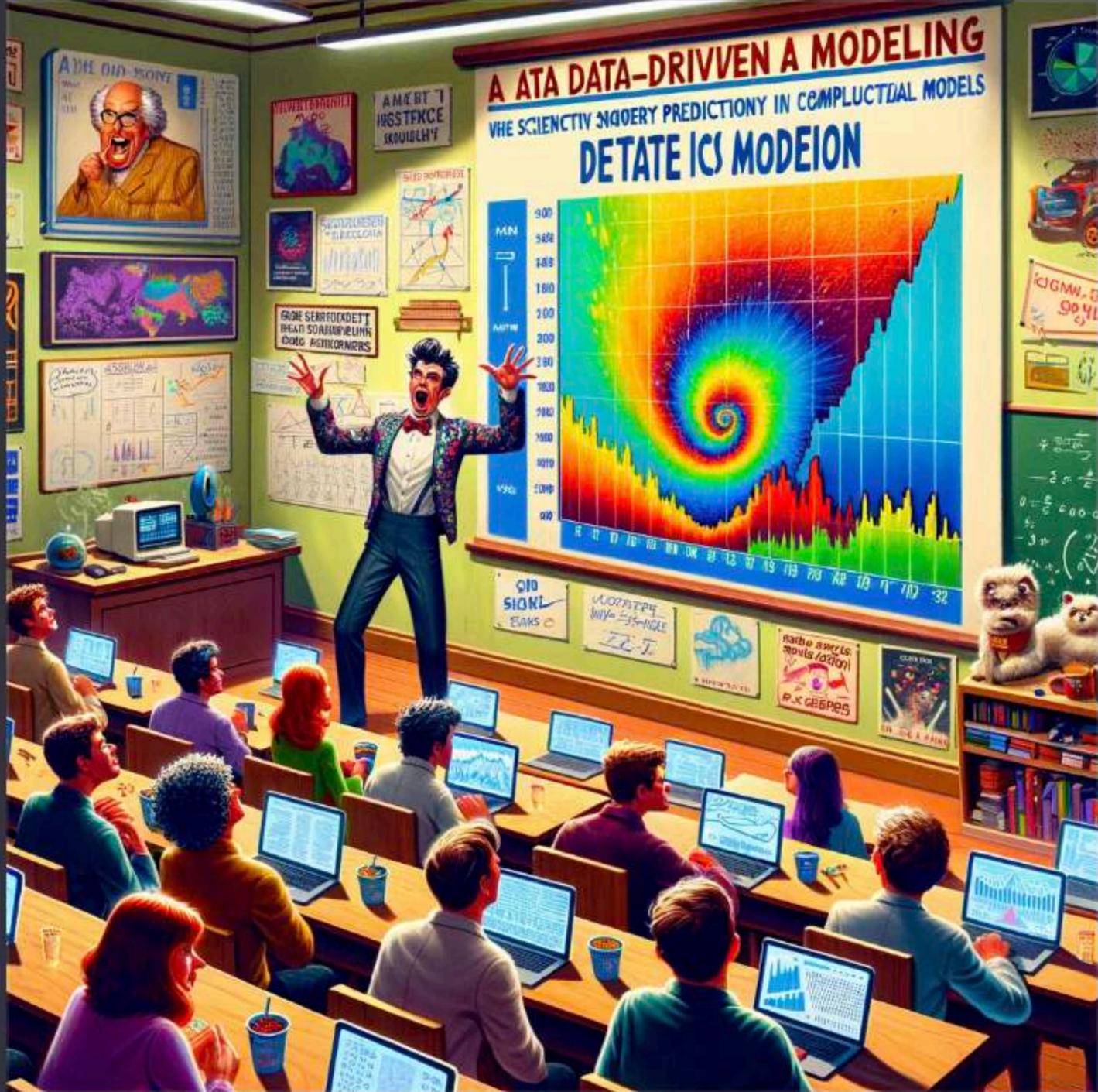
JB

You

make an illustration for this introduction

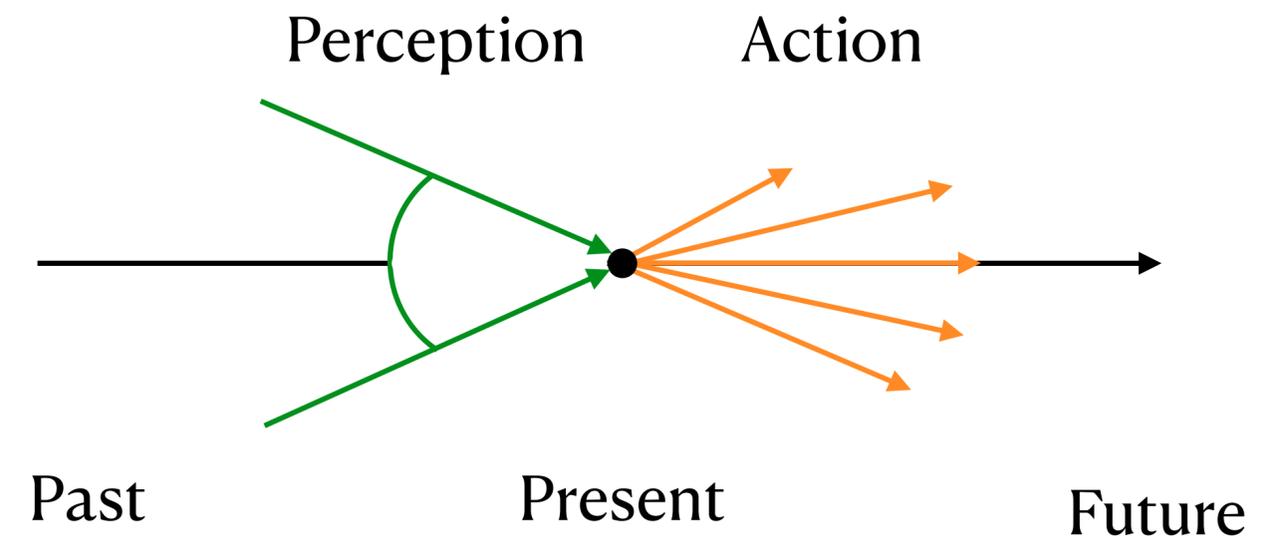
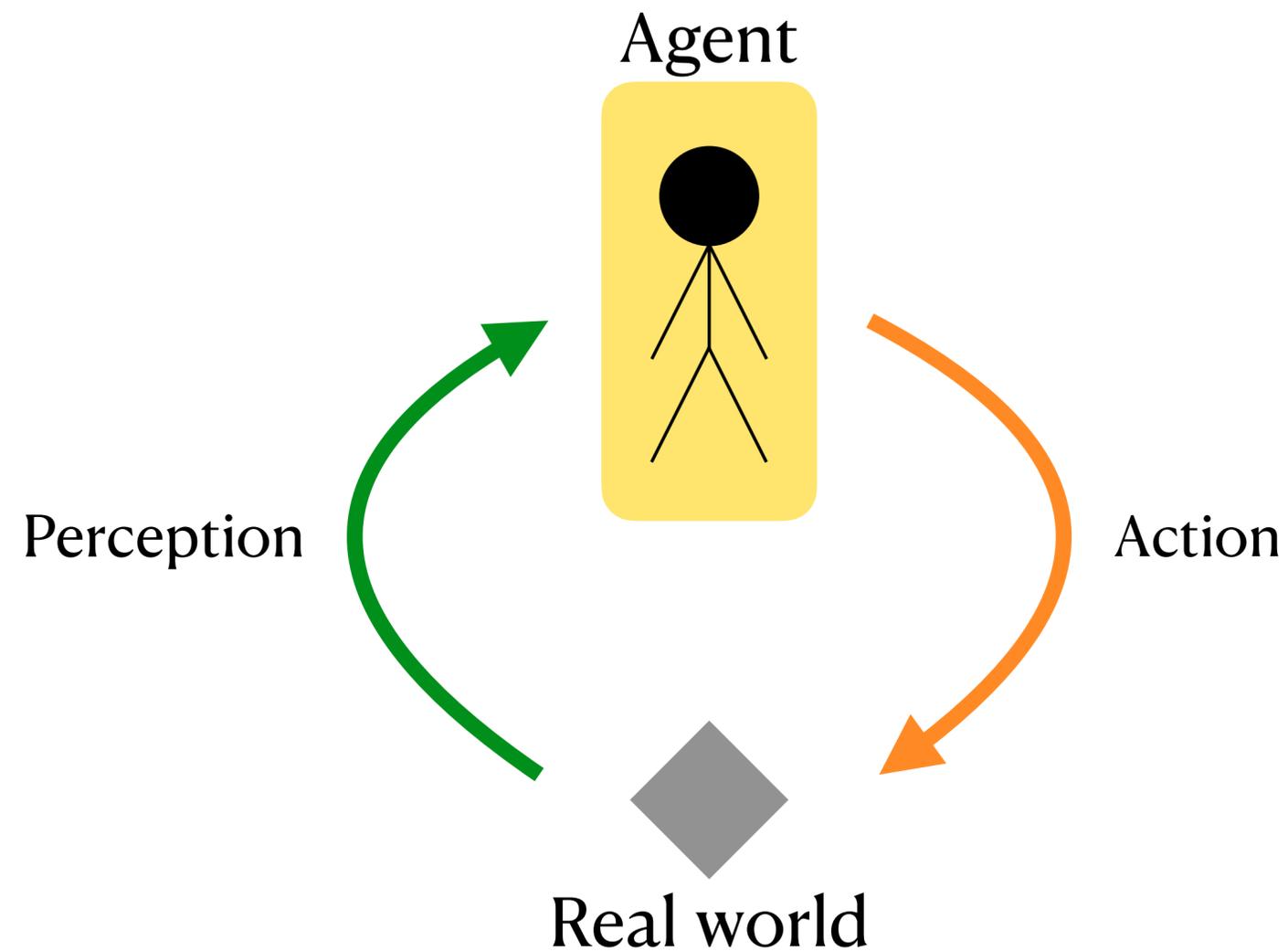


ChatGPT

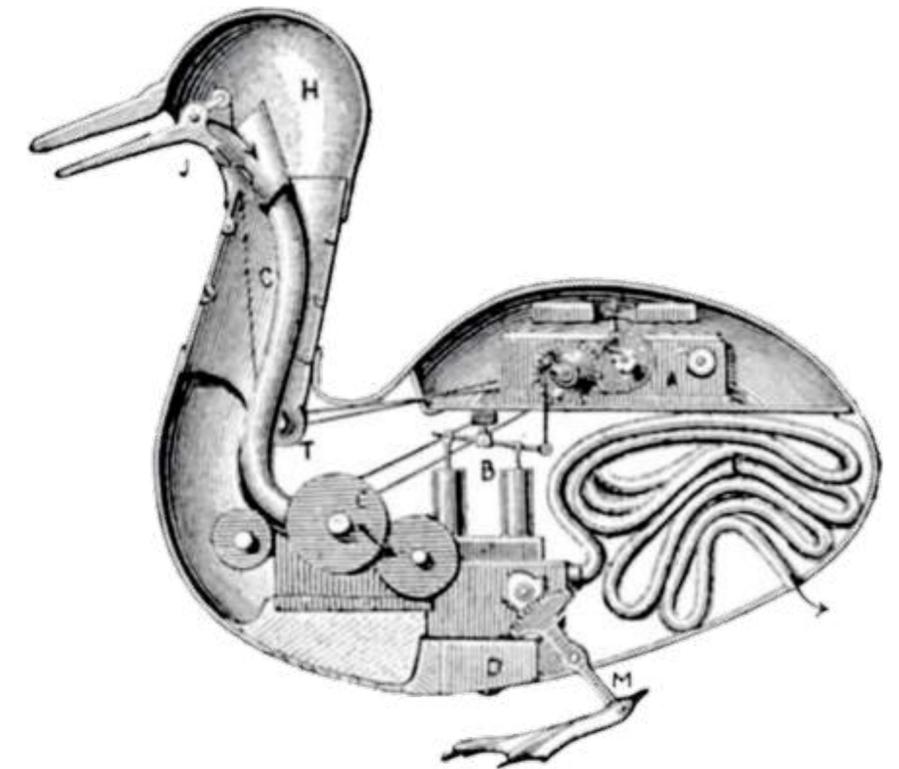


What is Intelligence?

Can we automate it?



Intelligent mechanical machines

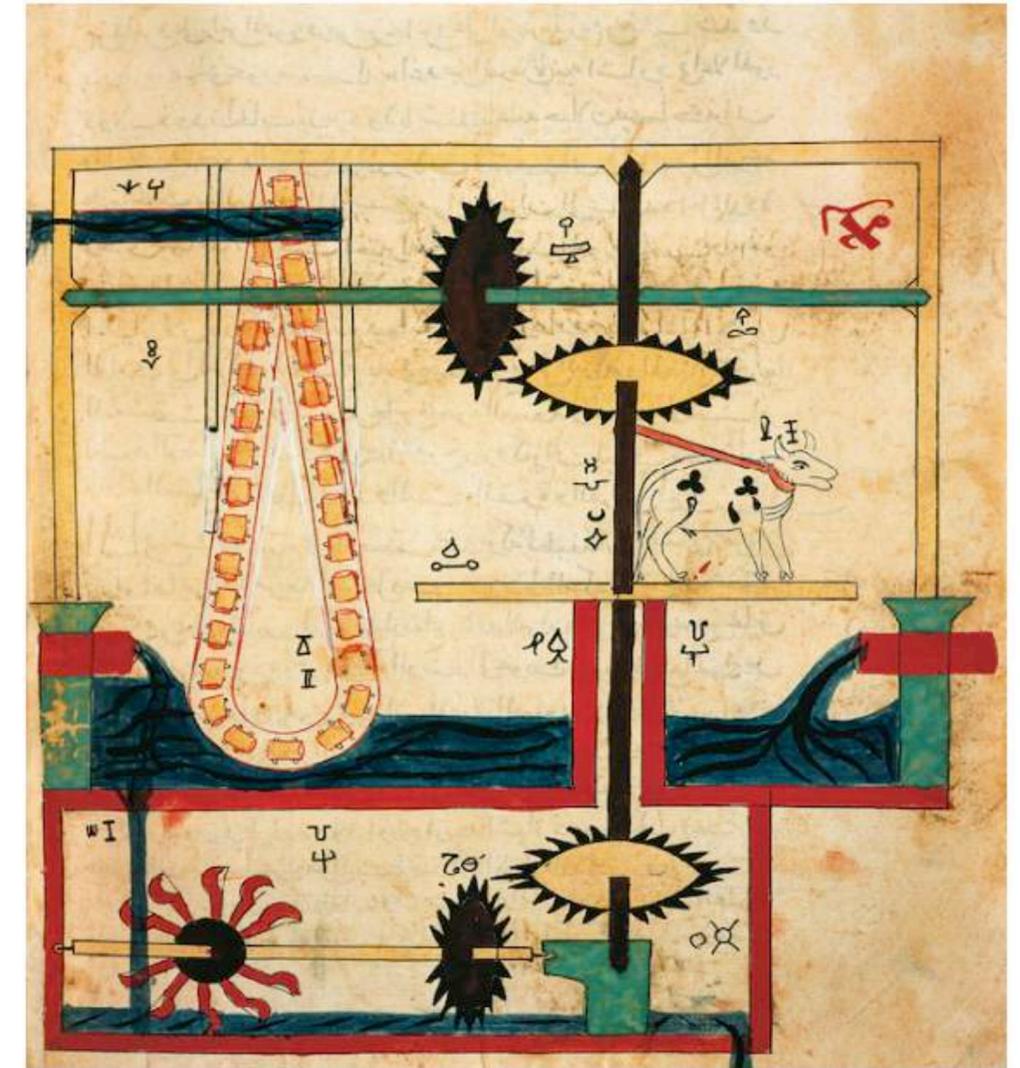
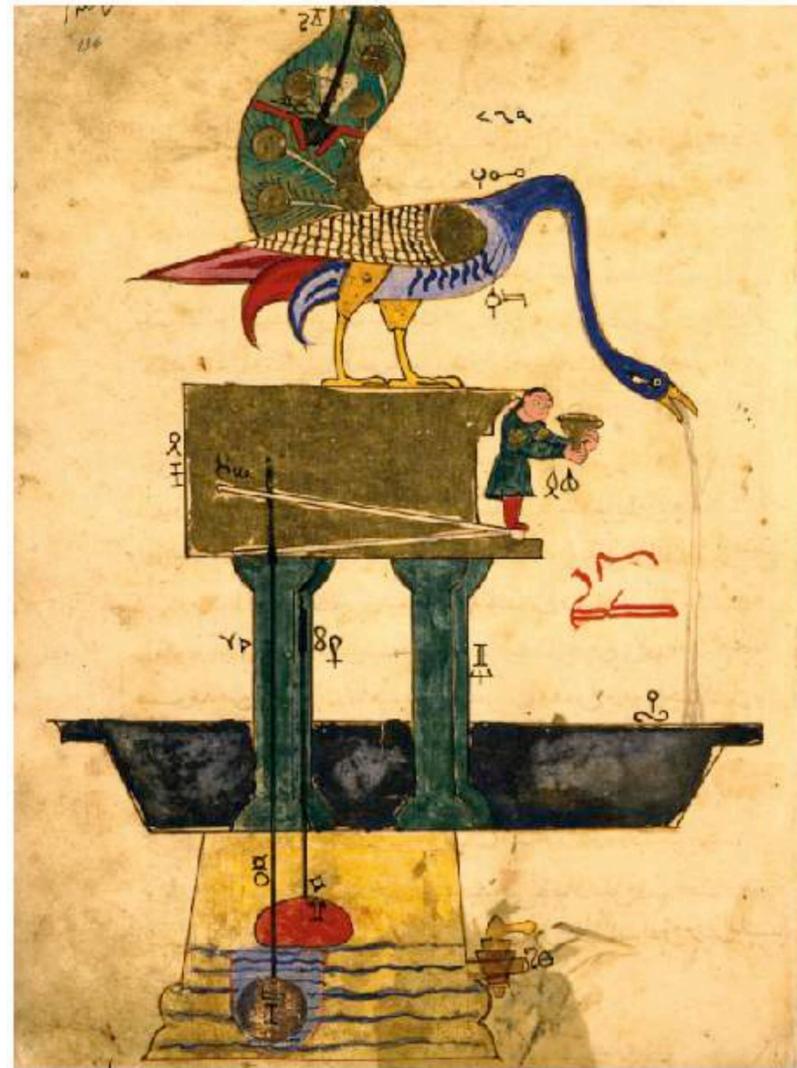


The Digesting Duck
Jacques Vaucanson (1739)

18th century automata

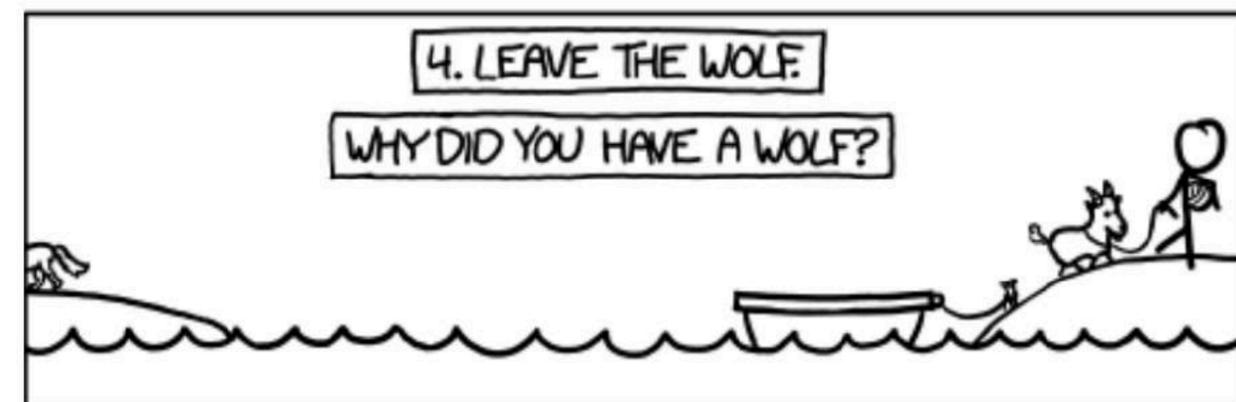
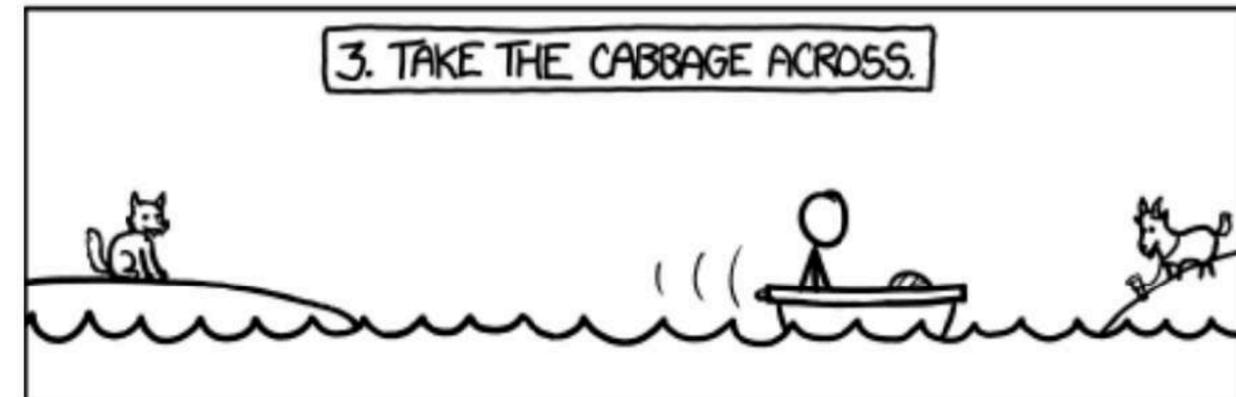
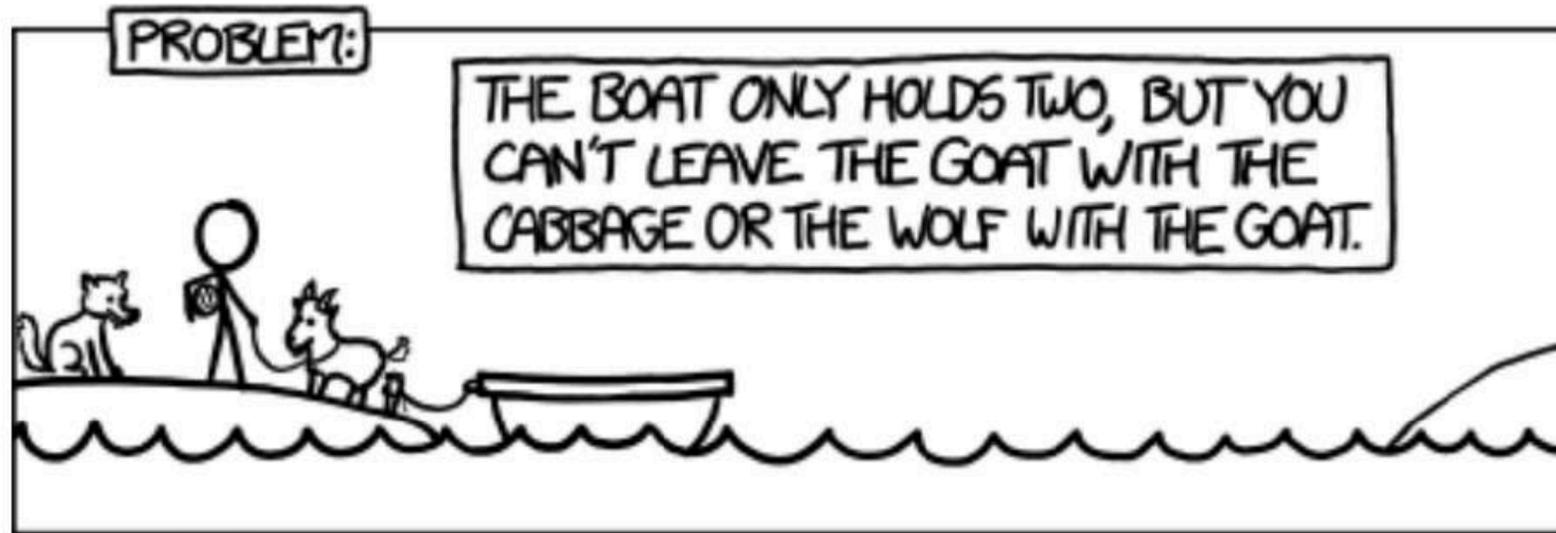
Early programmable “robots” for practical applications

بديع الزمان أَبُو الْعَزِزِ إِبْنُ إِسْمَاعِيلِ بْنِ الرَّزَّازِ الْجَزْرِي



1206

Artificial Intelligence 1950's- Solving puzzles

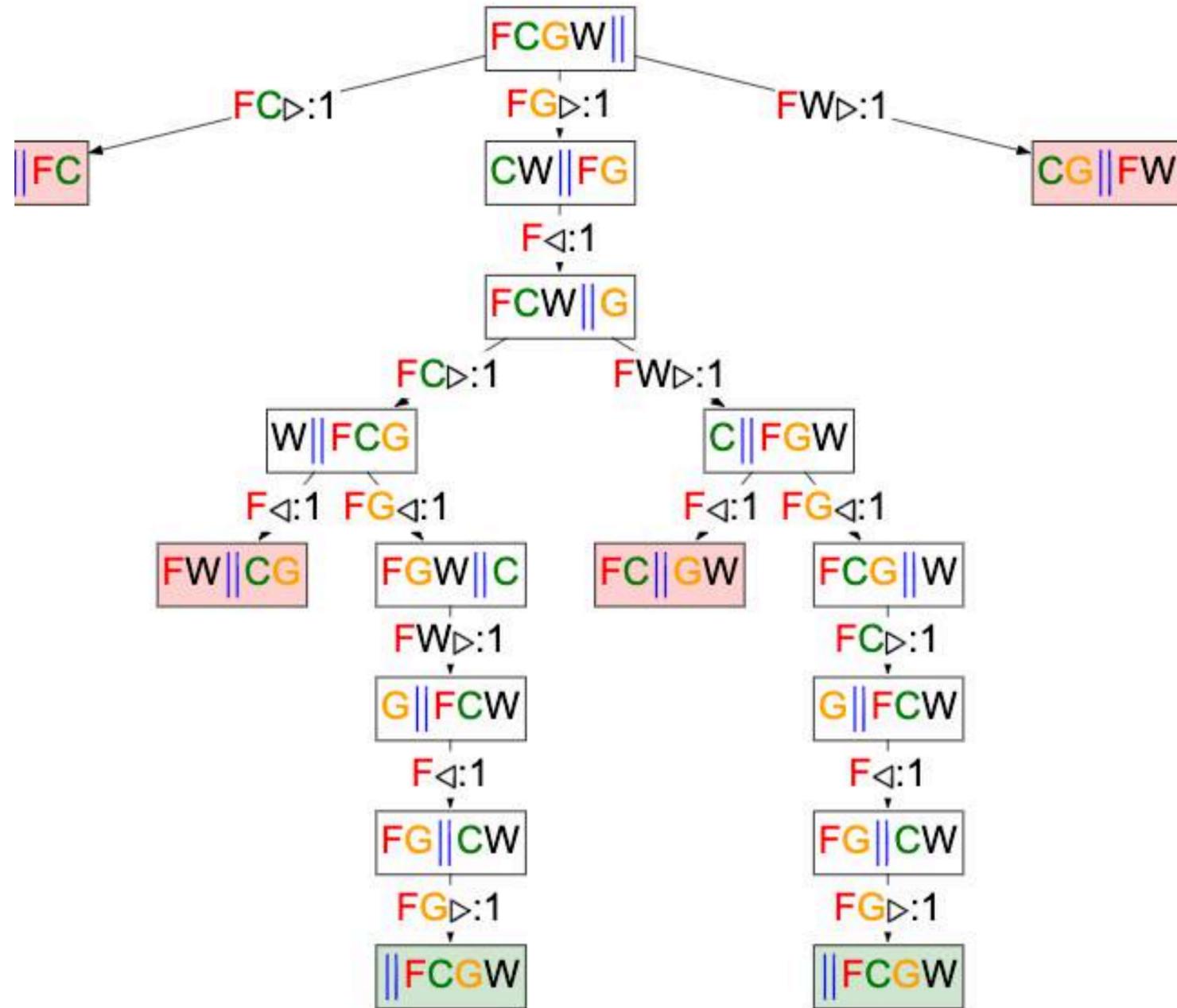


Find optimal search strategies



Farmer Cabbage Goat Wolf

F▷	F◁
FC▷	FC◁
FG▷	FG◁
FW▷	FW◁



Overwhelming optimism

The spirit is willing but the flesh is weak.



(Russian)



The vodka is good but the meat is rotten.

1950's

Rebirth of Artificial Intelligence

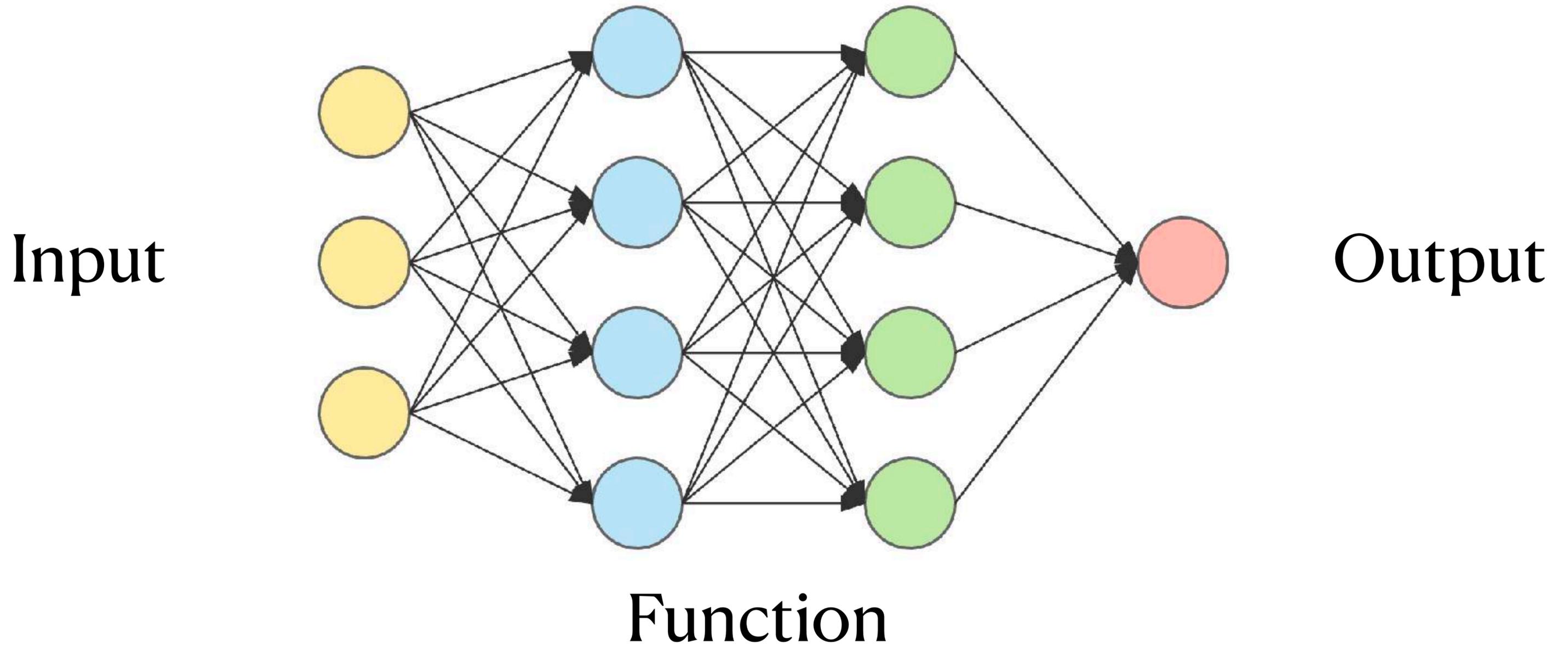
More real-world data

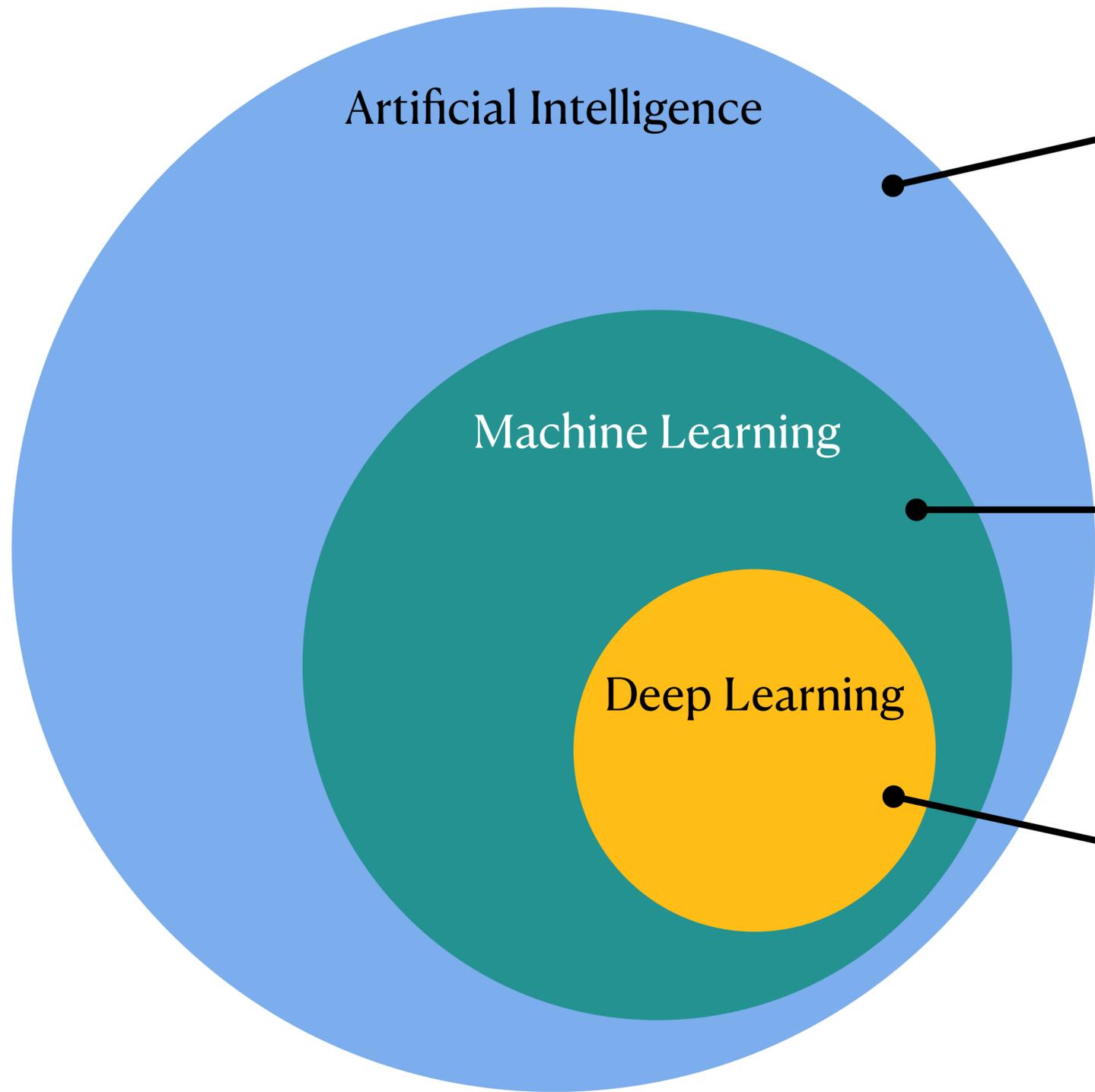
Faster computers

Better algorithms

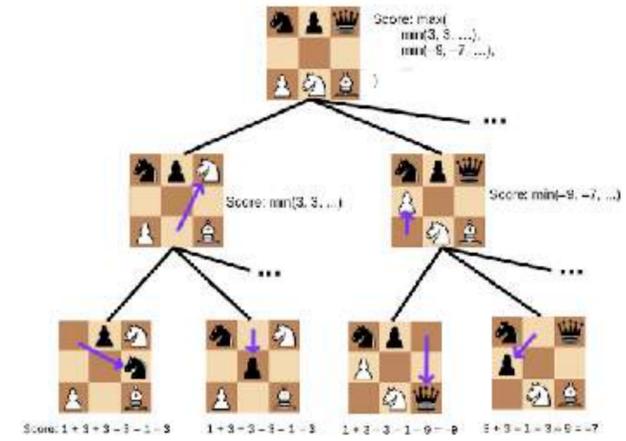
Deep Learning

Neural networks

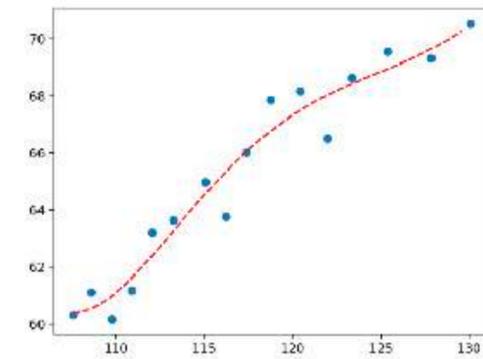




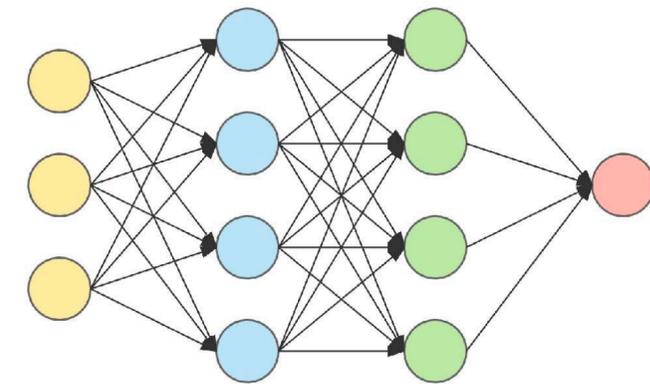
Symbolic AI



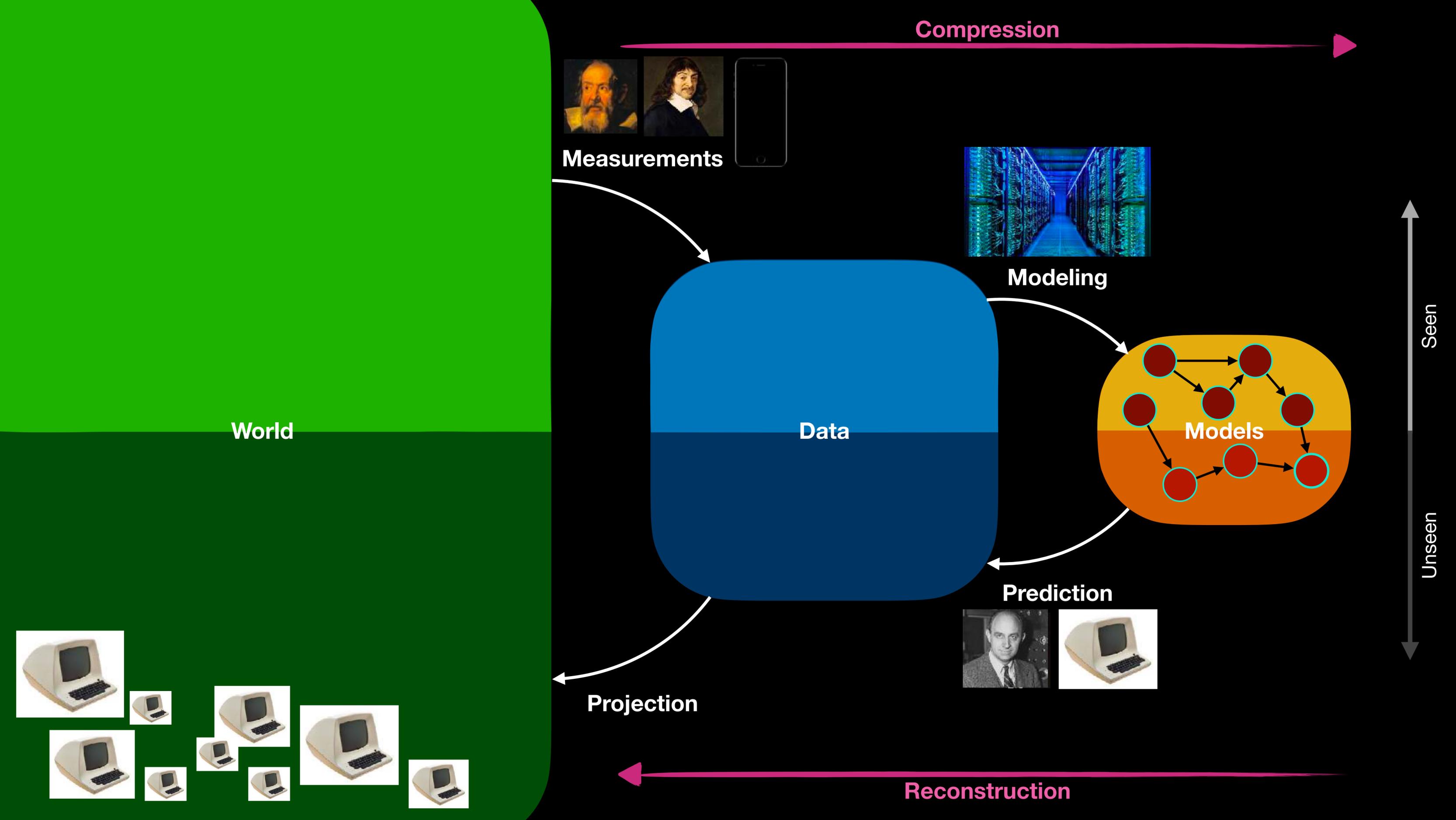
Statistical AI



Neural AI



How does the world work?



The world is:

Non-linear

High-dimensional

Noisy

Multi-scale →



Probability

Course plan

Discovering **Non-linear** Functions from Data

Supervised Learning. Parametric/non-parameteric functions etc.

Linear regression and classification

Learning theory: variance-bias trade-off, regularization etc.

Deep learning

....

Course plan

Reducing **High-dimensionality** of observations

Singular value decomposition

Reduced-order modeling: proper orthogonal decomposition

Spectral methods: Fourier transform

Auto-encoders

.....

Course plan

Machine Learning for Physical Modeling

Discovering/solving equations from data

System Identification

Symbolic Regression

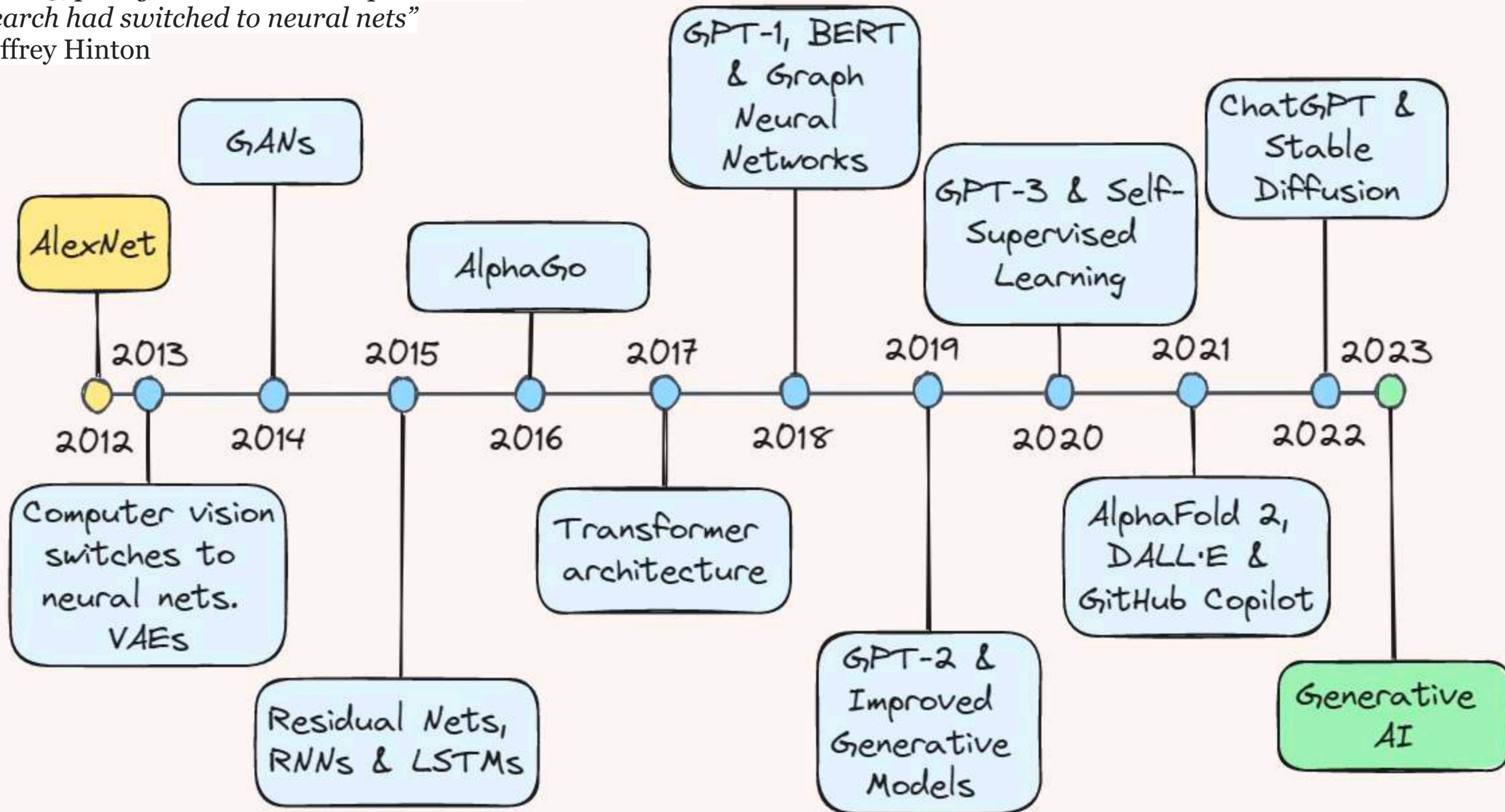
Sparse Identification of Differential Equations

Physics-Informed Neural Networks

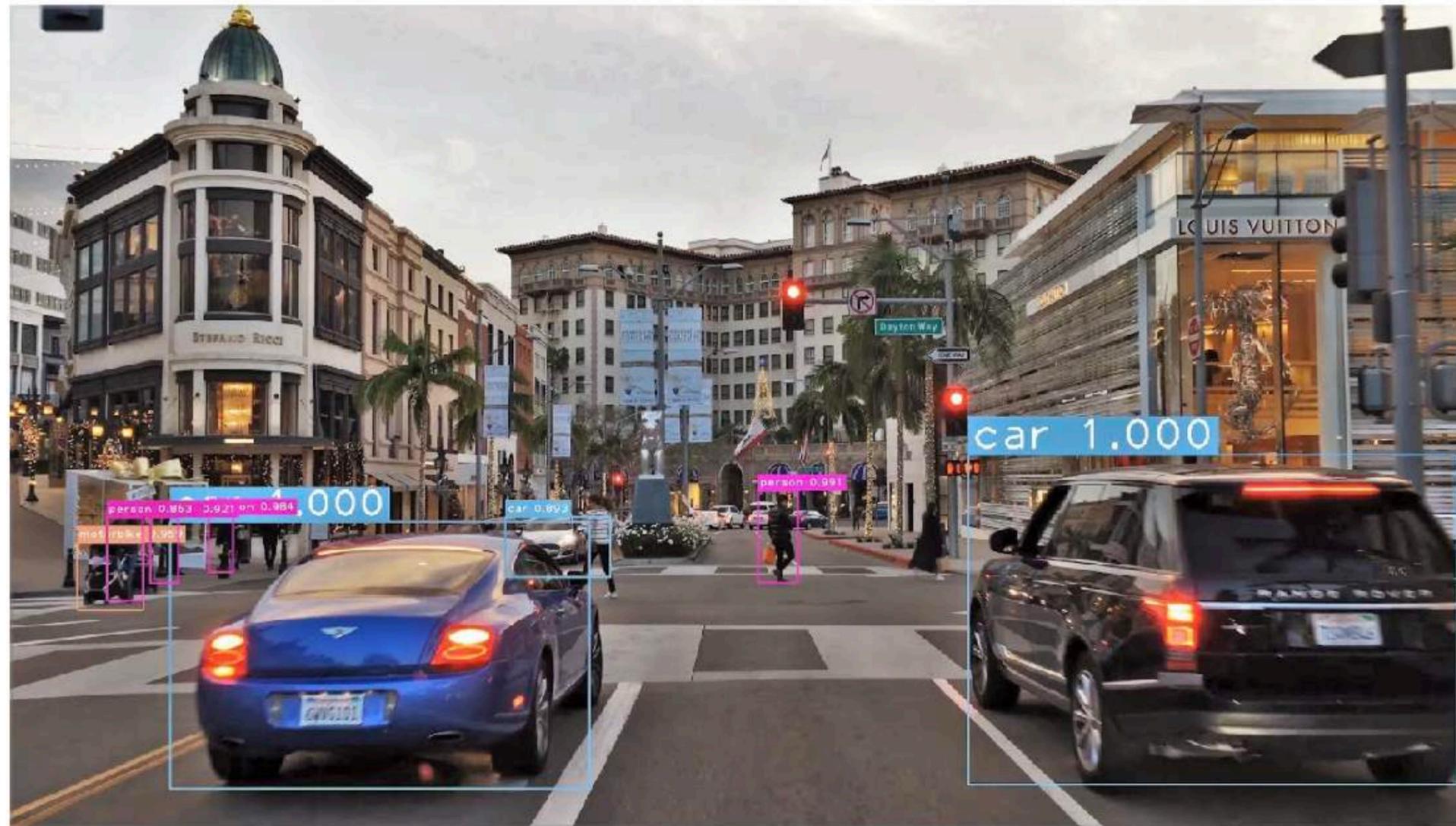
Fourier Neural Operators

Dynamic Mode Decomposition

“By 2013, pretty much all the computer vision research had switched to neural nets”
Geoffrey Hinton



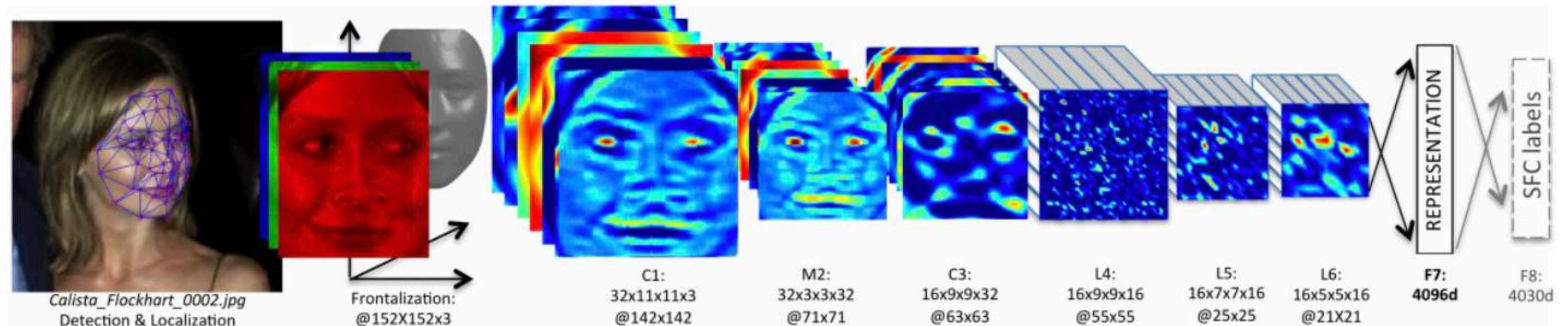
Autonomous Driving



Google announces Waymo in 2010

Image recognition

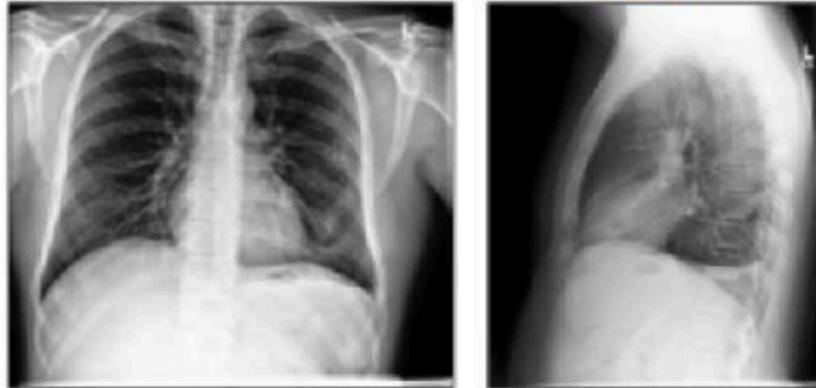
- Unlocking your phone
- Recognizing people in your photos



- Google Brain uses deep learning to recognize cats in images (2012)
- Facebook recognizes faces with 97% accuracy (2014)

Image recognition

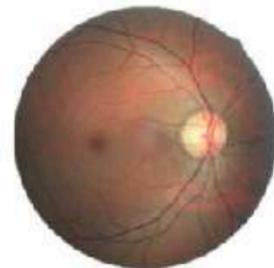
Chest radiology



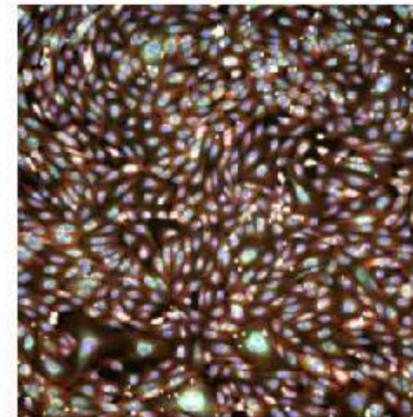
2019

Google AI outperforms radiologists at lung cancer detection

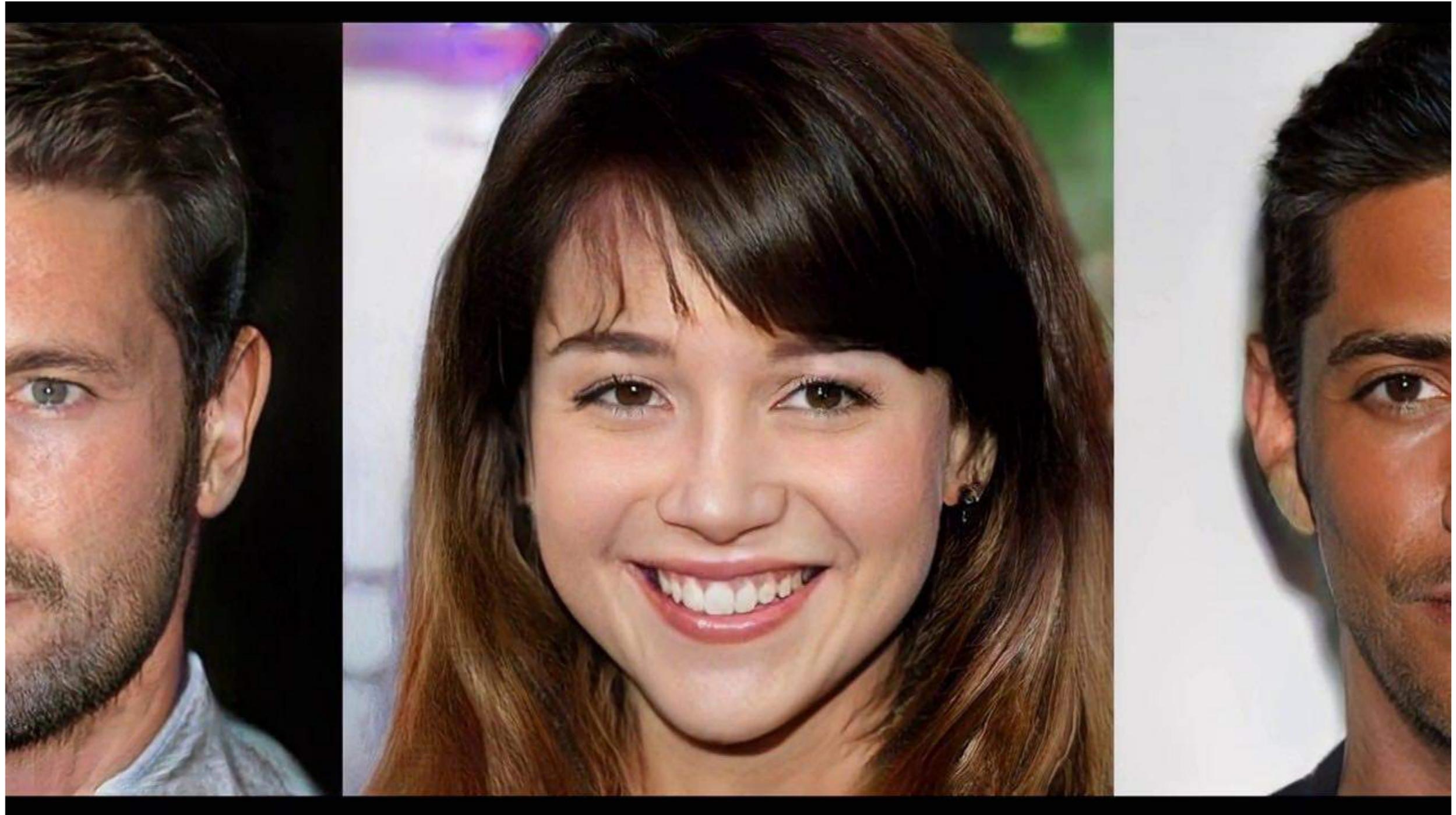
Diabetic retinopathy



Drug screening for COVID-19



Generative Adversarial Networks (2014)



Progressive Growing of GANs for Improved Quality, Stability, and Variation

https://www.youtube.com/watch?v=G06dEcZ-QTg&t=36s&ab_channel=TeroKarrasFI



**DIEP
NEP.**



DEEPPFAKE MORGAN FREEMAN

Deepfakes

AI image generation tech can now create life-wrecking deepfakes with ease



Natural Language Processing

Deep learning surpasses traditional approaches in speech recognition in 2010



2016

2014

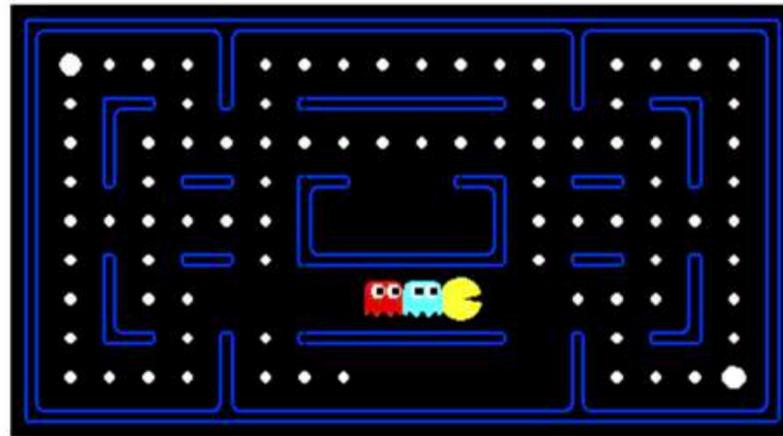
2011

IBM-Watson Defeats Humans in "Jeopardy!"



2011

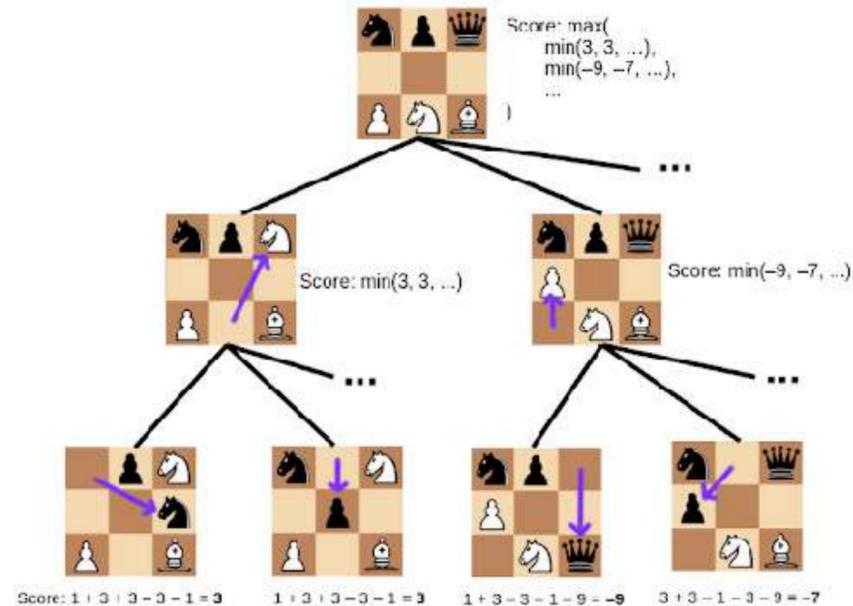
Solving puzzles



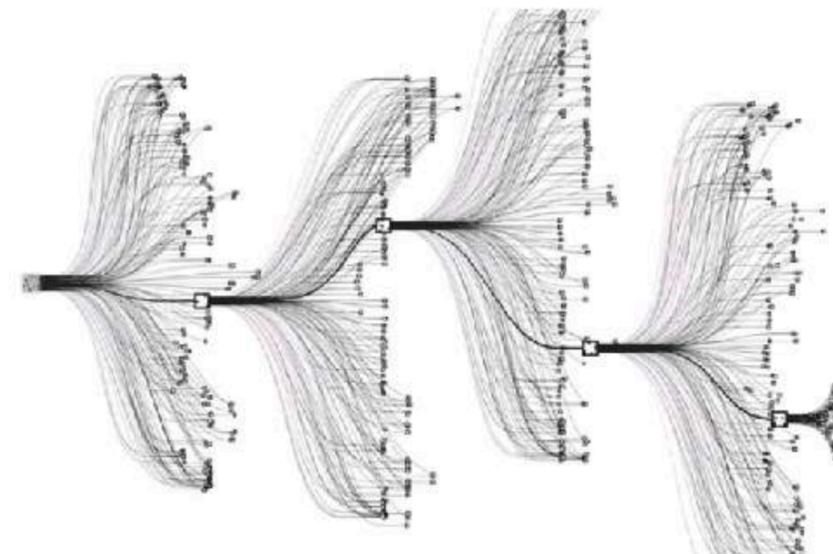
5	3		7				
6			1	9	5		
	9	8				6	
8			6			3	
4			8	3		1	
7			2			6	
	6				2	8	
			4	1	9		5
			8		7	9	



5	3	4	6	7	8	9	1	2
6	7	2	1	9	5	3	4	8
1	9	8	3	4	2	5	6	7
8	5	9	7	6	1	4	2	3
4	2	6	8	5	3	7	9	1
7	1	3	9	2	4	8	5	6
9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9



10^{120} possibilities



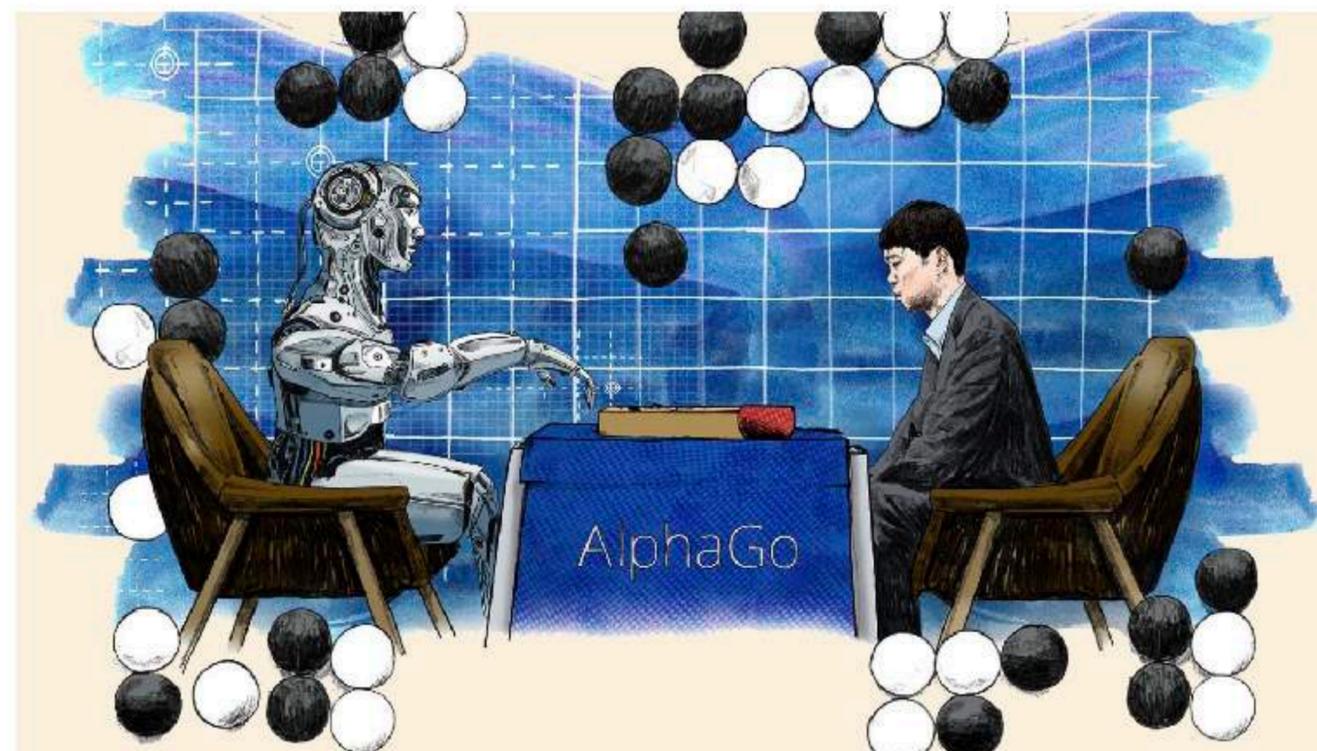
Games

IBM creates a checker playing program



1959

AlphaGo beats world's best Go player



2016

IBM Deep Blue beats Kasparov



1997

Trading

coursera Explore

Browse > Data Science > Machine Learning

Machine Learning for Trading Specialization

Start Your Career in Machine Learning for Trading. Learn the machine learning techniques used in quantitative trading.

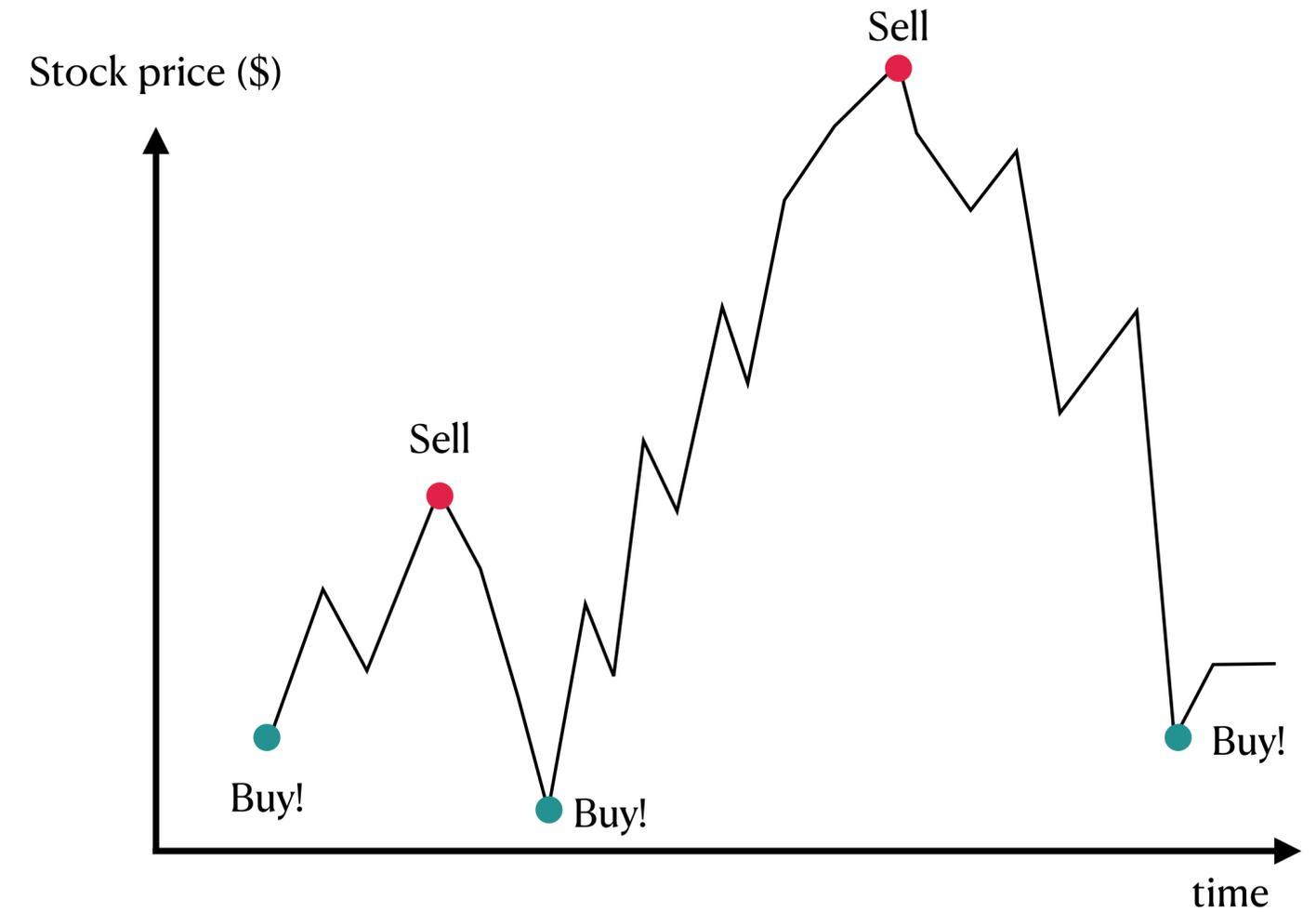
★★★★★ 3.9 795 ratings

 Jack Farmer [+1 more instructor](#)

Enroll for Free
Starts Aug 9

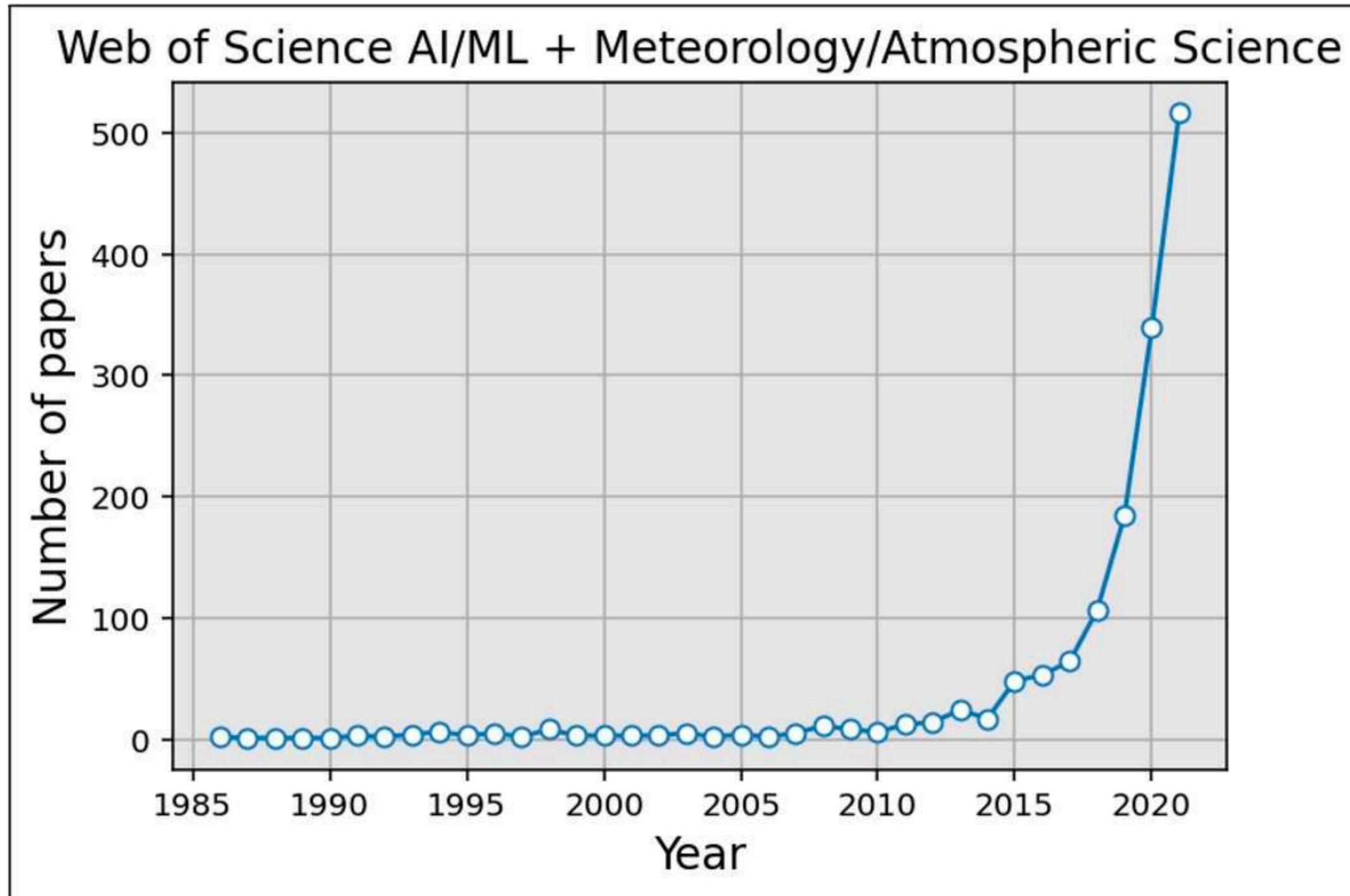
Financial aid available

14,817 already enrolled



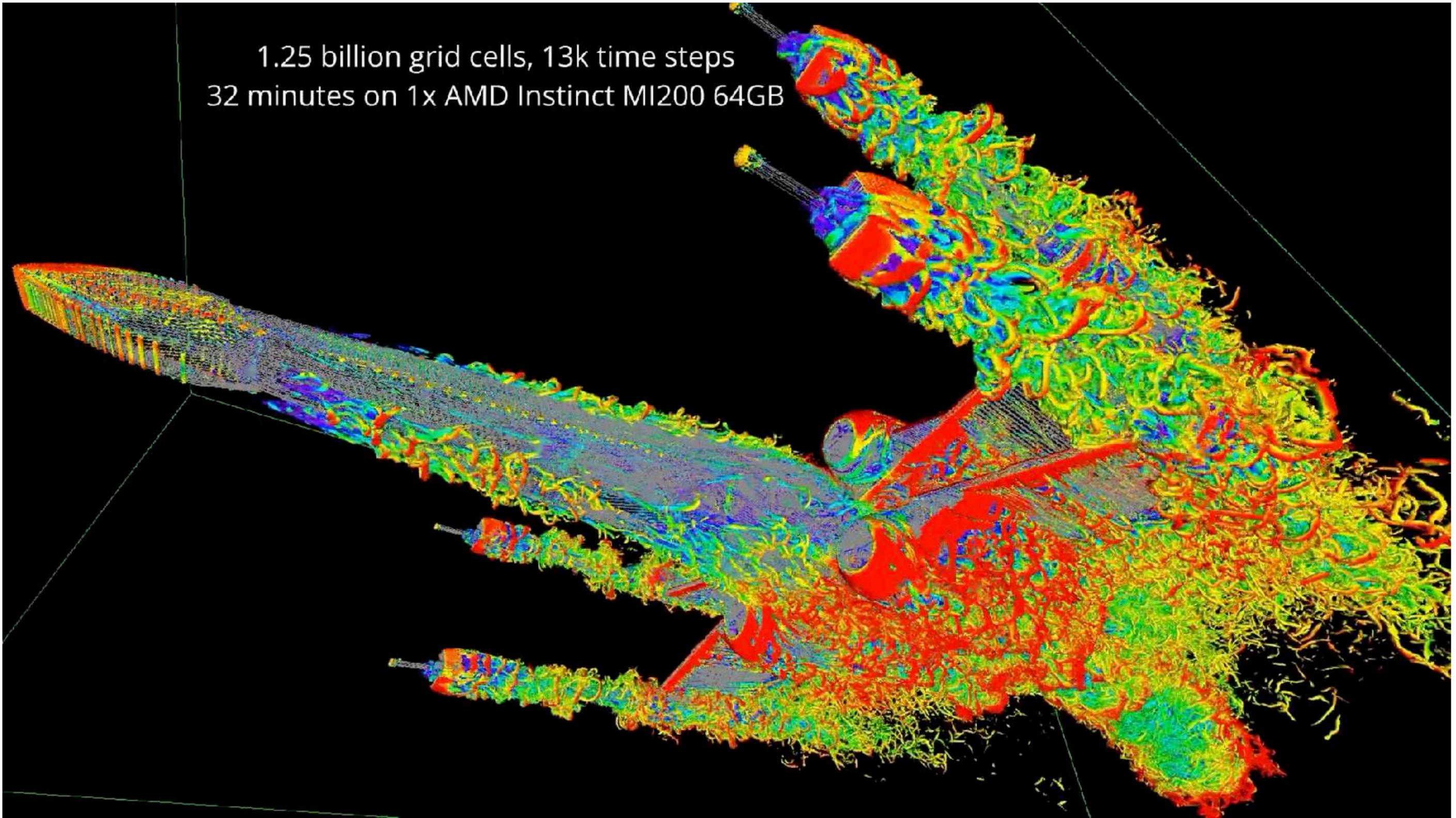
**Can we automate
the process of scientific discovery?**

Machine learning in Atmospheric Science



Fluid dynamics

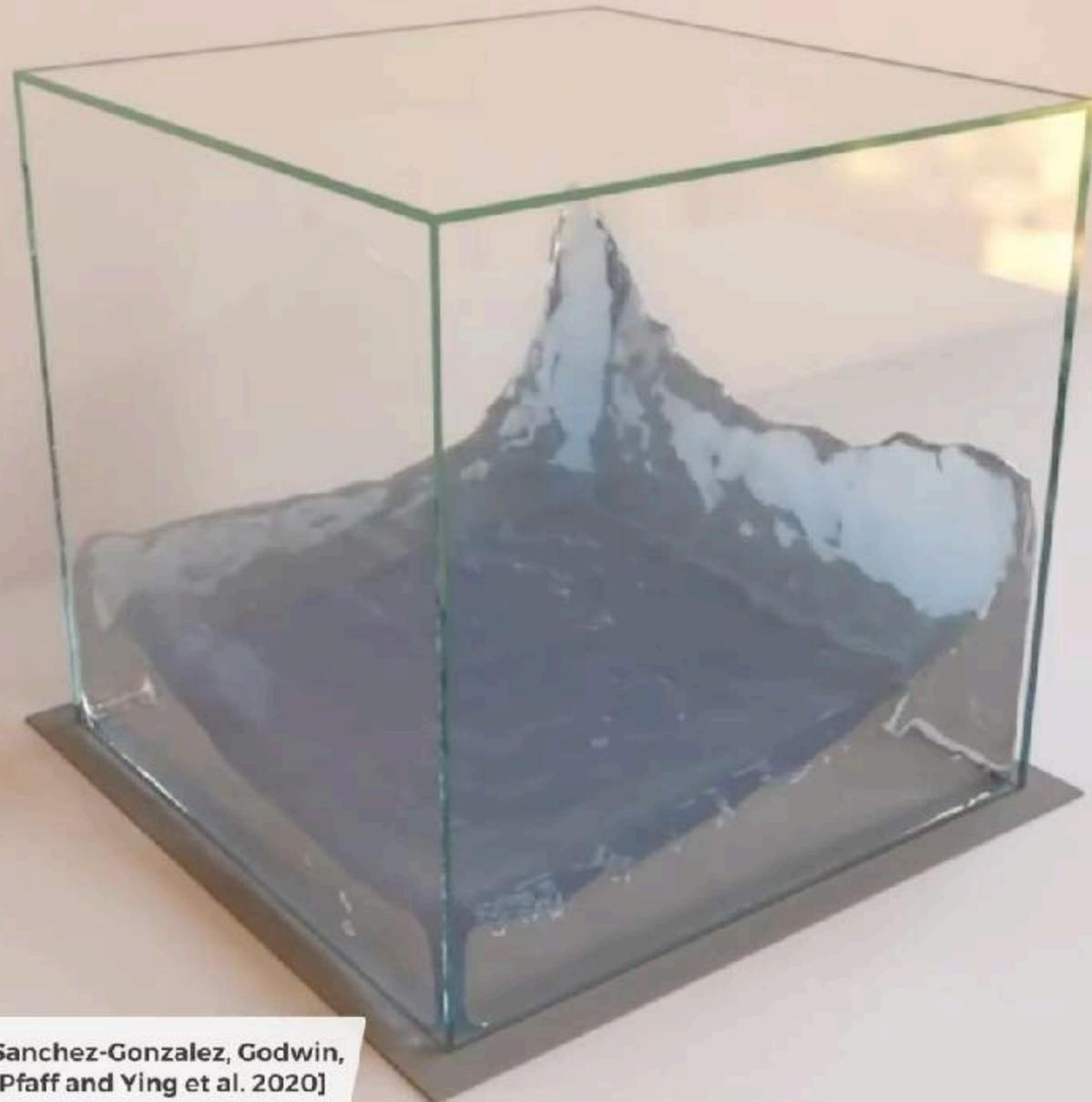
1.25 billion grid cells, 13k time steps
32 minutes on 1x AMD Instinct MI200 64GB



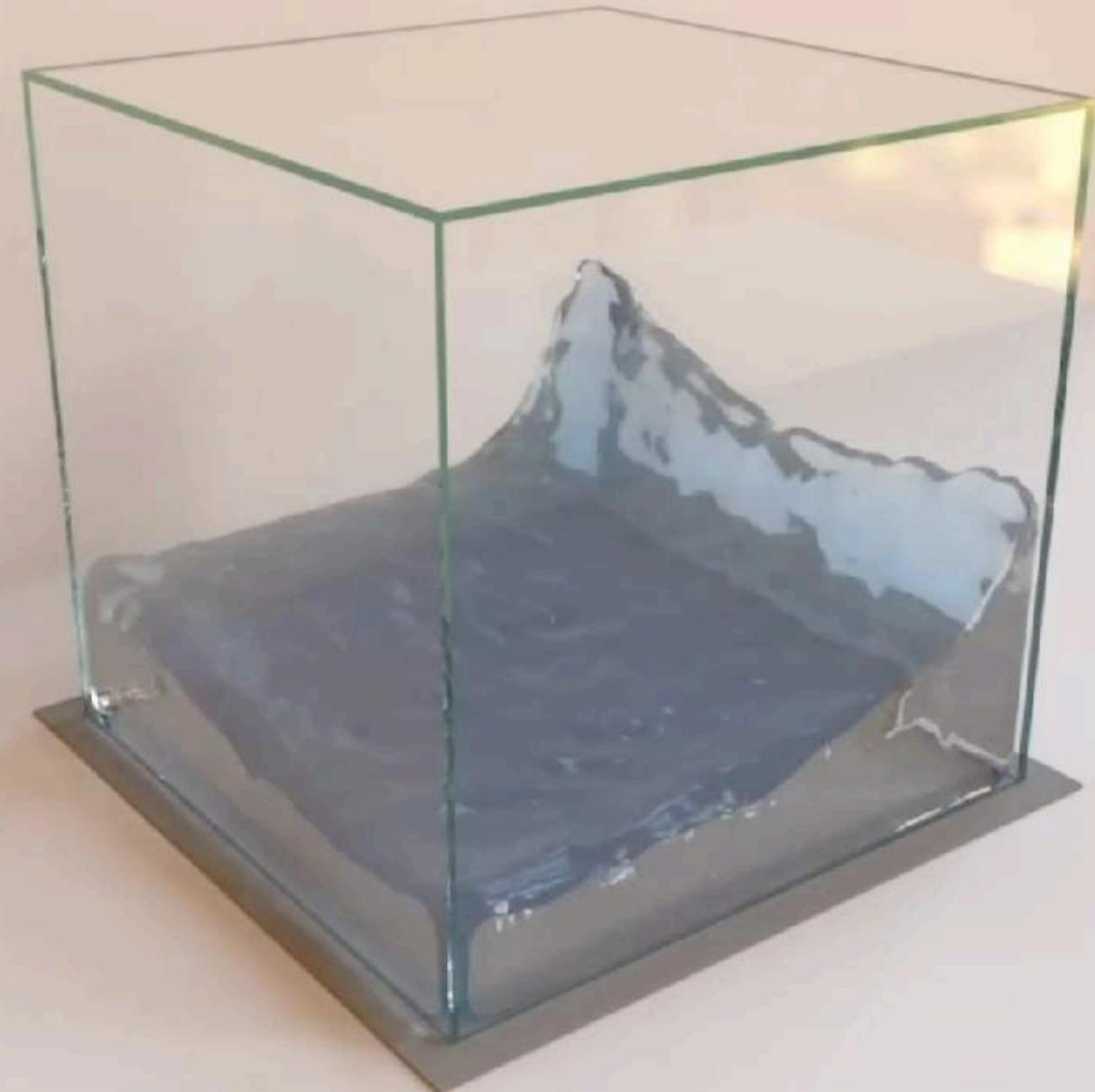
Fluid dynamics

Just to make sure: Ground truth = simulation, Prediction = AI

Ground truth



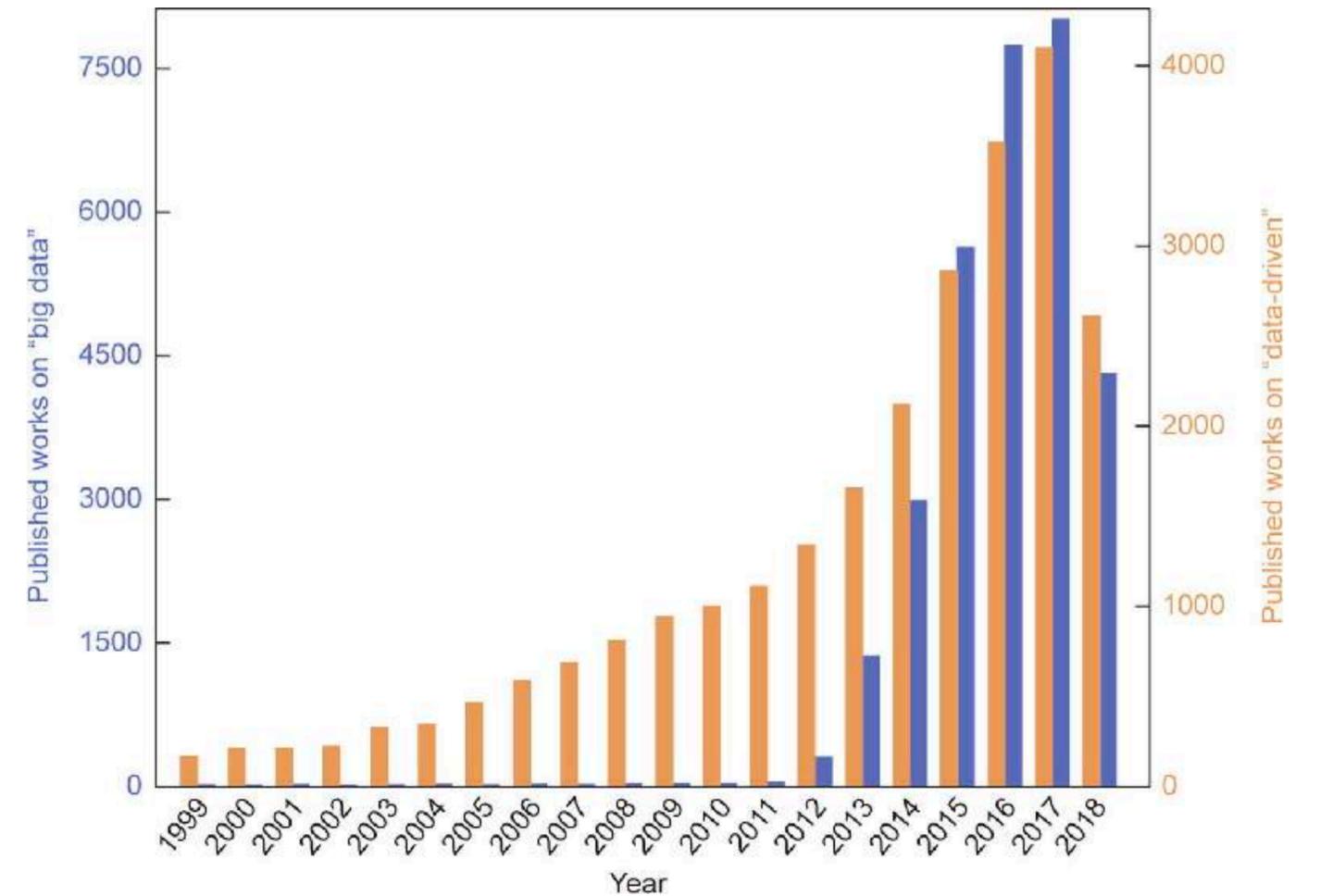
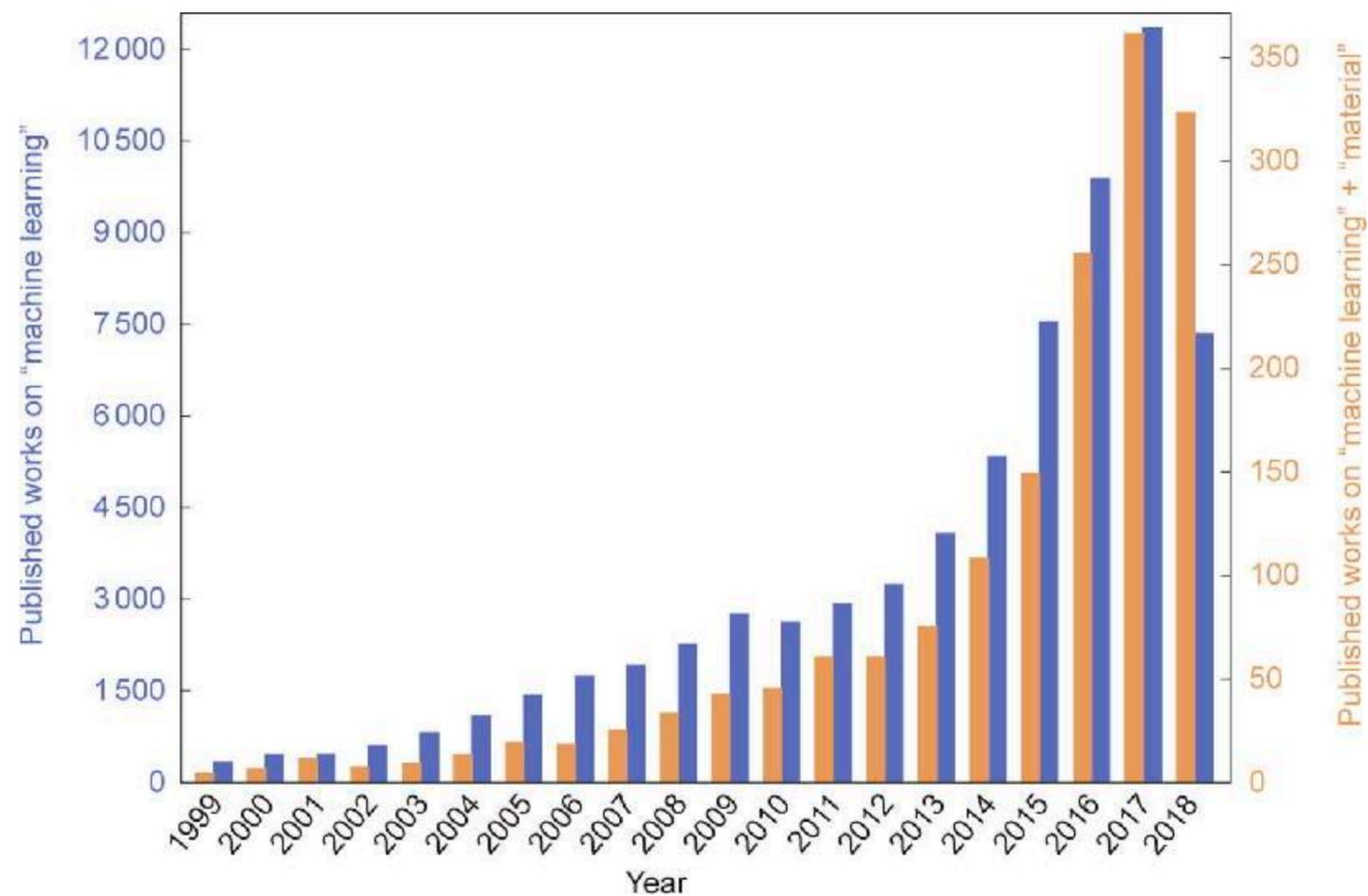
Prediction



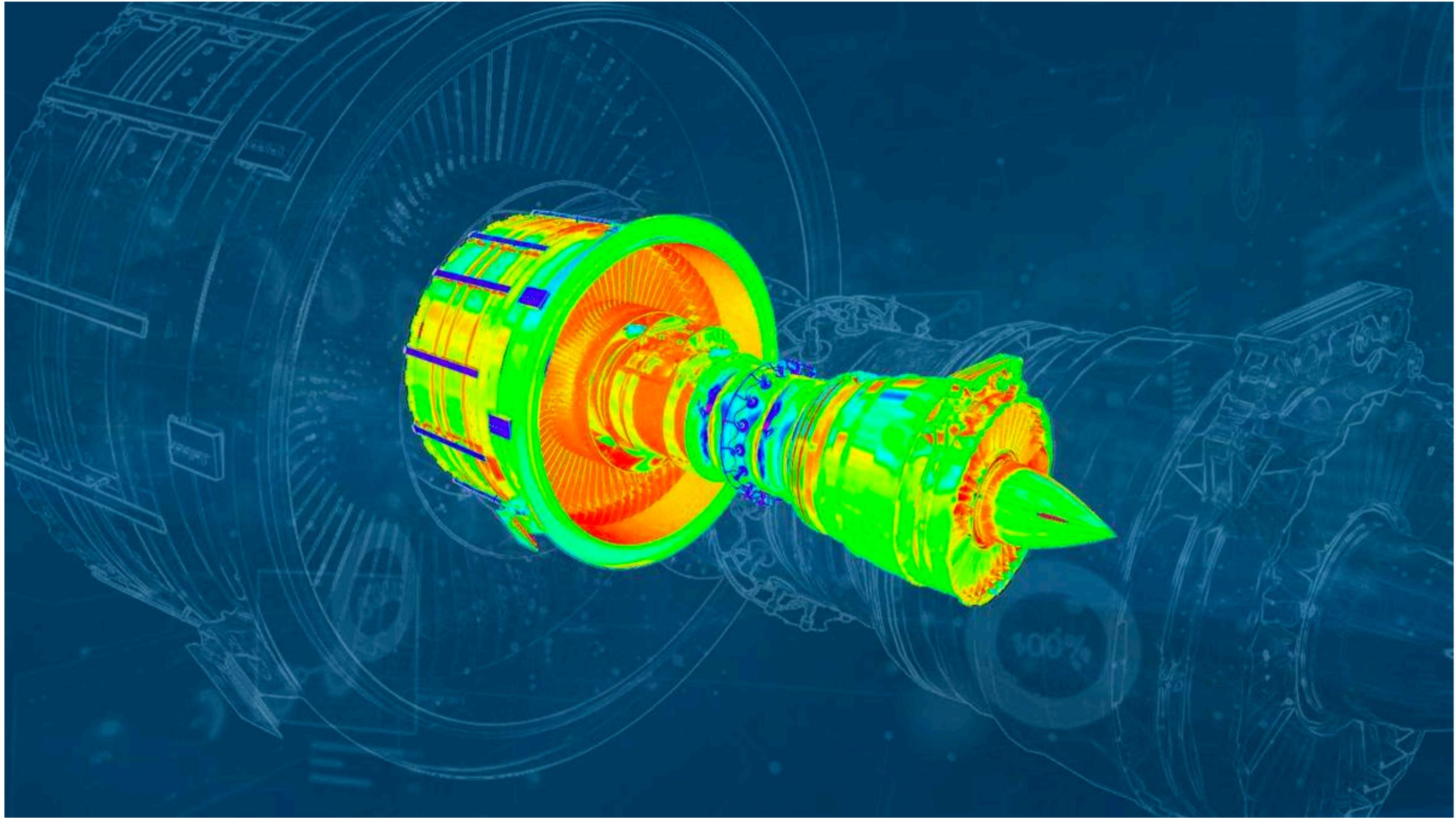
[Sanchez-Gonzalez, Godwin,
Pfaff and Ying et al. 2020]

Source

Machine learning in materials research



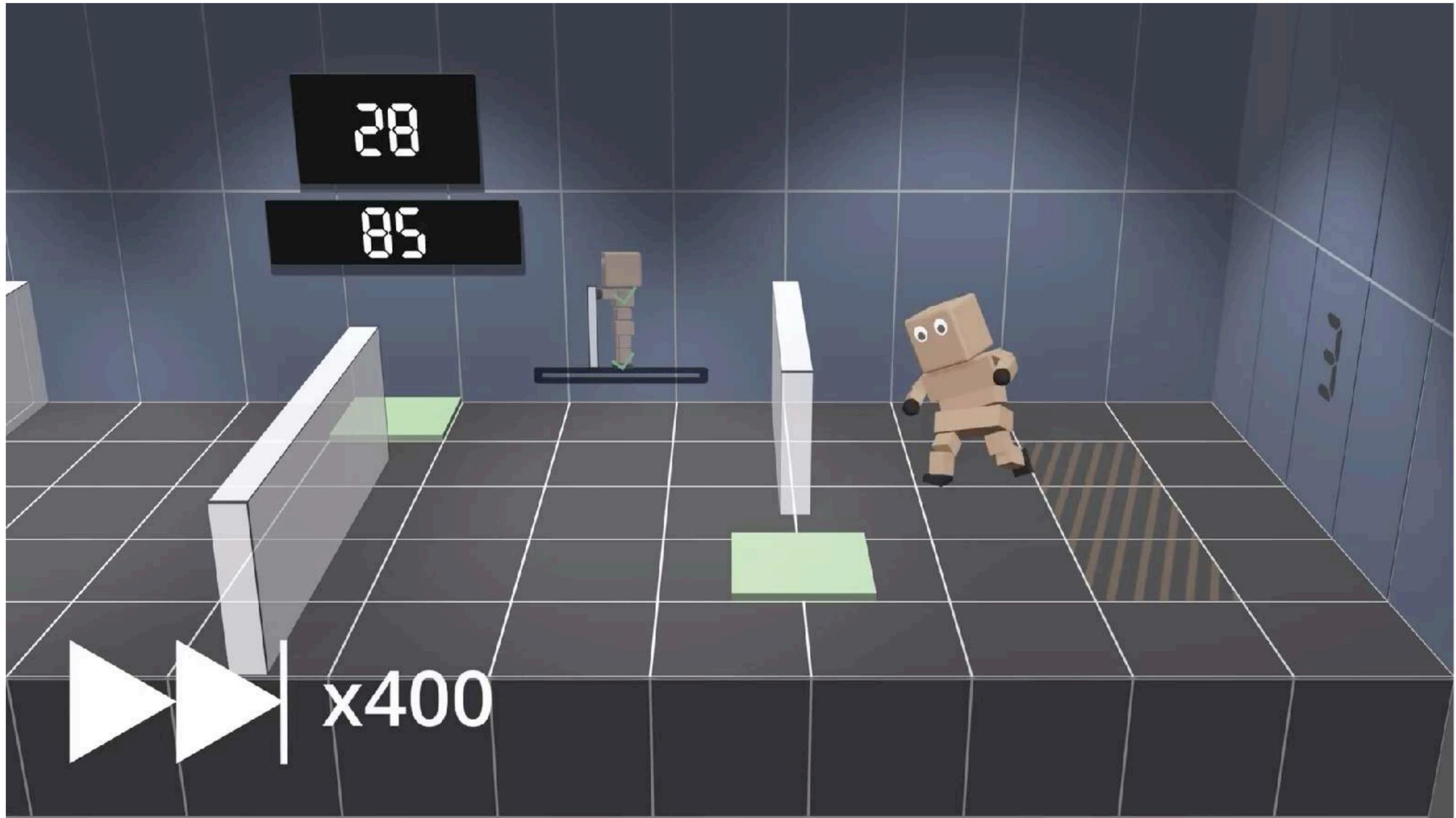
Machine learning in materials research



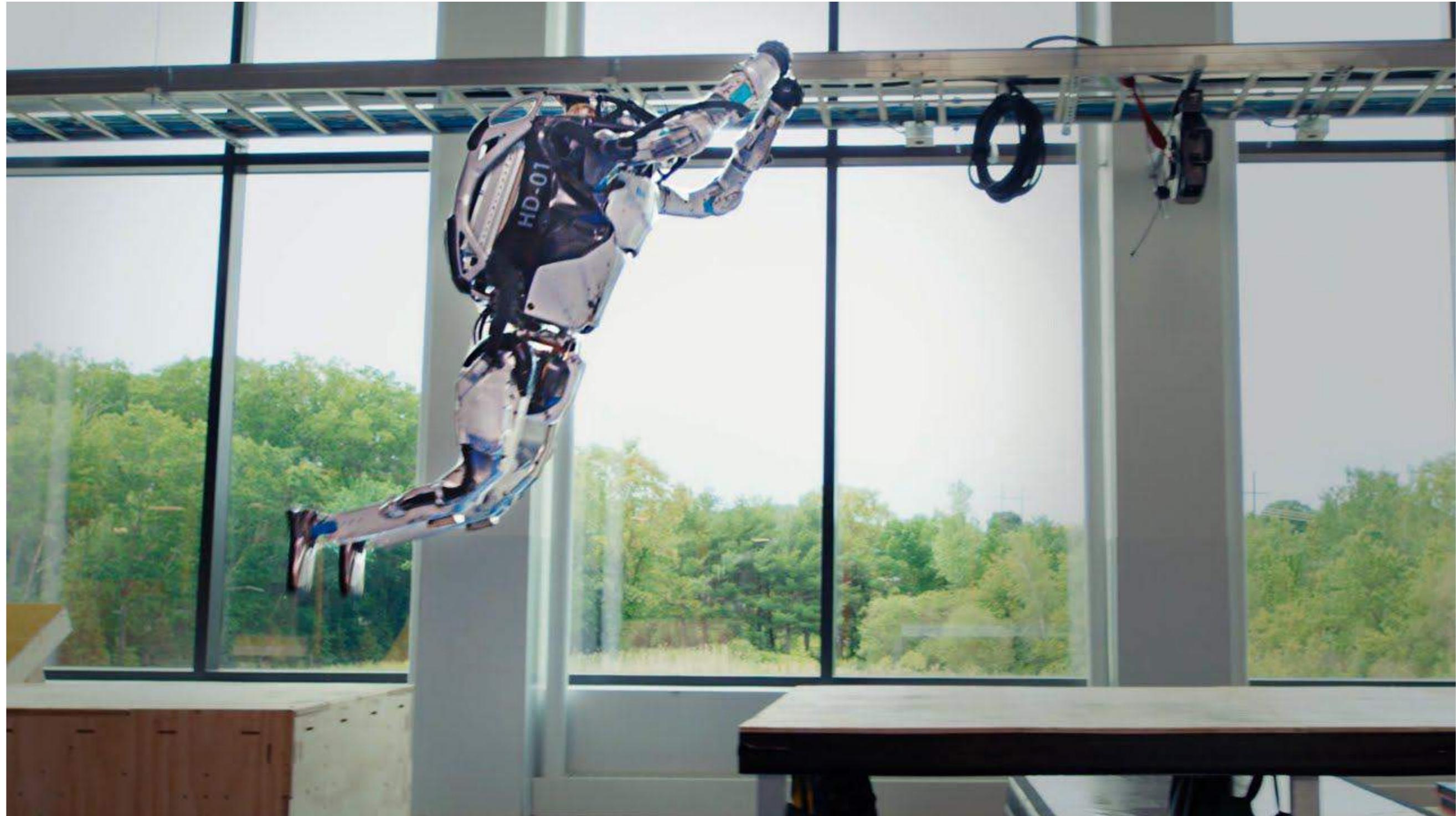
Robotics and Manufacturing



Robotics and games

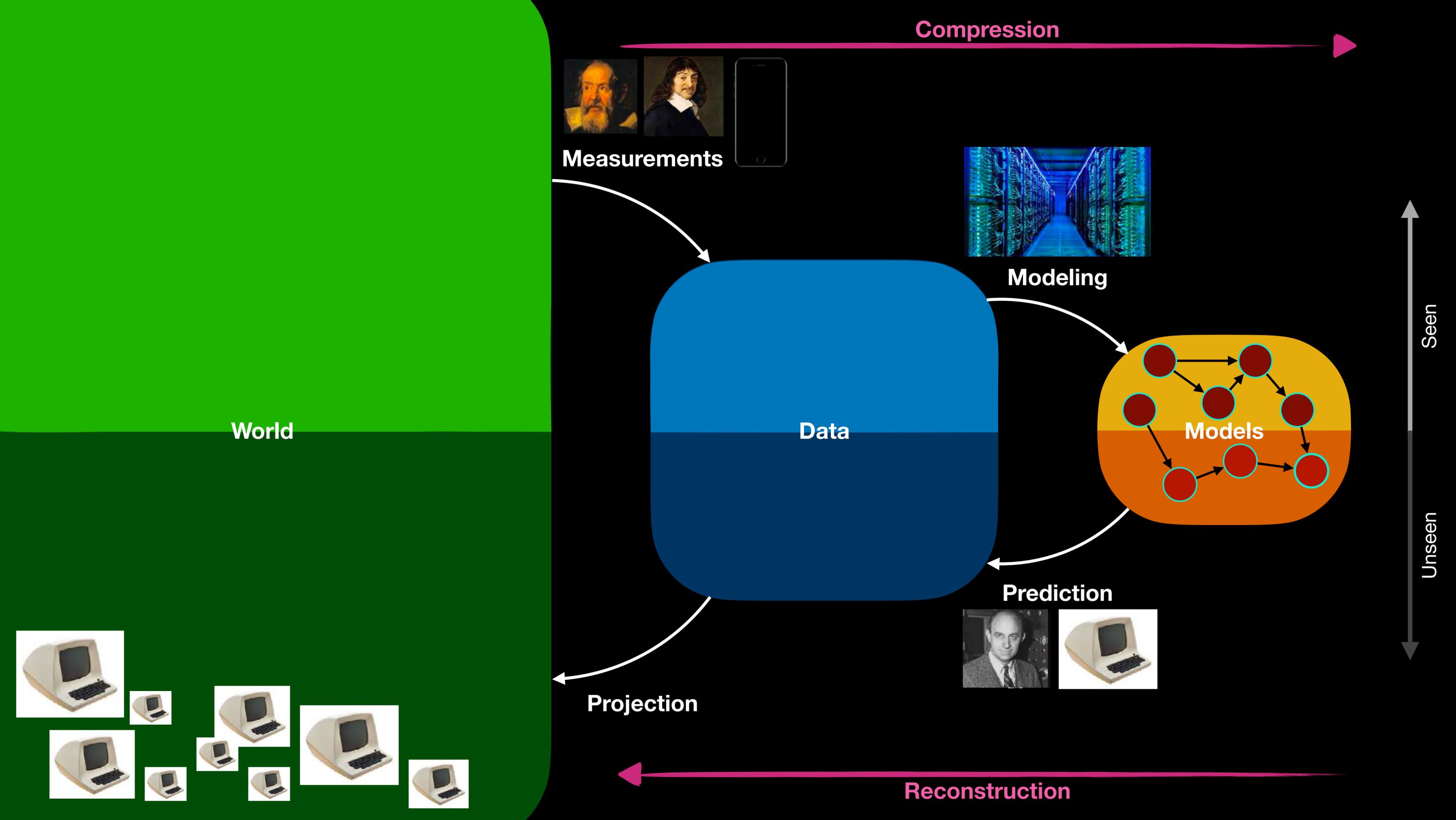


Robotics and games

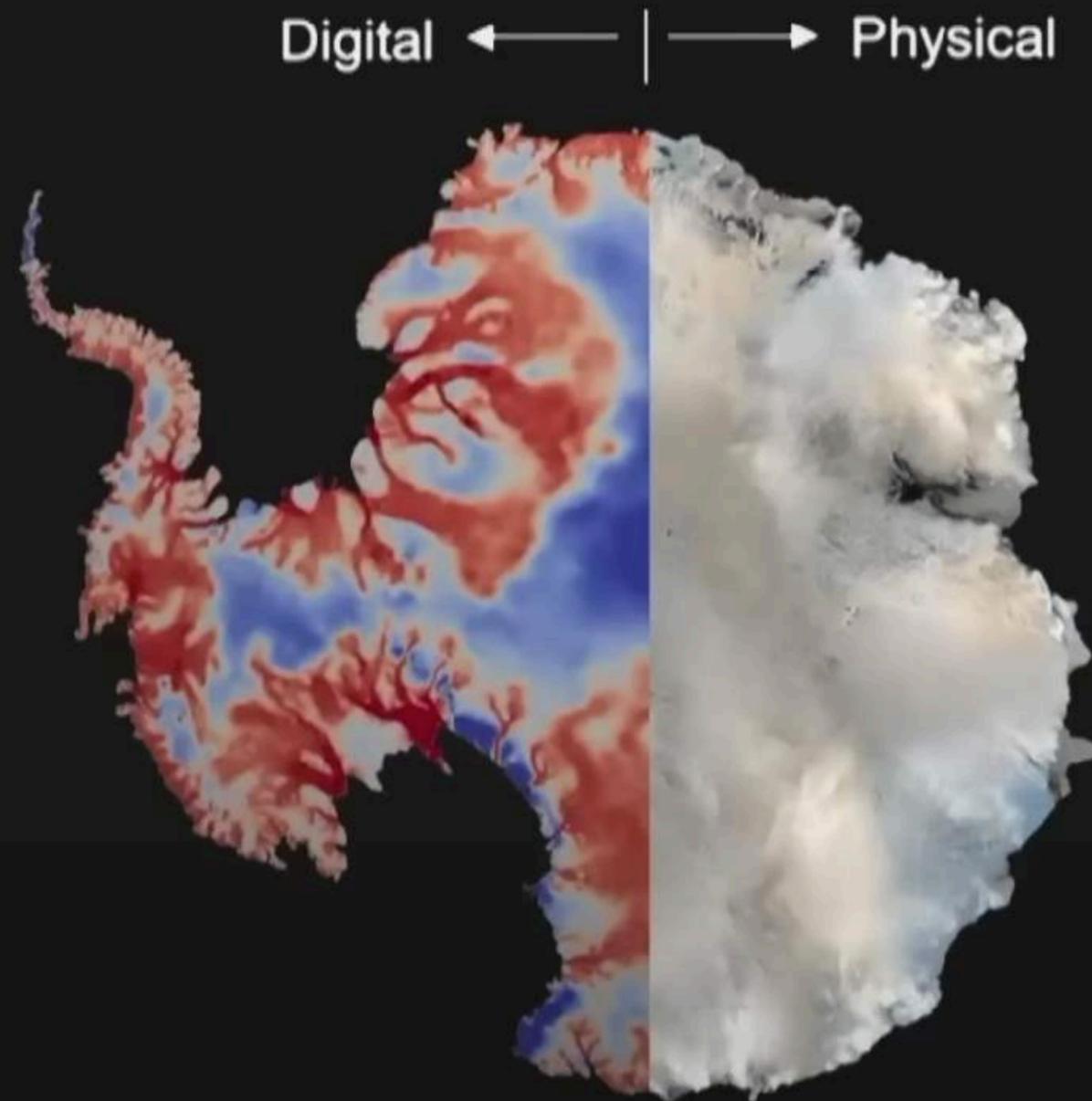


Self-driving cars





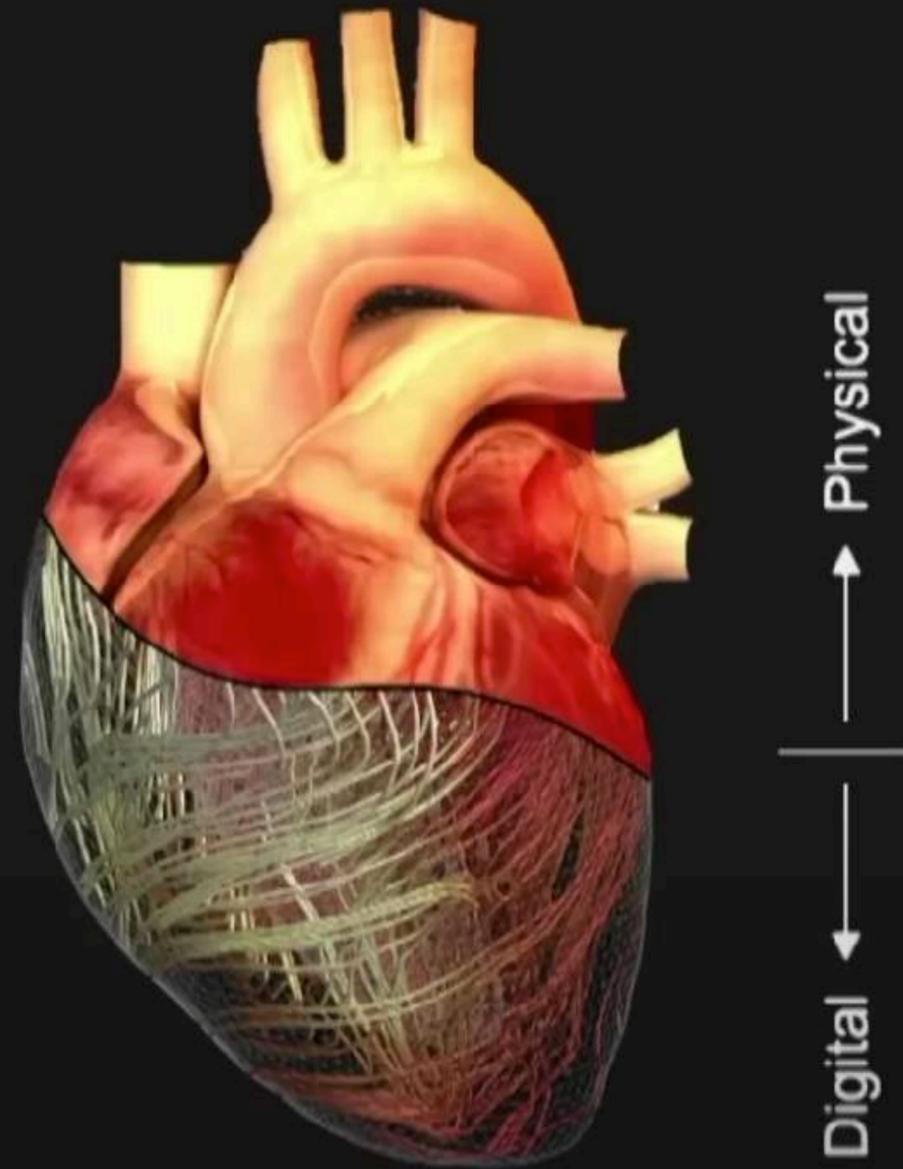
Digital twin of an Ice Sheet



https://www.youtube.com/watch?v=r2_VWdixchY&ab_channel=TED

Omar Ghattas
Oden Institute &
Jackson School of Geosciences

Digital twin of a heart?



https://www.youtube.com/watch?v=r2_VWdjxchY&ab_channel=TED

Michael Sacks
Oden Institute Willerson Center &
Biomedical Engineering

Biomedical Engineering



Mindaugas Galvosas, MD @MGalvosas · Jan 18

FDA just cleared the first AI device detecting all major skin cancer by DermoSensor.

Its pivotal trial showed sensitivity of 96% and a 97% chance of accurately identifying a skin lesion as benign.

Notably, the approval process began back in 2016.



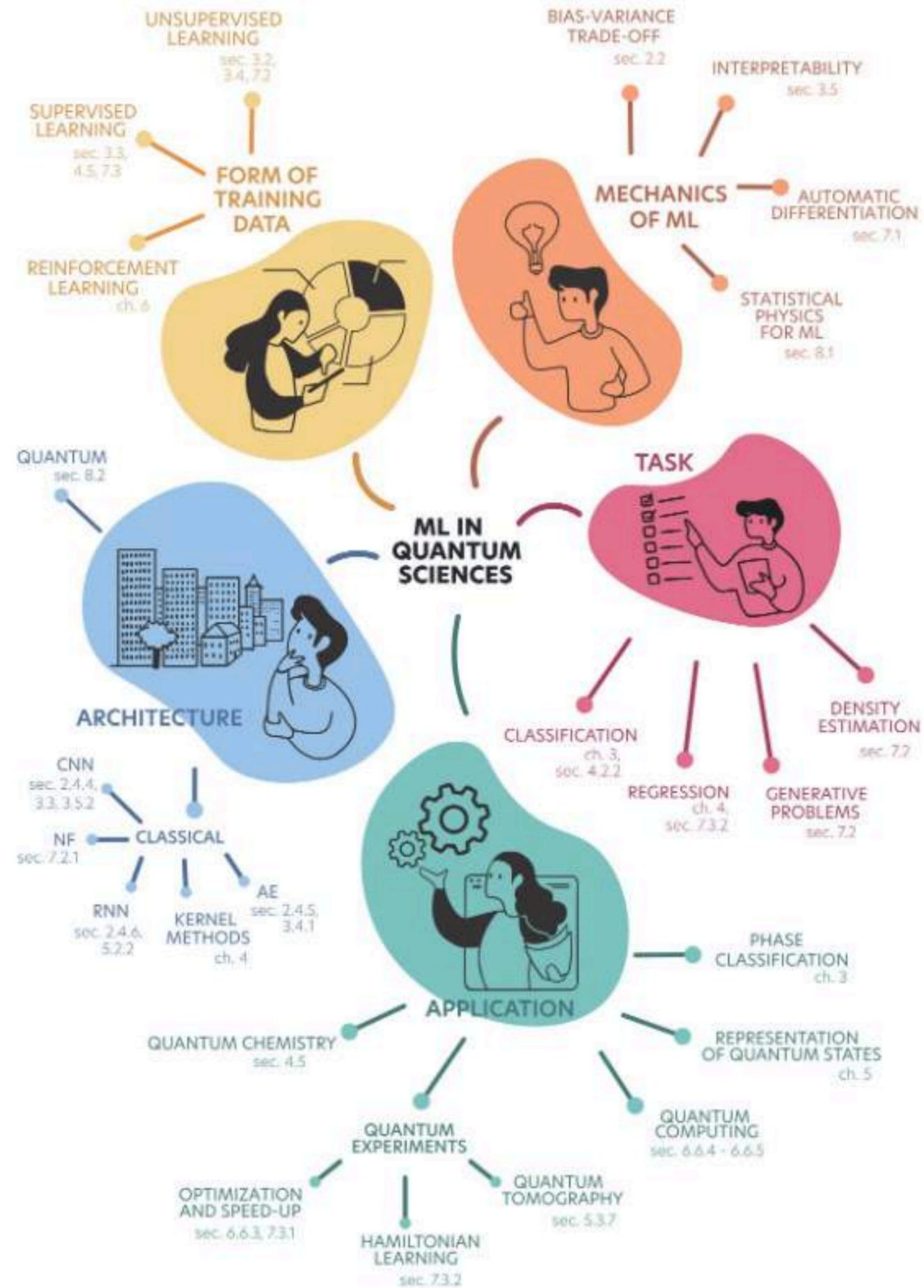
42

248

1K

257K

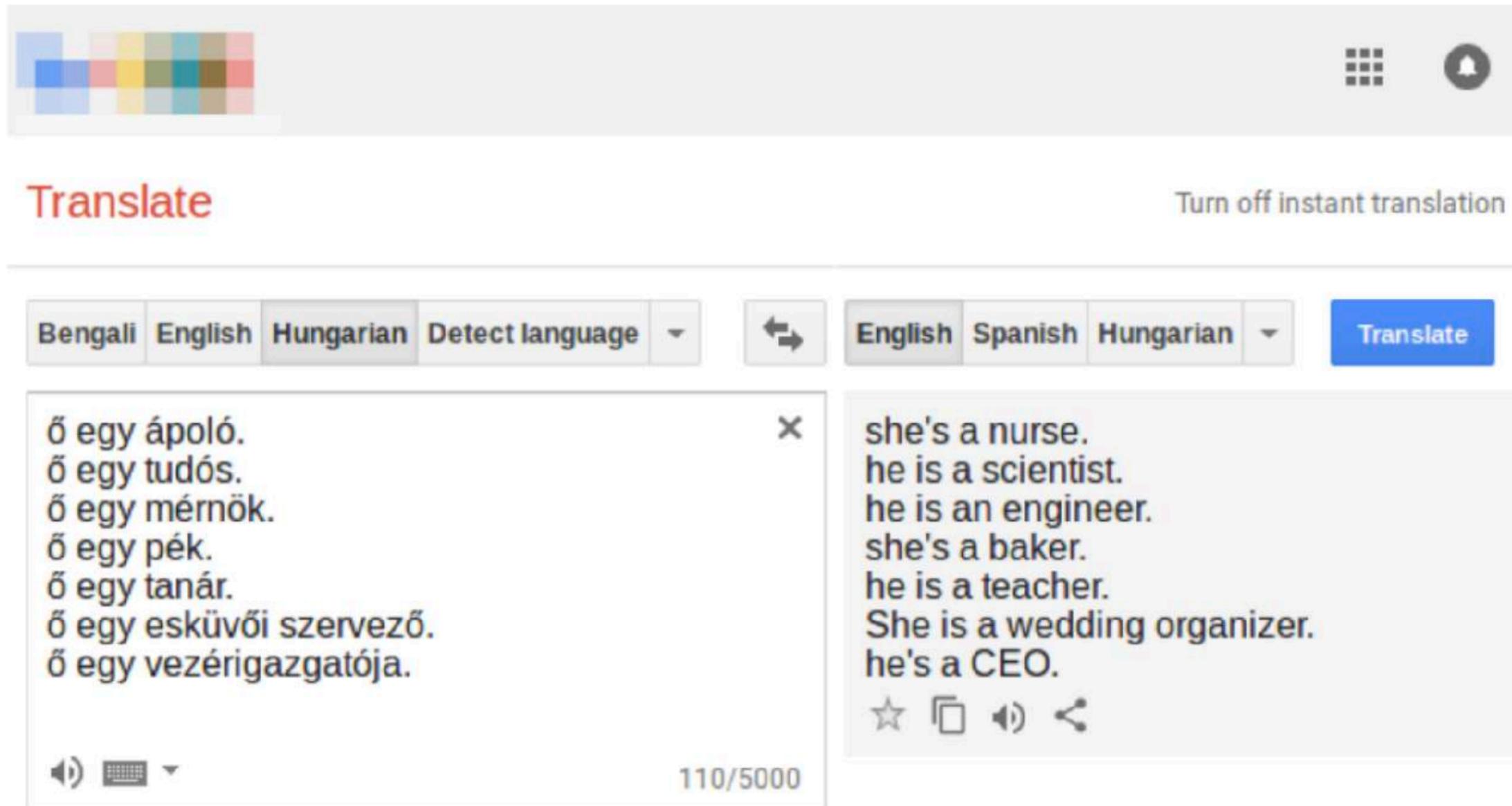




BUT...

New technologies come with new problems

Bias



Translate Turn off instant translation

Bengali English Hungarian Detect language ↕ English Spanish Hungarian Translate

ő egy ápoló.
ő egy tudós.
ő egy mérnök.
ő egy pék.
ő egy tanár.
ő egy esküvői szervező.
ő egy vezérigazgatója.

she's a nurse.
he is a scientist.
he is an engineer.
she's a baker.
he is a teacher.
She is a wedding organizer.
he's a CEO.

110/5000

Safety

[Sharif+ 2016]



[Evtimov+ 2017]

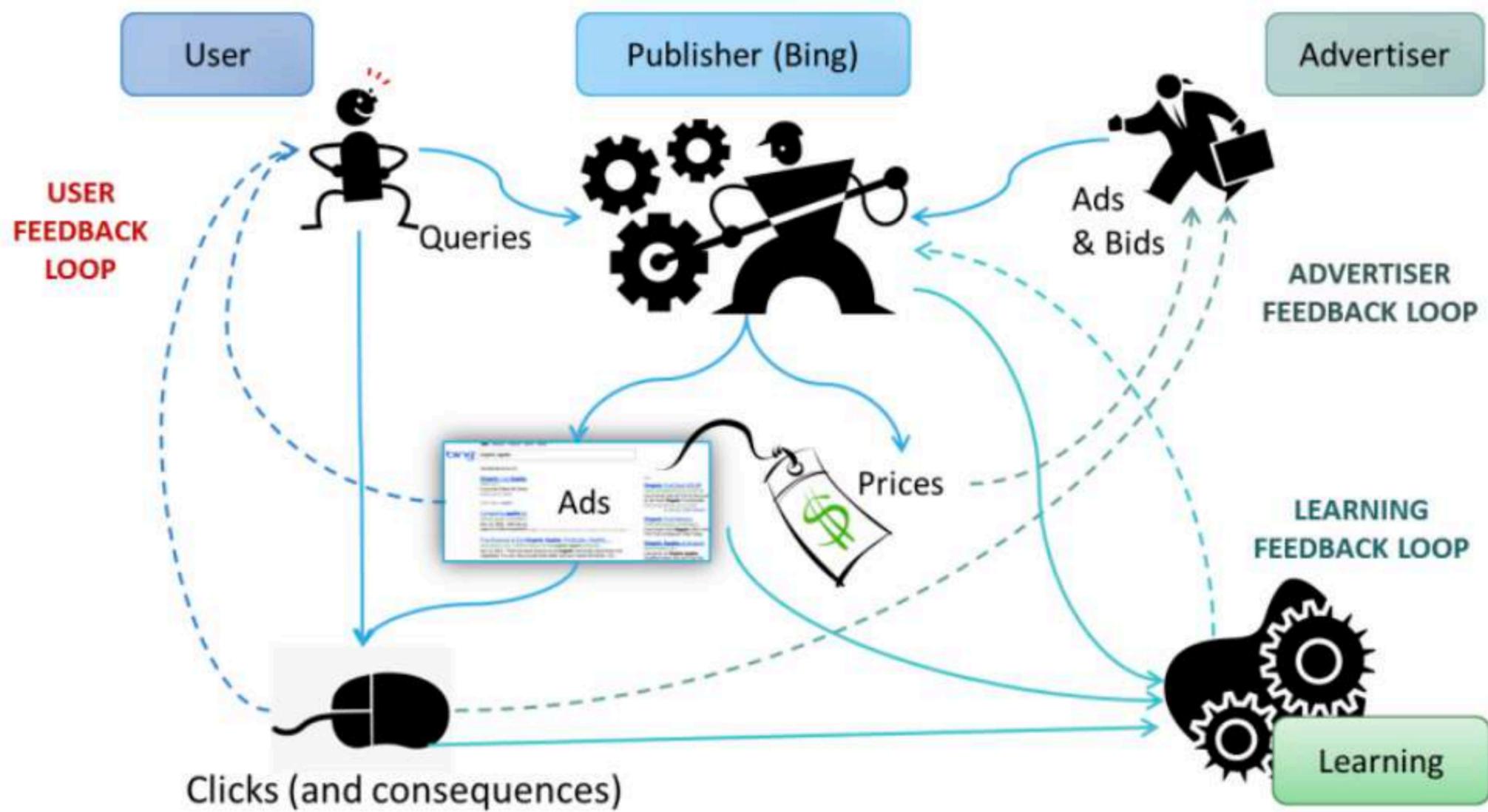


Privacy



Positive Feedback

[Leon Bottou]



Fairness

California just replaced cash bail with algorithms

By [Dave Gershgorn](#) · September 4, 2018

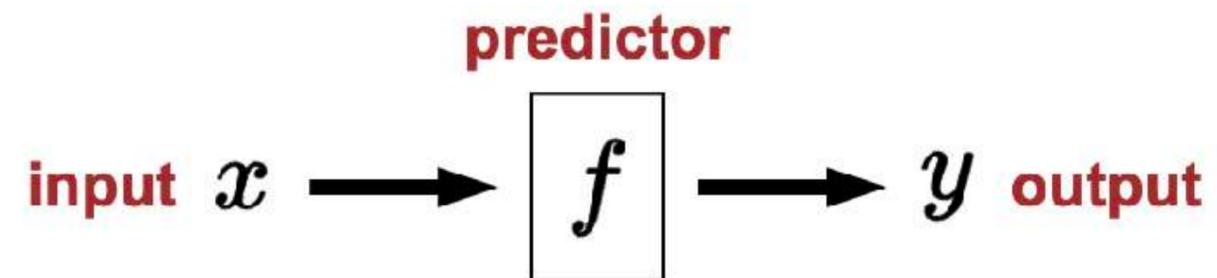


Machine Learning

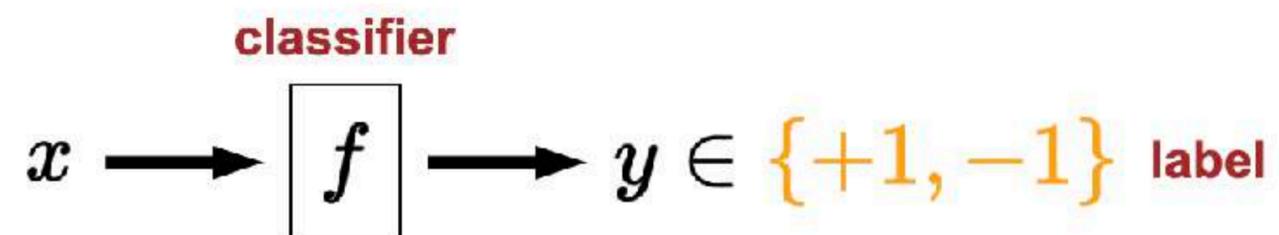
$$f(x) = 2^x \begin{pmatrix} x & 0, 1, 2, 3, 4, 5 \\ y & 1, 2, 4, 8, 16, ? \end{pmatrix}$$

$$\begin{matrix} x & y \\ \curvearrowright \end{matrix}$$

$$f(x) = 2x$$



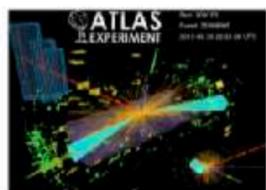
Classification



Fraud detection: credit card transaction \rightarrow fraud or no fraud



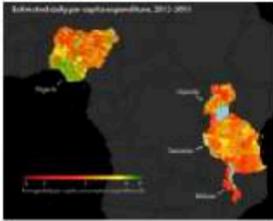
Toxic comments: online comment \rightarrow toxic or not toxic



Higgs boson: measurements of event \rightarrow decay event or background

Regression

$$x \longrightarrow \boxed{f} \longrightarrow y \in \mathbb{R} \text{ response}$$



Poverty mapping: satellite image \rightarrow asset wealth index



Housing: information about house \rightarrow price



Arrival times: destination, weather, time \rightarrow time of arrival

Structured Prediction

$$x \longrightarrow \boxed{f} \longrightarrow y \text{ is a complex object}$$



Machine translation: English sentence \rightarrow Japanese sentence



Dialogue: conversational history \rightarrow next utterance



Image captioning: image \rightarrow sentence describing image



Image segmentation: image \rightarrow segmentation