

UNIVERSITÀ
DEGLI STUDI
DI PADOVA

Machine Learning

2024/2025

AMCO
ARTIFICIAL INTELLIGENCE, MACHINE
LEARNING AND CONTROL RESEARCH GROUP

Lecture #01

Organization & Intro

Gian Antonio Susto



Let's start with some questions...

1. What is ~~Machine Learning~~ Artificial Intelligence (AI)?

Let's ask an Artificial Intelligence!



ChatGPT 4o ▾

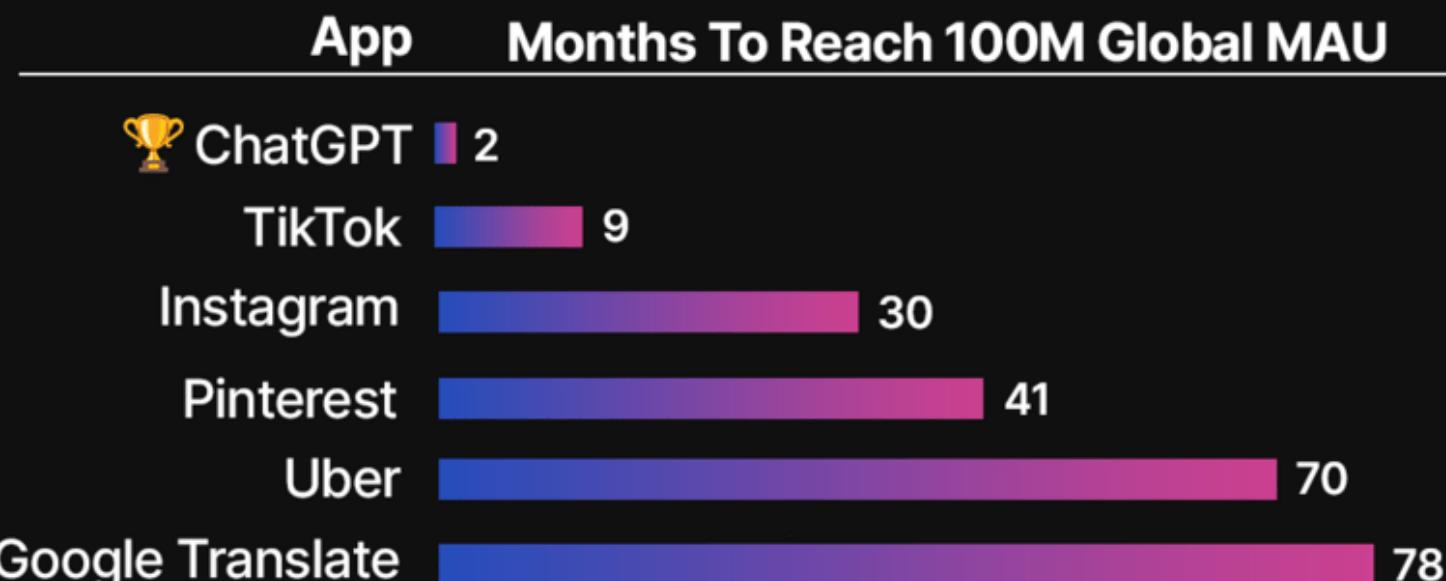
↑ Condiv

a definition of artificial intelligence

Artificial Intelligence (AI) is the field of computer science that focuses on creating systems capable of performing tasks that typically require human intelligence. These tasks include learning from experience, reasoning, problem-solving, understanding natural language, recognizing patterns, and making decisions. AI encompasses a variety of techniques, such as machine learning, deep learning, and natural language processing, enabling machines to adapt and improve their performance over time.

The fastest-growing software in history!

Time it took to reach **100 million monthly users**:



Source: UBS



What an AI can do: write emails!

ChatGPT 4o ▾

↑ Condividi

ST

can you write an email to a student who is asking
me why he should study machine learning?

Subject: Why Study Machine Learning?

Dear [Student's Name],

Thank you for reaching out with your question about why studying Machine Learning (ML) is worthwhile. It's a great topic to reflect on, especially given the growing role of ML across industries and research fields.

Machine Learning is at the core of modern artificial intelligence and has transformative applications in fields ranging from healthcare and finance to engineering and automation. By studying ML, you'll gain the ability to develop models that can analyze patterns in data, make predictions, and automate decision-making processes—skills that are highly valued in both academia and



What an AI can do: create images!

ChatGPT 4o ▾

can you make a logo for my machine learning course?



MACHINE LEARNING
— COURSE —



What an AI can do: code!

can you create a neural network for image classification?

Here is a Python implementation of a **Convolutional Neural Network (CNN)** for image classification using **TensorFlow** and **Keras**. This model can be trained on datasets like **CIFAR-10** or **MNIST** to classify images into different categories.

↔ Cnn Image Classification

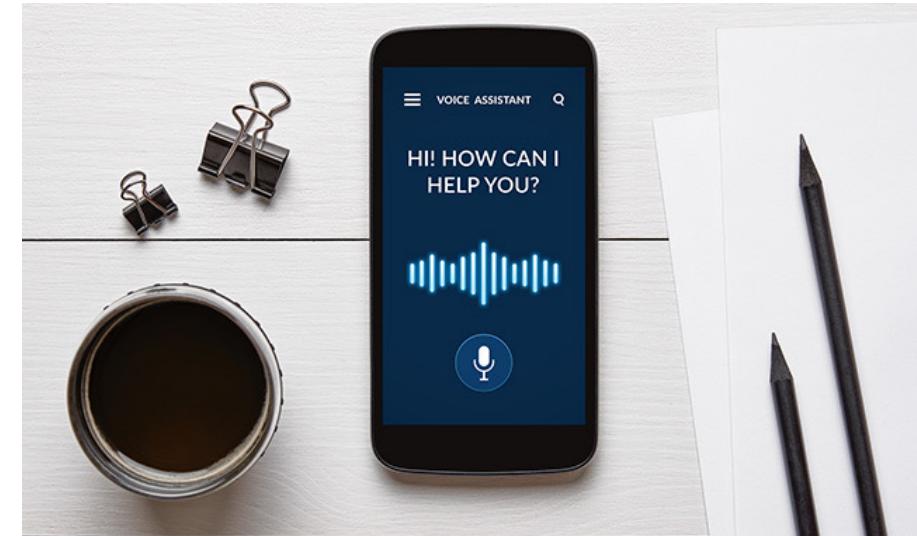


```
1 import tensorflow as tf
2 from tensorflow import keras
3 from tensorflow.keras import layers
4 import matplotlib.pyplot as plt
5 import numpy as np
6
7 # Load CIFAR-10 dataset
8 (x_train, y_train), (x_test, y_test) = keras.datasets.cifar10
9
```



2. Have you interacted with an AI in the last 24 hours (beside ChatGPT)?

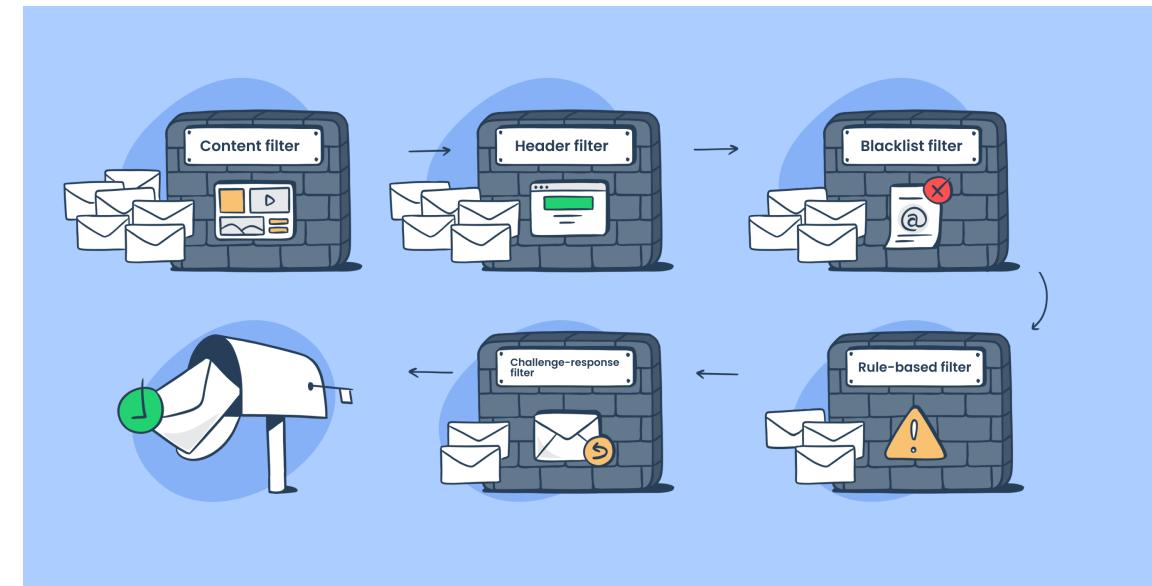
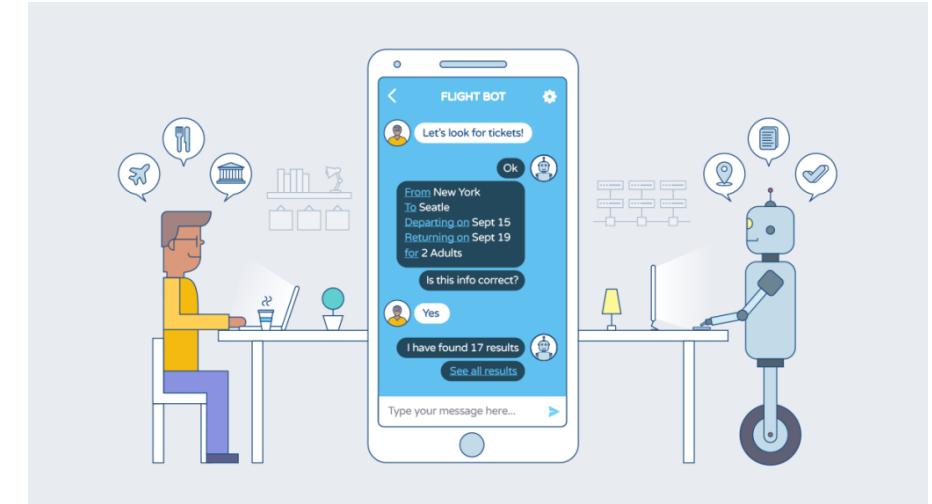
Probably, 20-50 AI techs



Testo predittivo; tocca un suggerimento per applicarlo.

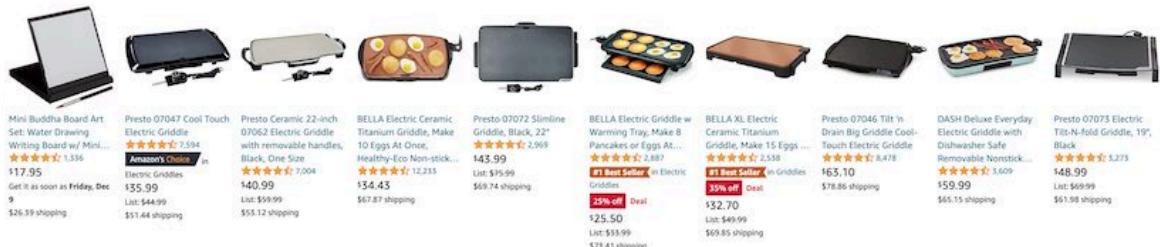


Probably, 20-50 AI techs



Probably, 20-50 AI techs

Customers who viewed items in your browsing history also viewed



Page 1 of 2

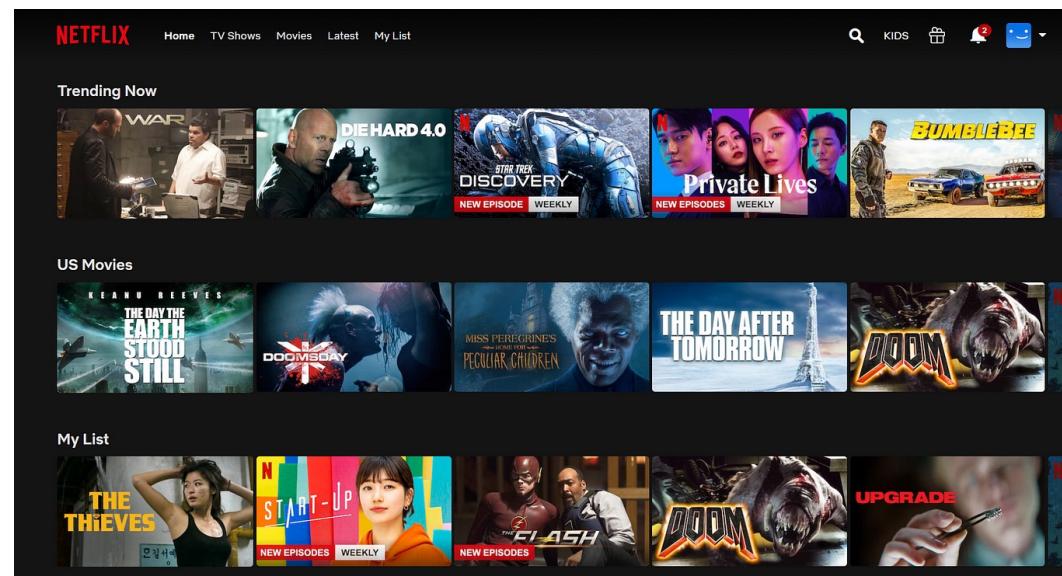
Product	Rating	Price
Mini Buddha Board Art Set: Water Drawing Writing Board w/ Mini...	4.5★ 1,356	\$17.95
Presto 07047 Cool Touch Electric Griddle	4.5★ 7,594	\$35.99
Presto Ceramic 22-inch 07062 Electric Griddle with removable handles, Black, One Size	4.5★ 7,004	\$40.99
Presto 07072 Slimline BELLA Electric Ceramic Titanium Griddle, Make 10 Eggs At Once, Healthy-Eco Non-stick...	4.5★ 12,233	\$43.99
BELLA Electric Griddle w/ Warming Tray, Make 8 Pancakes or Eggs At...	4.5★ 2,969	\$46.99
Presto 07046 Tilt 'n DASH Deluxe Everyday Electric Griddle	4.5★ 2,538	\$48.99
BELLA XL Electric Ceramic Titanium Griddle, Make 15 Eggs ...	4.5★ 8,478	\$52.70
Presto 07073 Electric Tilt-N-fold Griddle, 19"	4.5★ 5,275	\$59.99
Presto 07047 Slimline BELLA Electric Ceramic Titanium Griddle, Make 10 Eggs At Once, Healthy-Eco Non-stick...	4.5★ 2,887	\$63.10
Presto 07046 Tilt 'n DASH Deluxe Everyday Electric Griddle	4.5★ 3,609	\$69.86 shipping
BELLA Electric Griddle w/ Warming Tray, Make 8 Pancakes or Eggs At...	4.5★ 2,887	\$69.85 shipping
Presto 07046 Tilt 'n DASH Deluxe Everyday Electric Griddle	4.5★ 3,609	\$69.85 shipping
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Presto 07073 Electric Tilt-N-fold Griddle, 19"	4.5★ 5,275	\$69.85 shipping

Gift ideas inspired by your shopping history

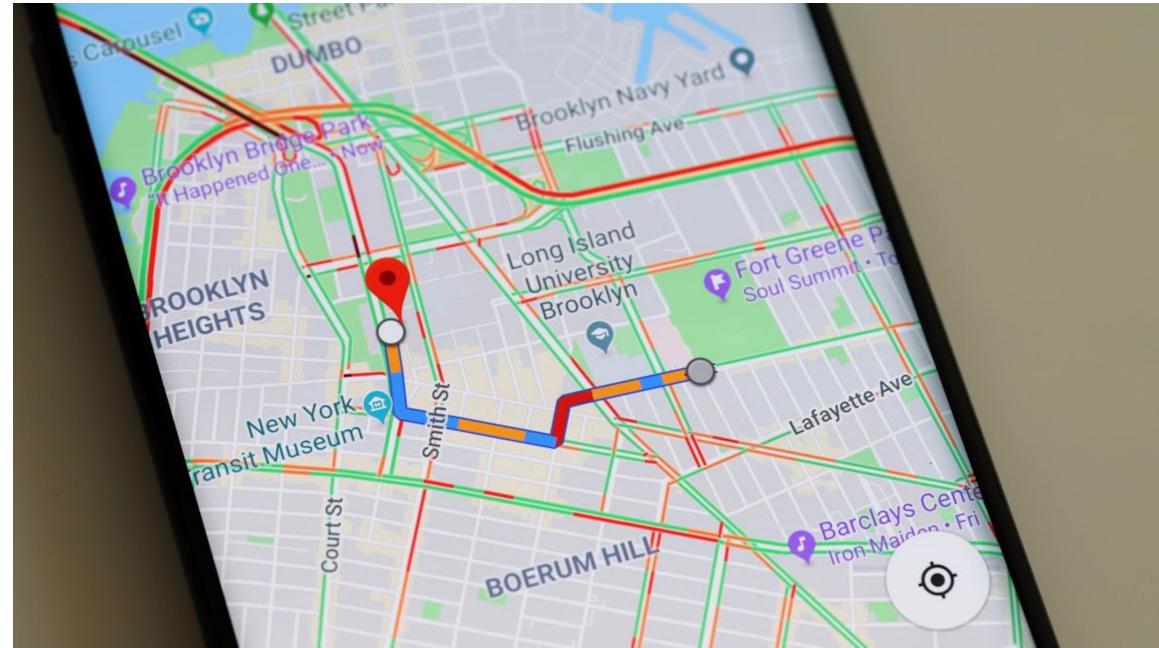


Page 1 of 3

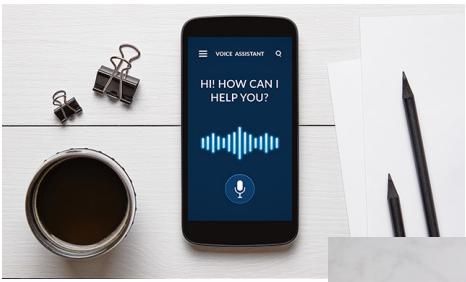
Product	Rating	Price
SAMSUNG Galaxy Tab A7 Lite 8.7" 32GB Android Tablet w/ Compact, Slim Design, Sturdy Metal...	4.5★ 10,337	\$109.99
SAMSUNG Galaxy Tab A8 10.5" 32GB Android Tablet w/ LCD Screen, Long Lasting Battery,...	4.5★ 8,698	\$119.99
Laptop Shoulder Bag 15.6-inch Laptop or Tablet, Sleek, Durable, and Stylish	4.5★ 17,240	\$159.00
Laptop Shoulder Bag 15.6-inch Laptop or Tablet, Sleek, Durable, and Stylish	4.5★ 17,240	\$159.00
Lenovo Laptop Shoulder Bag 15.6-inch Laptop or Tablet, Sleek, Durable, and Stylish	4.5★ 17,240	\$159.00
Presto 06852 16-Inch Electric Skillet with Glass Cover	4.5★ 11,875	\$164.99
Crayola Colored Pencils Classpack, 240 Count, Bulk Classroom Supplies For Teachers, 12...	4.5★ 3,108	\$164.99
SAMSUNG Galaxy Tab A7 Lite 8.7" 32GB WiFi Android Tablet w/ Long-Lasting Battery, 8.7" HD Screen, and 32GB Storage	4.5★ 10,337	\$169.00
Amazon Basics 6-Piece Nonstick, Carbon Steel Oven Bakeware Baking Set	4.5★ 4,633	\$169.00
OXO Good Grips Silicone Flexible Pancake Turner	4.5★ 4,633	\$169.00
Sceptre 24" Curved 75Hz Gaming LED Monitor Full HD 1080P HDMI VGA Speakers, VESA Wall...	4.5★ 16,572	\$169.97
Crayola Bulk Broad Line Washable Markers, School Supplies Classpack, 200 Count,...	4.5★ 898	\$171.27 (\$0.16/Count)
Crayola Bulk Broad Line Washable Markers, School Supplies Classpack, 200 Count,...	4.5★ 898	\$171.27 (\$0.16/Count)



Probably, 20-50 AI techs



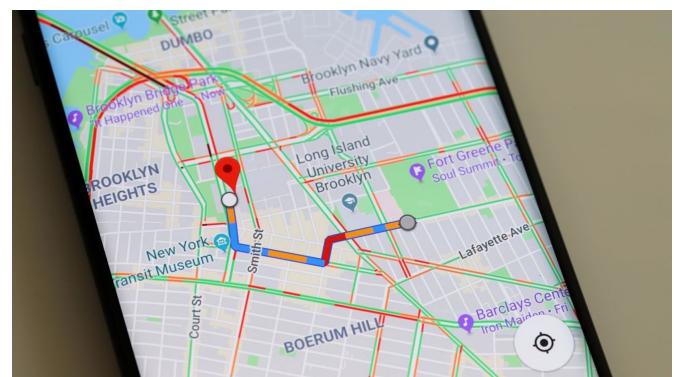
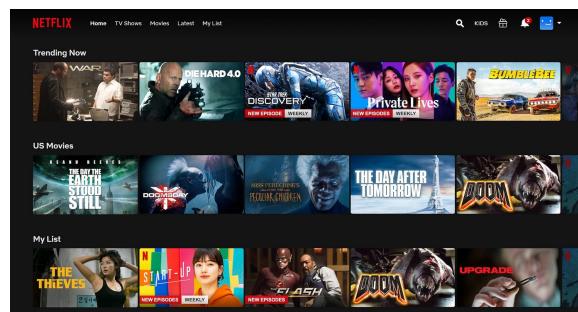
AI is pervasive



Customers who viewed items in your browsing history also viewed

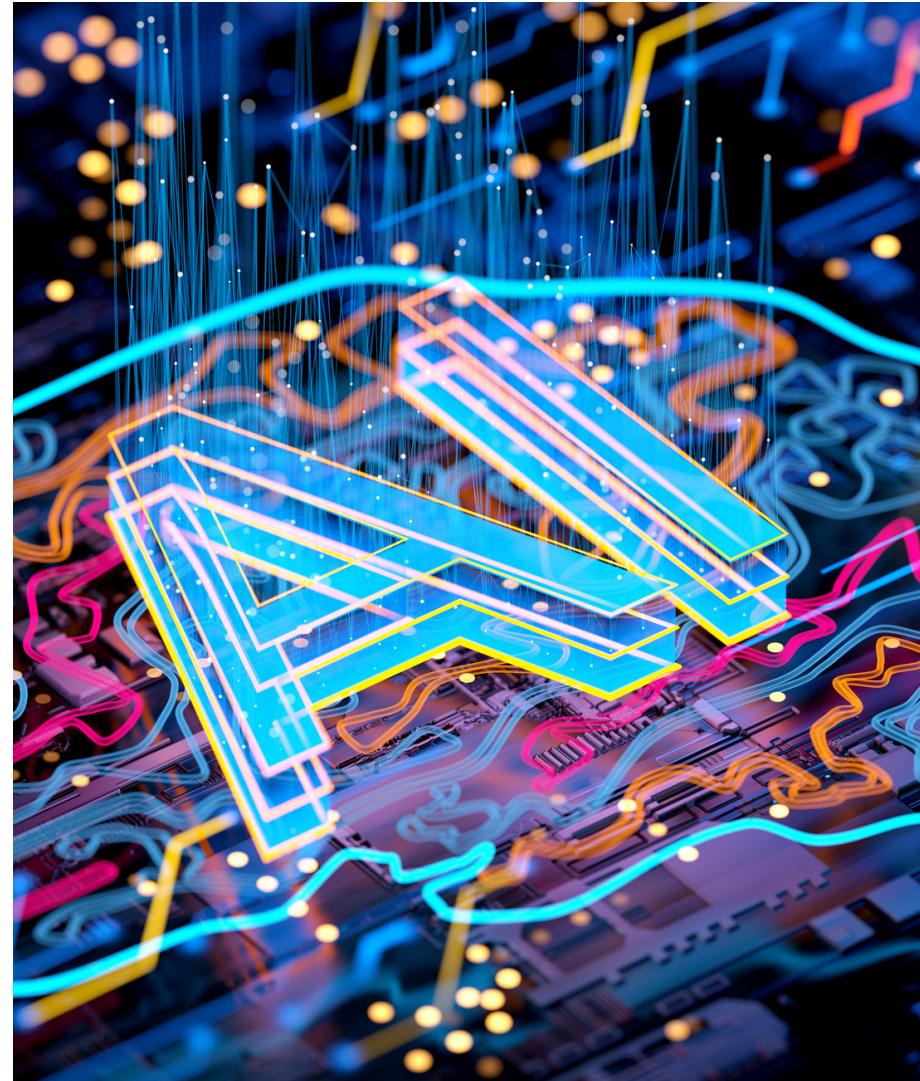


Gift ideas inspired by your shopping history

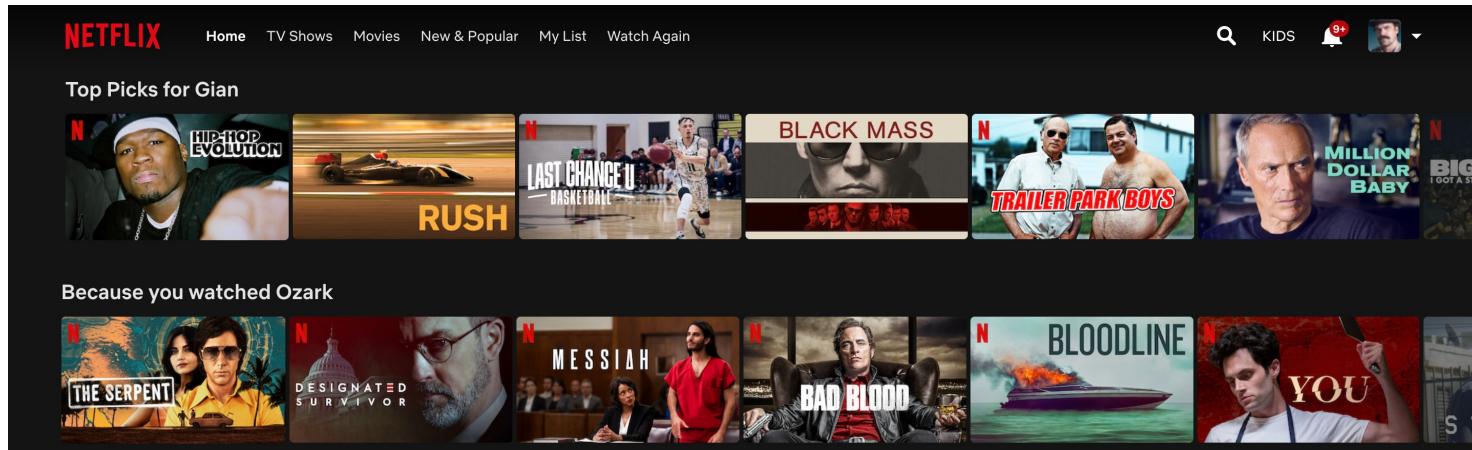


AI technologies performs really well in specific tasks

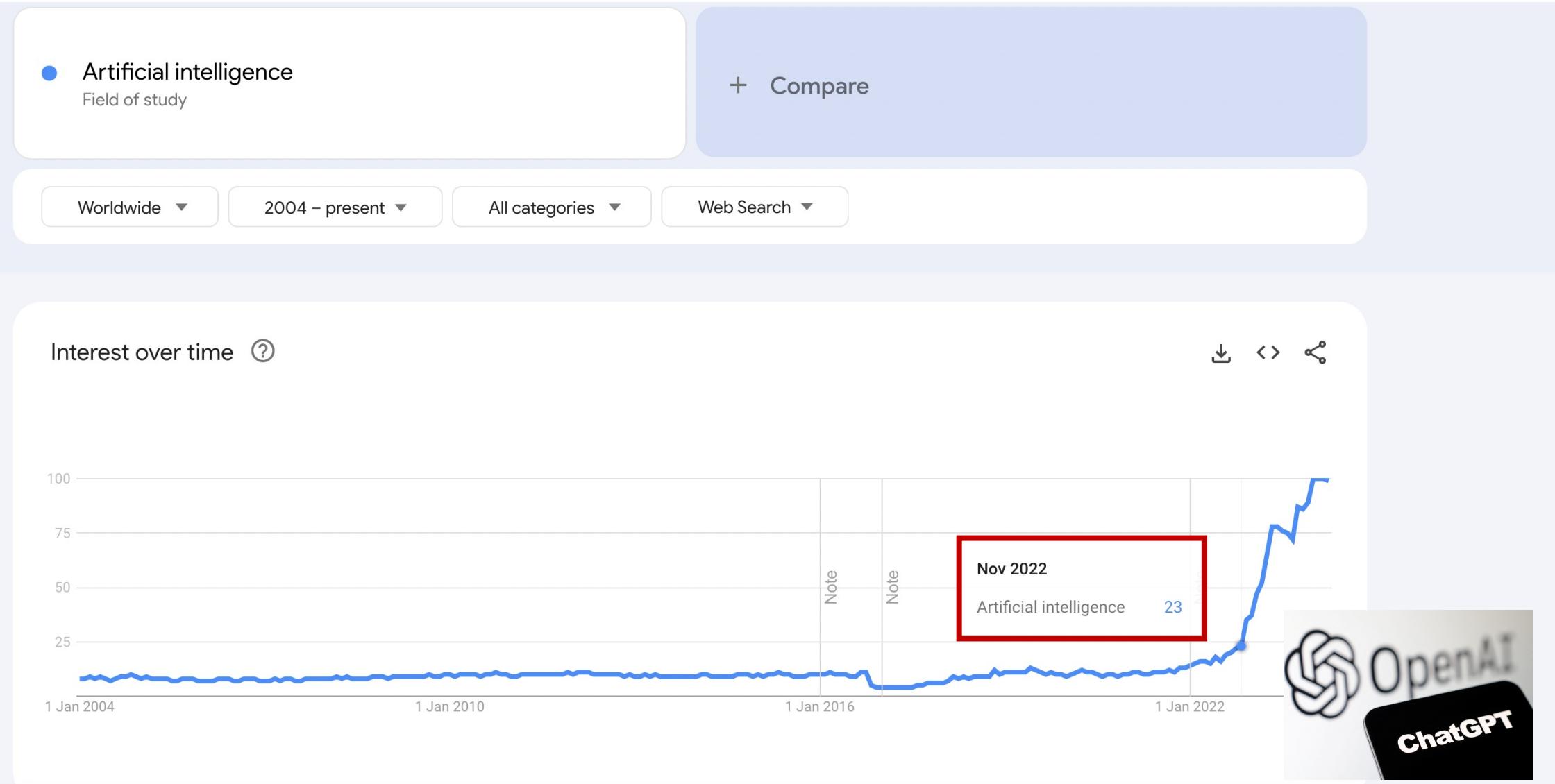
- While there are some AI tools (like ChatGPT) whose capabilities are quite broad and general, AI-based technologies solves well specific tasks
- And AI-based technologies are everywhere: we have countless AI-based tools for specific tasks



AI technologies performs really well in specific tasks... this is why AI is pervasive



AI is pervasive also in everyday discussions!



AI is pervasive also in everyday discussions!

≡ 🔎 24 Finanza Microsoft, investimento miliardario in Giappone nell'Intelligenza artificiale

Finanza **FTSE MIB** 33902,85 -0,40% **Spread BTP-Bund 10Y** 135,79 +0,95% **EUR/USD** 1,074065

Homepage | Tutti i dati Servizio | Big Tech

Microsoft, investimento miliardario in Giappone nell'Intelligenza artificiale

L'intento è rafforzare lo sviluppo di questa tecnologia nel Paese asiatico

di Redazione Finanza 10 aprile 2024

CORRIERE DELLA SERA

I NUOVI MODELLI LINGUISTICI

Llama 3 e Gpt-5 saranno le prime intelligenze artificiali generative «capaci di ragionare»? Cosa significa

di Eugenio Spagnuolo

Gli eredi di ChatGpt e Llama, l'AI di Open AI e Meta, promettono capacità di ragionamento umano. Ma cosa significa esattamente?



≡ 🔎 **Il Messaggero** CONDIVISO DAL 1878

TECNOLOGIA



Scoperta la vulnerabilità dell'Intelligenza Artificiale grazie a una nuova tecnica

L'INCONTRO



"AttraiAmo il futuro", il convegno su intelligenza artificiale e eccellenza delle filiere economiche

G CALCIO MOTORI TENNIS CICLISMO ALTRI SPORT ... Risultati Abb

FANTA CONSIGLI



Da Carneseccchi a Bisceck, i consigli per la 32ª giornata al Fantacampionato

S. Mandaro • 49 minuti fa

Con l'aiuto dell'intelligenza artificiale, ecco i giocatori da schierare nel...

Tutto sulla Serie A >

AI is pervasive also in everyday discussions!



Rai Play

Festival di Sanremo
Fiorello A.I. sul palco dell'Ariston

1:44

Play ▶️ | Back ⏪ | Forward ⏩ | Volume 🔊 | Download 📁 | Chat 🗣 | Settings 🛡 | Fullscreen 🌐

Festival di Sanremo
Fiorello A.I. sul palco dell'Ariston
St 2024 6 min

Al Festival di Sanremo irrompe una copia di Rosario Fiorello generata dall'intelligenza artificiale



Finanza Microsoft, investimento miliardario in Giappone nell'Intelligenza artificiale

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Tutto sulla Serie A >

Growth and impact of AI



40B \$ market in 2022,
estimated market 1300B \$ in
2032

Bloomberg Bloomberg Intelligence Interactive Calculator: Generative AI Market Opportunity

(\$ million, unless otherwise specified)

Generative AI Revenue Projections	2022	2027E	2032E	2022-32E CAGR
Hardware	\$37,973	\$223,615	\$641,737	33%
Devices (Inference)	\$4,128	\$82,965	\$168,233	45%
Computer Vision AI Products	\$1,032	\$22,124	\$60,564	50%
Conversational AI Products	\$3,096	\$60,841	\$107,669	43%
Infrastructure (Training)	\$33,845	\$140,650	\$473,505	30%
AI Server	\$22,563	\$49,641	\$133,817	19%
AI Storage	\$9,025	\$33,094	\$92,642	26%
Generative AI Infrastructure as a Service	\$2,256	\$57,915	\$247,046	60%
Software	\$1,493	\$58,826	\$279,899	69%
Specialized Generative AI Assistants	\$447	\$20,864	\$89,035	70%
Coding, DevOps and Generative AI Workflows	\$213	\$12,617	\$50,430	73%
Generative AI Workload Infrastructure Software	\$439	\$13,468	\$71,645	66%
Generative AI Drug Discovery Software	\$14	\$4,042	\$28,343	113%
Generative AI Based Cybersecurity Spending	\$9	\$3,165	\$13,946	109%
Generative AI Education Spending	\$370	\$4,669	\$26,500	53%
Generative AI Based Gaming Spending	\$190	\$20,668	\$69,414	80%
Generative AI Driven Ad Spending	\$57	\$64,358	\$192,492	125%
Generative AI Focused IT Services	\$83	\$21,690	\$85,871	100%
Generative AI Based Business Services	\$38	\$10,188	\$34,138	97%
Total	\$39,834	\$399,345	\$1,303,551	42%

Source: Bloomberg Intelligence, IDC, eMarketer, Statista

Growth and impact of AI



Ursula von der Leyen [in](#) · Following
President of the European Commission
1d ·

The AI race is just beginning. And Europe will become an AI continent.

To lead this race, we need massive investments.

This is why today, I am glad to announce InvestAI, a public-private partnership that aims to mobilise 200 billion euros in AI investments in Europe.

We will build European GigaAI factories. These massive computing hubs will be accessible to everyone – researchers and entrepreneurs – to push the innovation frontiers of AI.

EU launches InvestAI
€200 billion
of investment in
**Artificial
Intelligence**



Growth and impact of AI

Governo Italiano Presidenza del Consiglio dei Ministri

"L'Intelligenza Artificiale per l'Italia", il videomessaggio del Presidente Meloni

Martedì, 12 Marzo 2024

Il videomessaggio del Presidente del Consiglio, Giorgia Meloni, in occasione dell'evento "L'Intelligenza Artificiale per l'Italia", organizzato dal Dipartimento per la trasformazione digitale della Presidenza del Consiglio dei ministri e AgID - Agenzia per l'Italia Digitale.



CanadianPM @CanadianPM · Apr 7
AI has the potential to transform the economy. Today, PM Trudeau announced new #Budget2024 measures to harness the full potential of AI, which will create good-paying jobs for every generation while raising productivity, and growing our economy. Details: pm.gc.ca/eng/news-releases/2024/04/07/securing-canadas-ai-advantage



dcast Cerca **"POST"** Shop Regala

BITS | **MONDO** | Mercoledì 13 marzo 2024

Il Parlamento Europeo ha approvato l'AI Act, la prima legge al mondo per regolamentare l'intelligenza artificiale

Condividi Aggiungi ai preferiti



Ursula von der Leyen  · Following
President of the European Commission
1d · 

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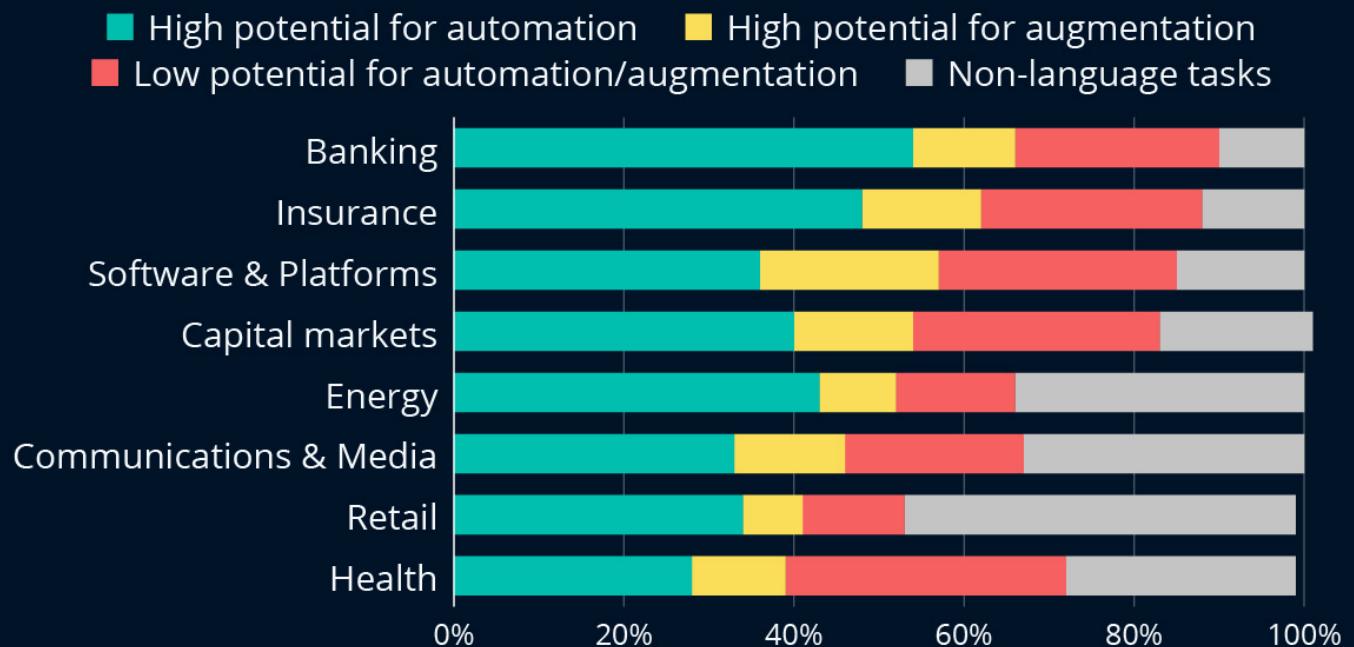
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AI: technological revolution!

In Which Industries Could AI Do Most of the Heavy Lifting?

Share of working hours in selected industries in the U.S. that could be automated/augmented by the use of AI



Tasks with high potential for automation can be transformed by AI with little human involvement, tasks with high potential for augmentation require more human involvement

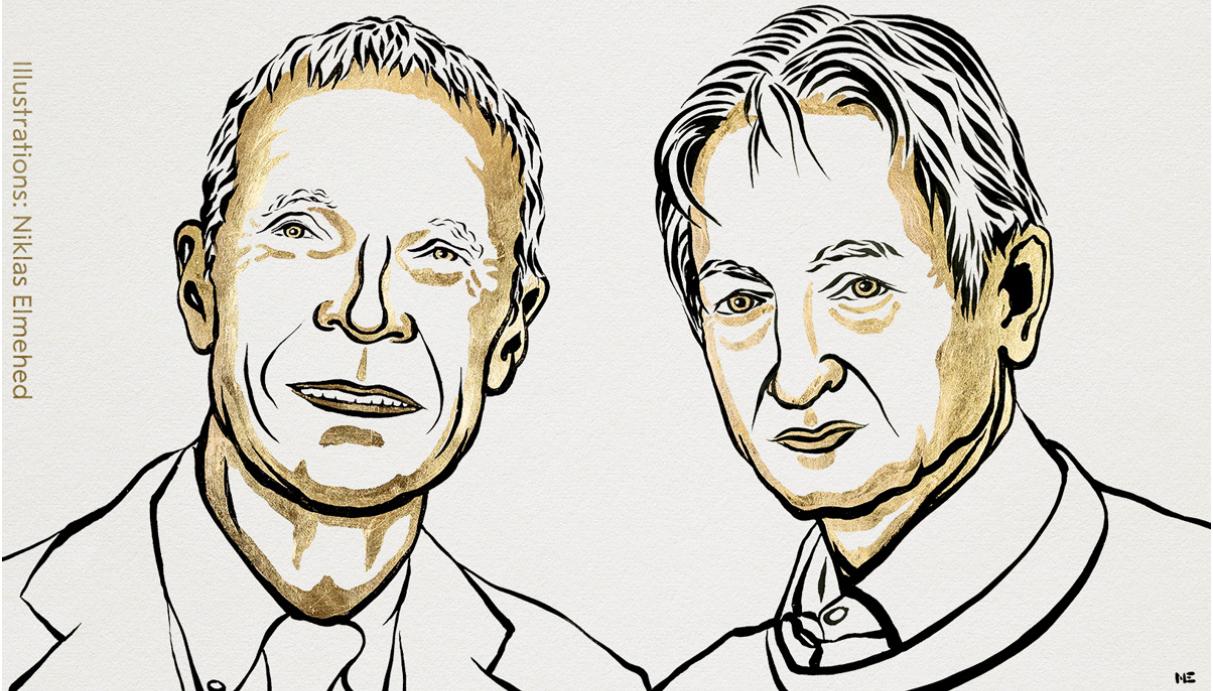
Source: Accenture



AI: scientific revolution!

Illustrations: Niklas Elmehed

THE NOBEL PRIZE
IN PHYSICS 2024



John J. Hopfield

Geoffrey E. Hinton

"for foundational discoveries and inventions
that enable machine learning
with artificial neural networks"

THE ROYAL SWEDISH ACADEMY OF SCIENCES

Illustrations: Niklas Elmehed

THE NOBEL PRIZE
IN CHEMISTRY 2024



David
Baker

"for computational
protein design"

Demis
Hassabis

"for protein structure prediction"

John M.
Jumper

THE ROYAL SWEDISH ACADEMY OF SCIENCES

3. What is the difference between AI
and **Machine Learning**?

**Difference between machine
learning and AI:
If it is written in Python,
it's probably machine learning
If it is written in PowerPoint,
it's probably AI**

Curt Simon Harlinghausen / PUBLICIS.SAPIENT | 48FRWD AI ML

From rules to data-driven AI

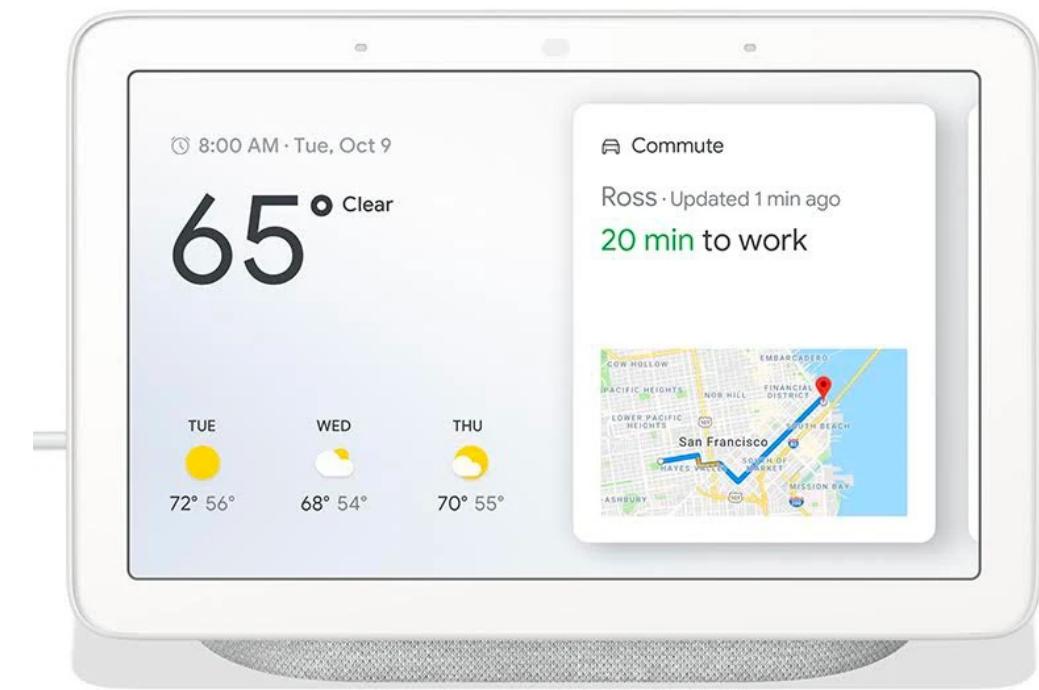
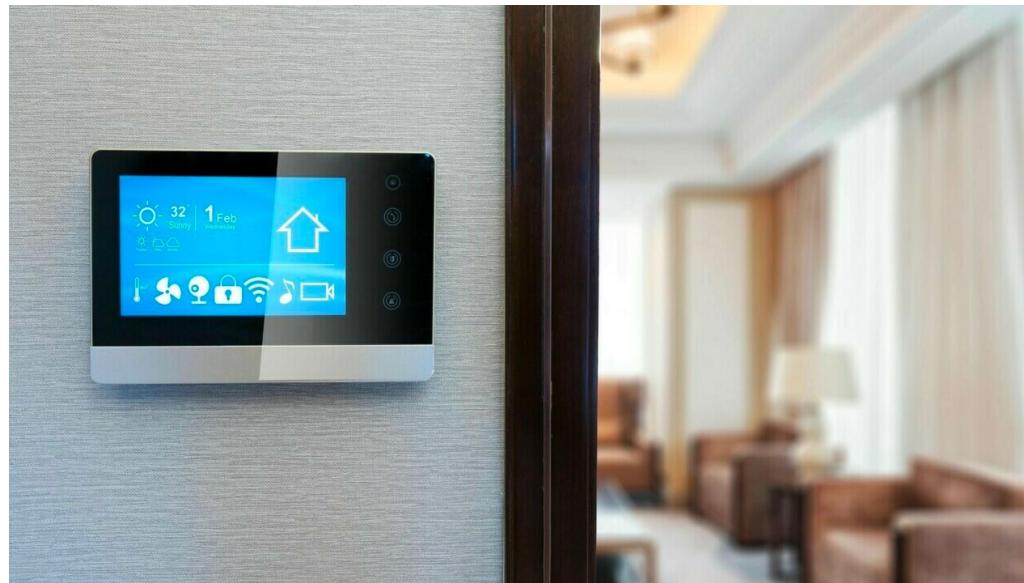
Machine Learning ('Apprendimento Automatico') is the part of AI that develops solutions based on data and not strictly on rules



From rules to data-driven AI



From rules to data-driven AI



Nowadays, most important AI technologies are data-driven, ie. Machine Learning-based technologies!



Outline

- Organizational Aspects
- Intro to Machine Learning
- Course Outline

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Lecturer



Research on:

- Reinforcement Learning
- Anomaly Detection
- Continual Learning
- Explainability and Fairness
- Deep Learning
- Machine Learning Applications

Lecturer



Research on:

- Reinforcement Learning
- Anomaly Detection
- Continual Learning
- Explainability and Fairness
- Deep Learning
- Machine Learning Applications

Lecturer



Gian Antonio Susto
gianantonio.susto@unipd.it

Research on:

- Reinforcement Learning
- Anomaly Detection
- Continual Learning
- Explainability and Fairness
- Deep Learning
- Machine Learning Applications

Collaborations with several companies:
Statwolf, Infineon, Technogym, Diasorin,
LFoundry, Seagate, Breton, Swegon,
Galdi, Santex, GoldenGoose, Electrolux,
Zoppas Industries, Maschio Gaspardo,
Luxottica, Pietro Fiorentini, ...

Teaching Assistants

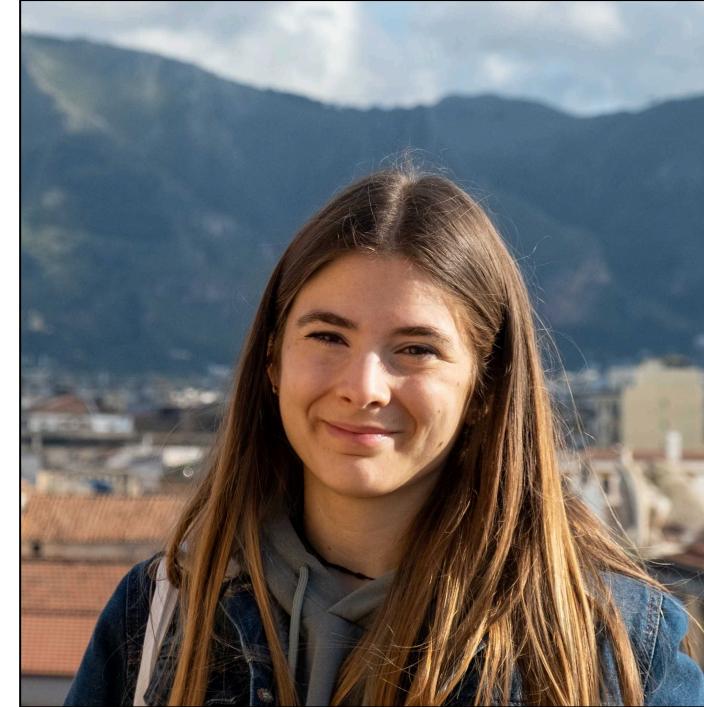


Francesco Borsatti, PhD Student

Mechatronic Engineer

Working on AI for edge applications & for heating elements systems

francesco.borsatti.1@phd.unipd.it



Valentina Zaccaria, PhD Student

Control Systems Engineer

Working on Anomaly Detection, Explainable Artificial Intelligence & Active Learning

valentina.zaccaria@unipd.it

Teaching Assistants



Marina Ceccon, PhD Student
Computer Engineer
Working on Deep Learning and Continual Learning for Fairness
marina.ceccon@phd.unipd.it



Matteo Cederle, PhD Student
Control Systems Engineer
Working on Smart Mobility, Autonomous Driving and Reinforcement Learning
matteo.cederle@phd.unipd.it

Lectures and Course Page

Lectures on:

Monday @ 12:30-14:00 – Room De

Thursday @ 12:30-14:00 – Room 14C
(Padiglione 14 Fiera)

Friday @ 12:30-14:00 – Room Ue/Te (if we are
having lab)
OR Room Me

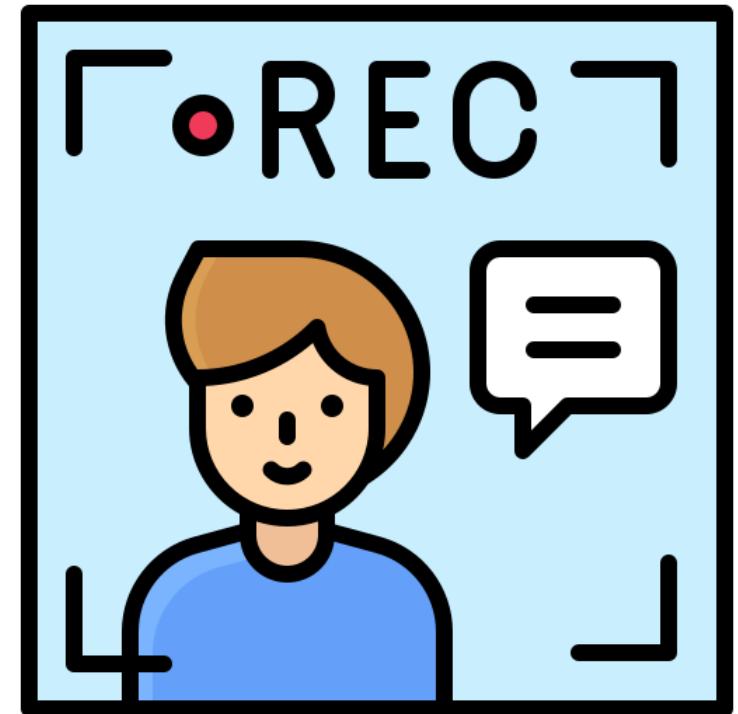


Moodle Page:

<https://stem.elearning.unipd.it/course/view.php?id=12269>

Course Recordings

Lecture and laboratories recordings will be made available shortly after the lecture.



Course Material

- Main reference:

1. Course Slides

- Other reference:

2. G. James et al. 'An Introduction to Statistical Learning'

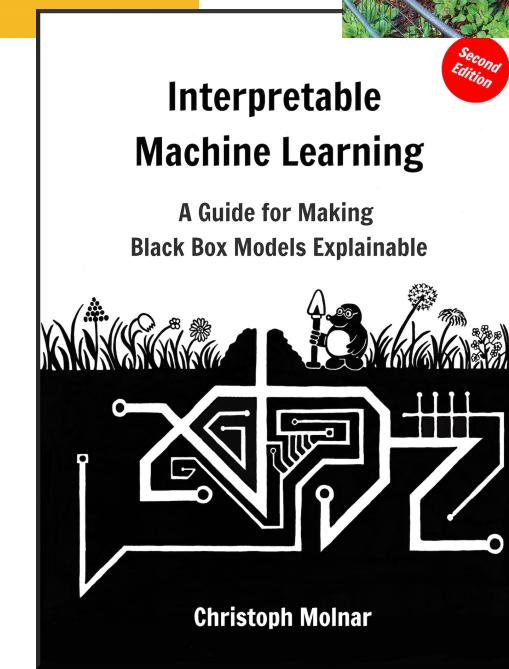
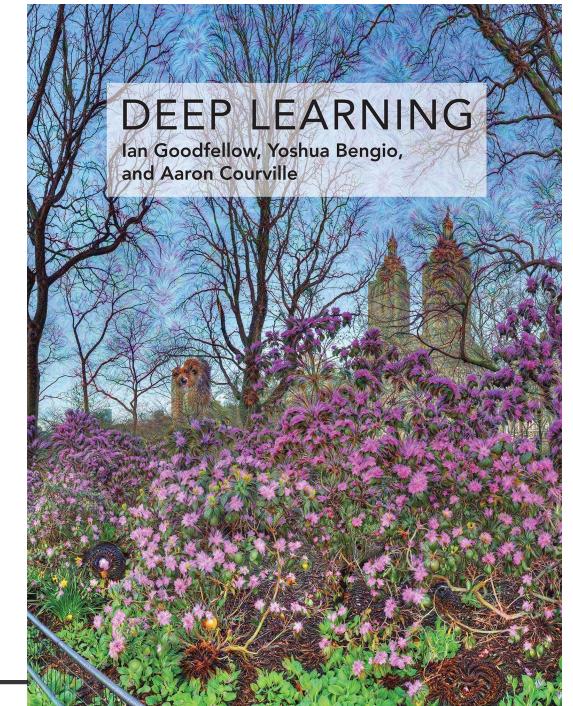
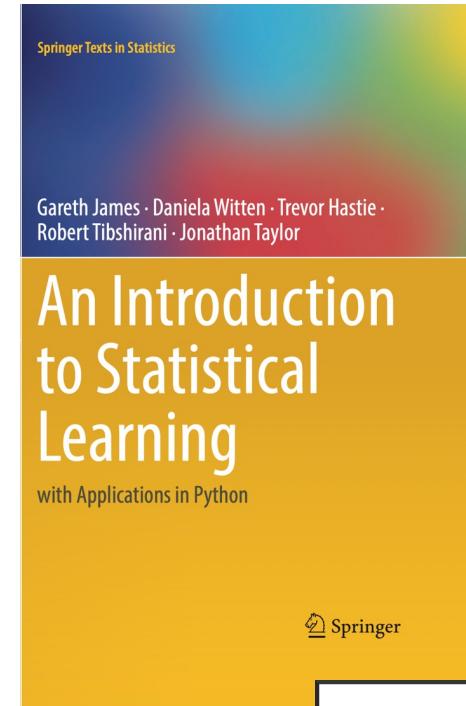
<https://www.statlearning.com/>

3. I. Goodfellow, Y. Bengio, A. Courville 'Deep Learning'

<https://www.deeplearningbook.org/>

4. C. Molnar 'Interpretable Machine Learning'

<https://christophm.github.io/interpretable-ml-book/>



Exam

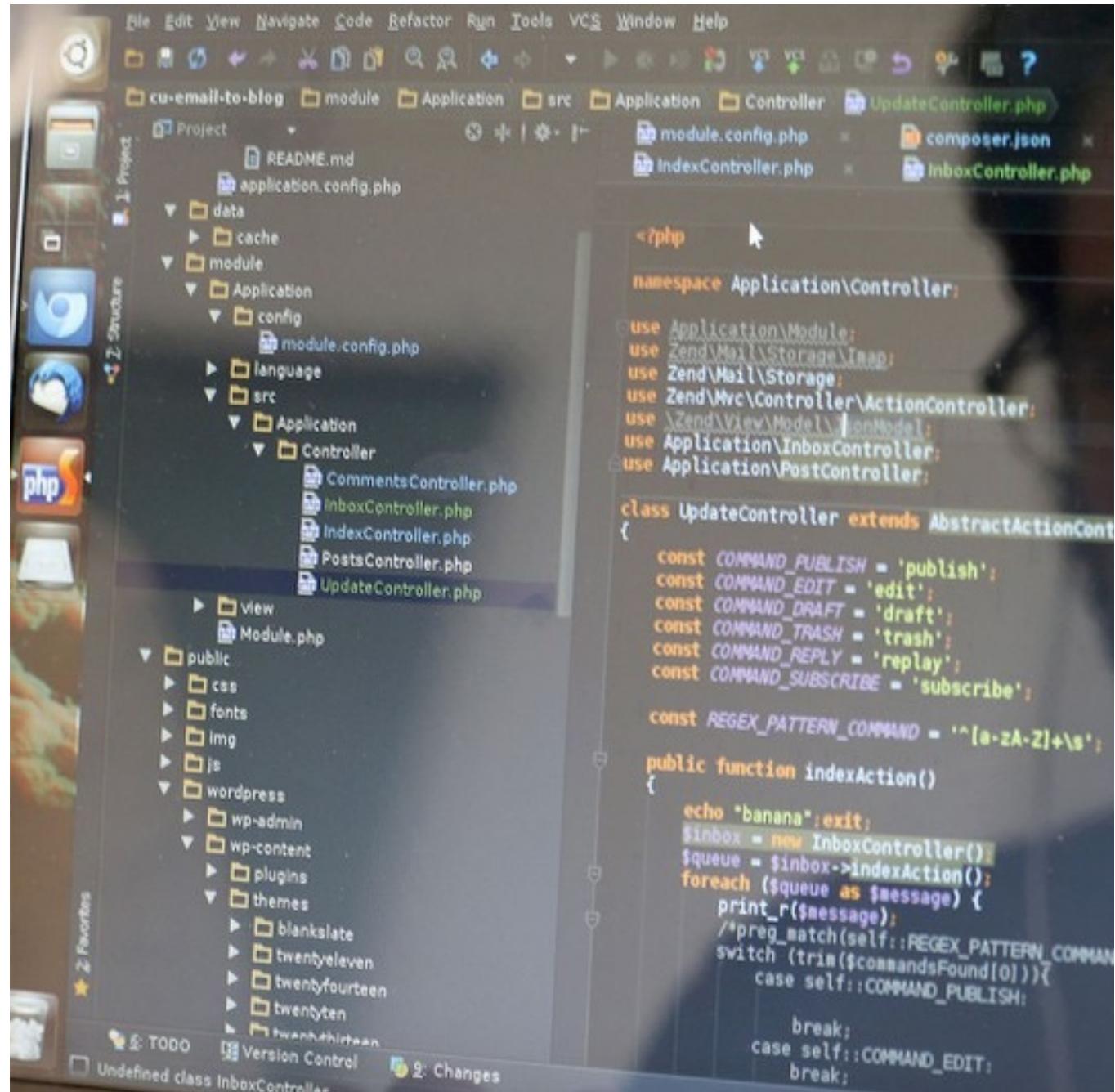
Written exam (on the same day):

1. Theoretic exam
2. *Python programming exam

*A student can take the programming exam only after achieving a sufficient score in the theoretical part

Dates

- June 17th, 2025 from 13:30
- July 3rd, 2025 from 13:30
- August 29th, 2025 from 9:00
- January 23rd, 2026 from 9:00



The screenshot shows a PHP development environment with the following details:

- Project Structure:** The project is named "cu-email-to-blog" and contains a "module" folder. The "module" folder has subfolders "Application", "config", "language", "src", and "view". The "src" folder contains "Application" and "Controller" subfolders, which in turn contain "CommentsController.php", "InboxController.php", "IndexController.php", "PostsController.php", and "UpdateController.php".
- Code Editor:** The right pane shows the "UpdateController.php" file. The code defines a class "UpdateController" that extends "AbstractActionController". It includes several constants for command names and a regular expression for command matching. The "indexAction" method is defined with logic to handle different commands (PUBLISH, EDIT, DRAFT, TRASH, REPLY, SUBSCRIBE) and a message queue.

```
<?php

namespace Application\Controller;

use Application\Module;
use Zend\Mail\Storage\Imap;
use Zend\Mail\Storage;
use Zend\Mvc\Controller\AbstractController;
use Zend\View\Model\ViewModel;
use Application\InboxController;
use Application\PostController;

class UpdateController extends AbstractActionController
{
    const COMMAND_PUBLISH = 'publish';
    const COMMAND_EDIT = 'edit';
    const COMMAND_DRAFT = 'draft';
    const COMMAND_TRASH = 'trash';
    const COMMAND_REPLY = 'replay';
    const COMMAND_SUBSCRIBE = 'subscribe';

    const REGEX_PATTERN_COMMAND = '^[a-zA-Z]+\s';

    public function indexAction()
    {
        echo "banana":exit;
        $inbox = new InboxController();
        $queue = $inbox->indexAction();
        foreach ($queue as $message) {
            print_r($message);
            /*preg_match(self::REGEX_PATTERN_COMMAND, $message['command']);
            switch (trim($commandsFound[0])) {
                case self::COMMAND_PUBLISH:
                    break;
                case self::COMMAND_EDIT:
                    break;
            }*/
    }
}
```

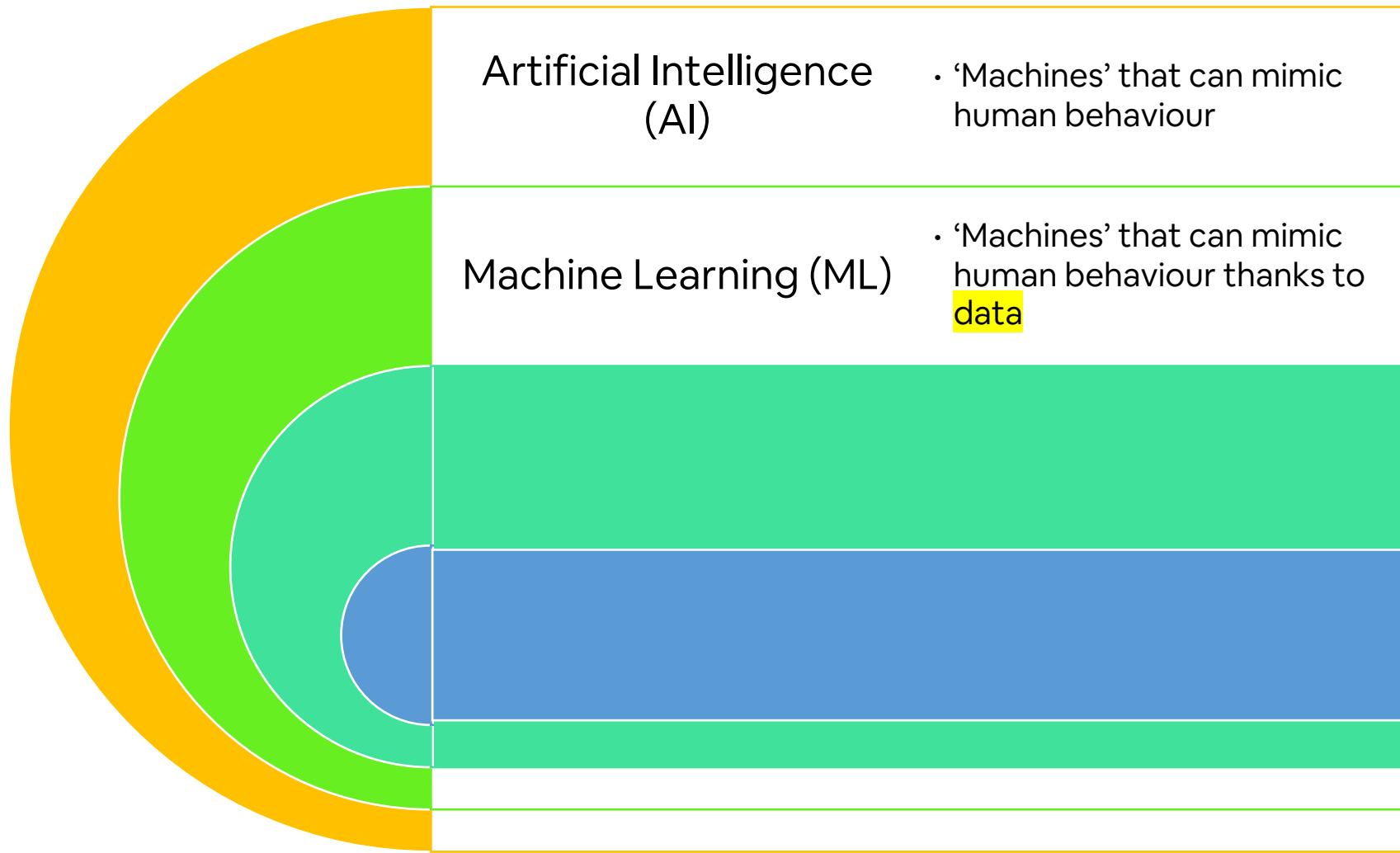
Communications

- In email communications, please use object '[ML2024-25]<your title>'
- If you have a question, probably your colleagues has the same/similar one: we will try to answer during the lectures

Outline

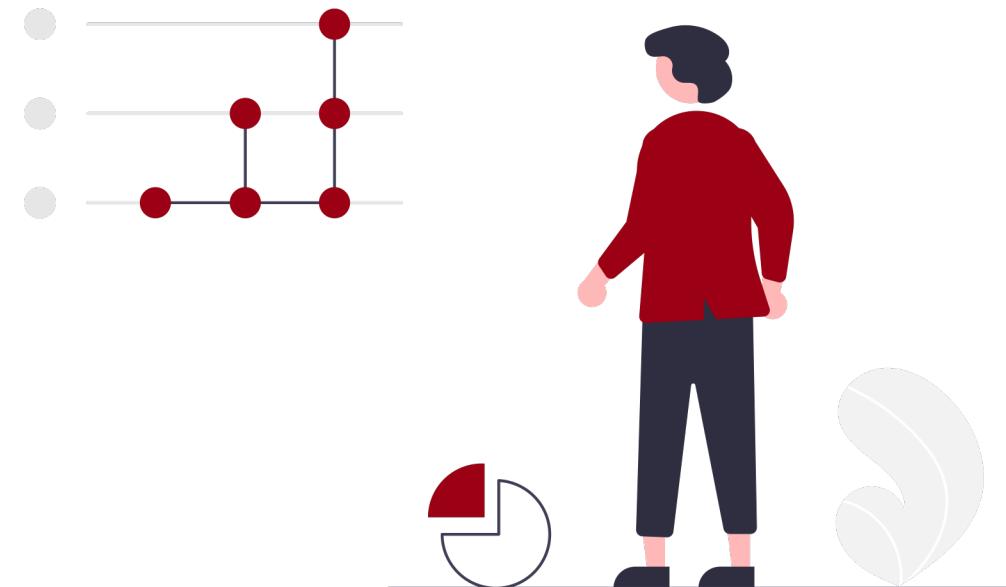
- Organizational Aspects
- **Intro to Machine Learning**
- Course Outline

The keywords

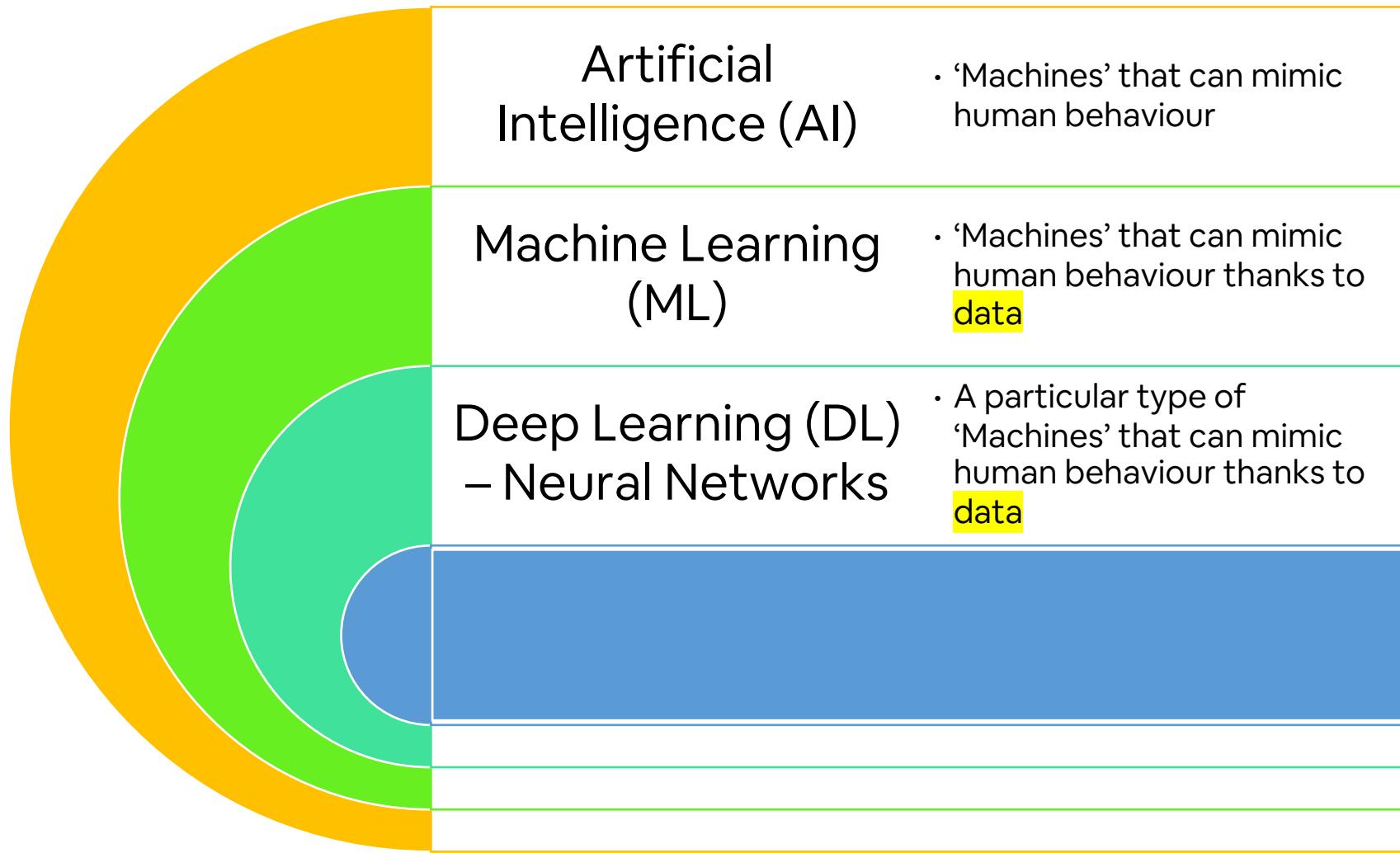


What Machine Learning algorithms can do:

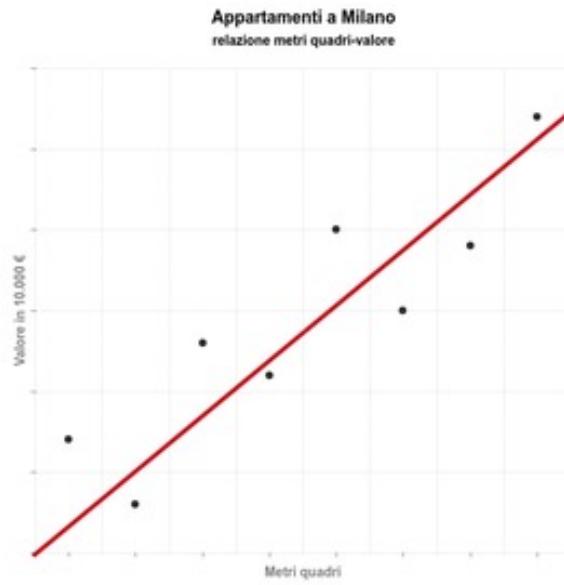
- Define the relationship between input and output and make predictions
- Find anomalies ('strange' data)
- Make forecast of time-series
- Find Groups in the data
- Find patterns
- Extract information from any type of data: tabular, images, video, text... you name it!



The keywords



Machine Learning Approaches

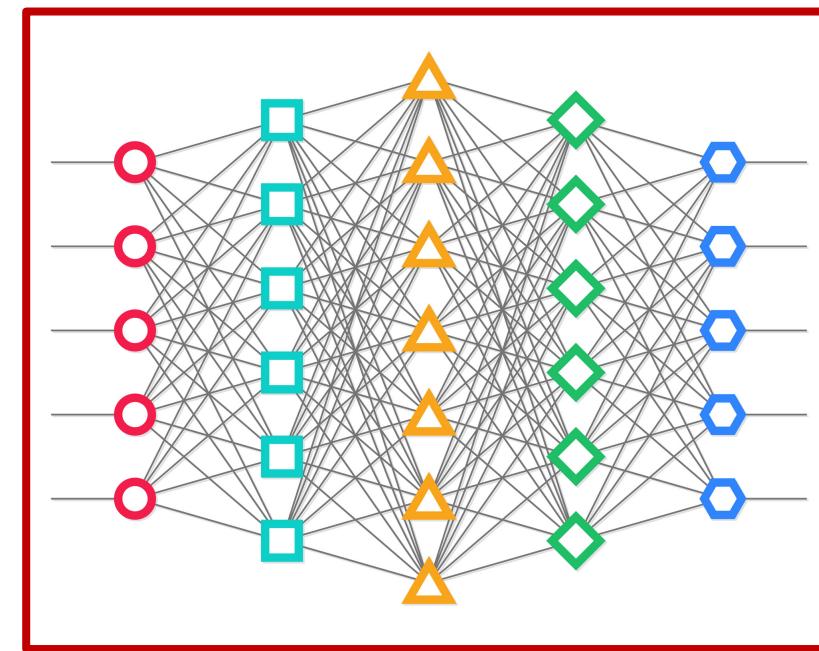
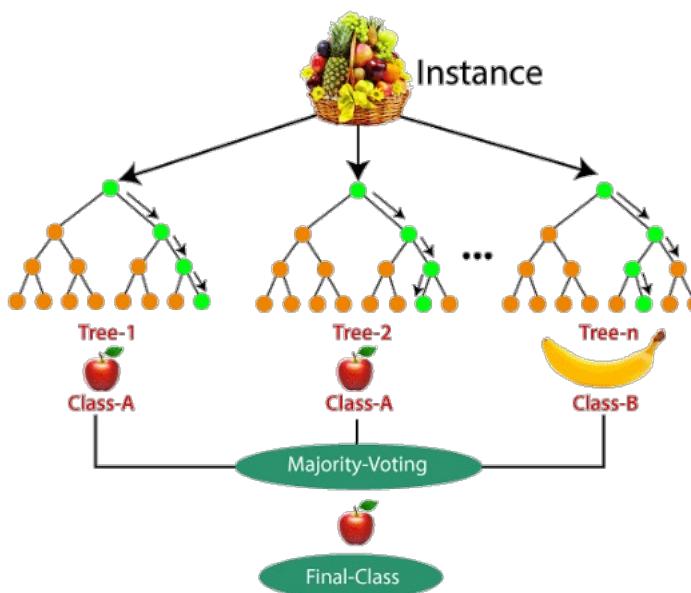
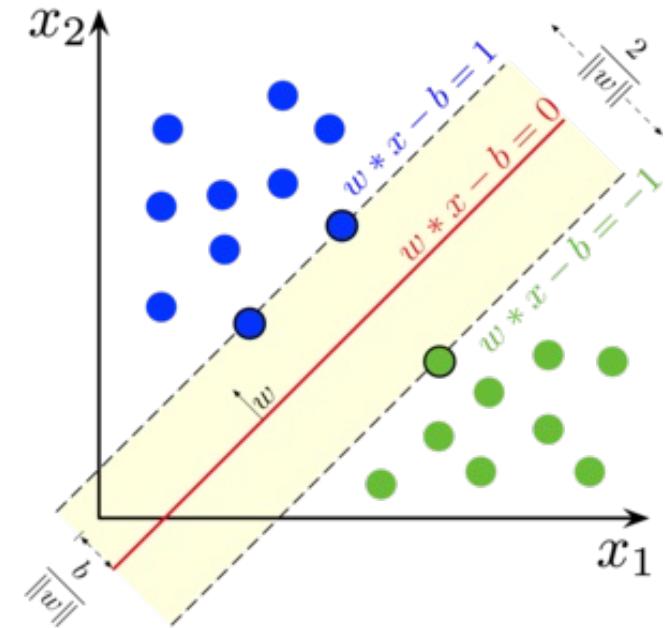


La regressione lineare

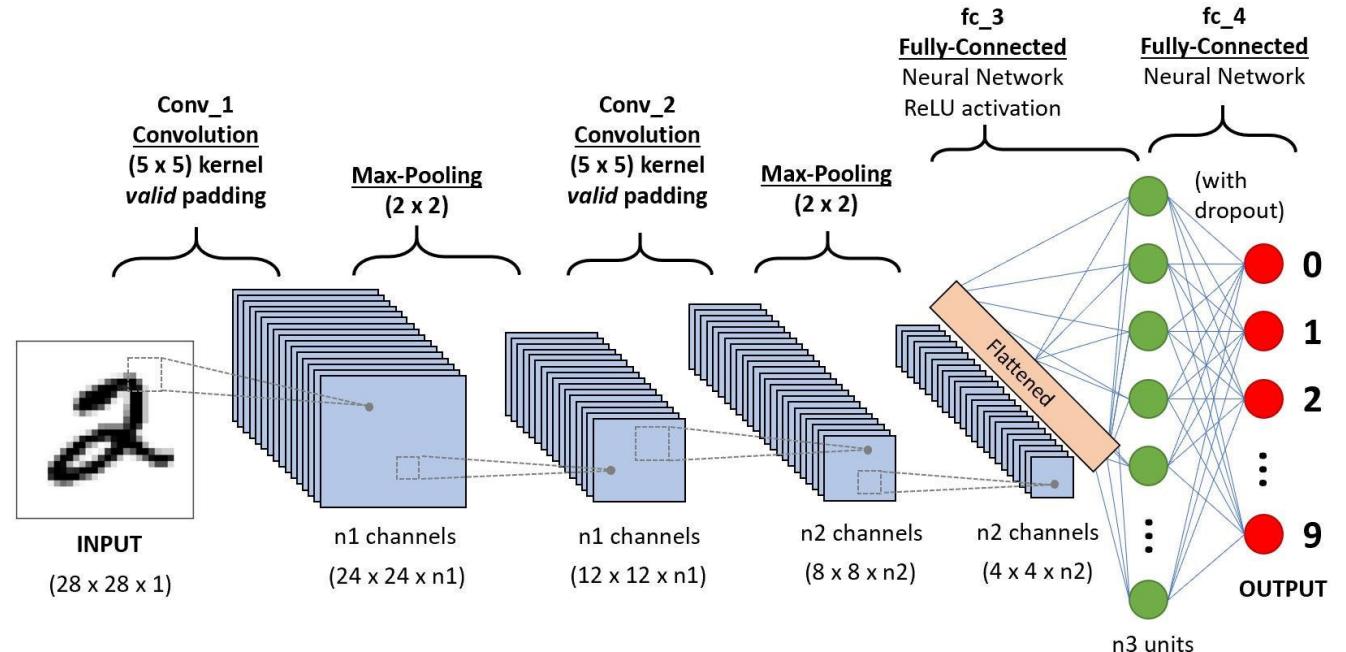
$$y = b + wx$$

BIAS
↓
PREDIZIONE

PROPRIETÀ
↑
PESO

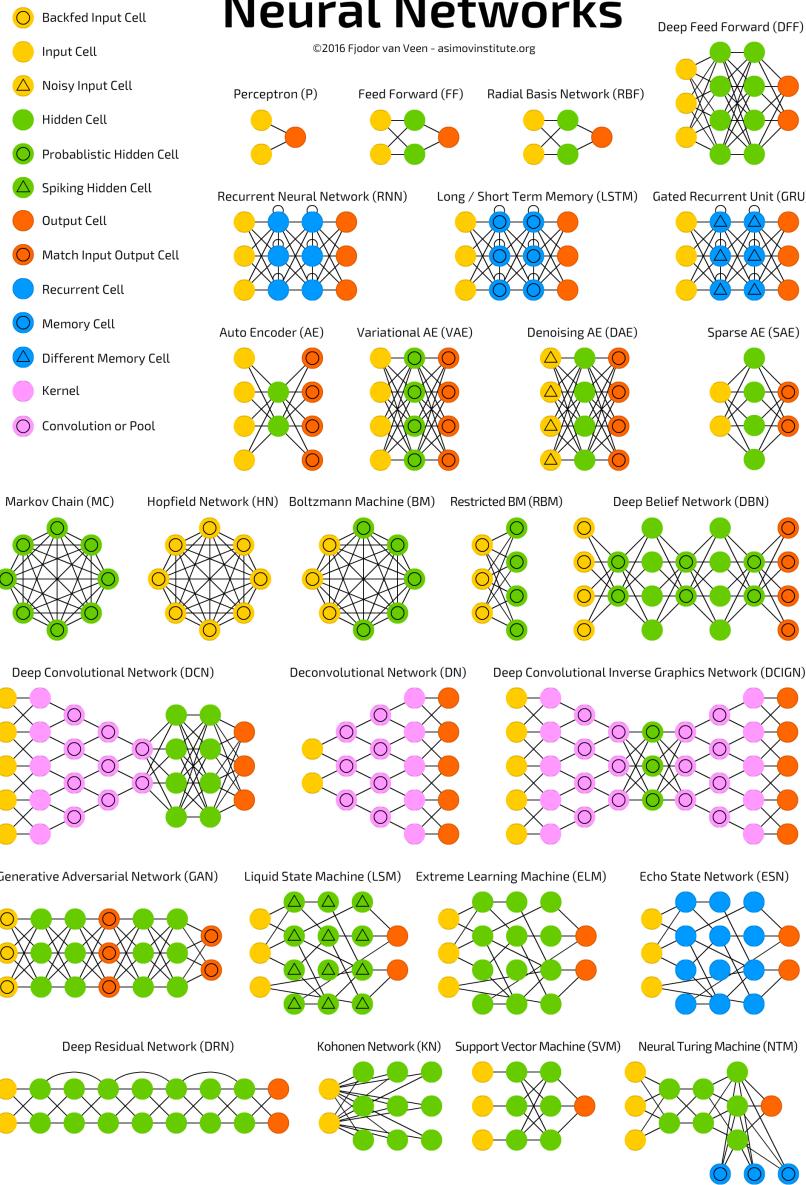


Neural Networks / Deep Learning

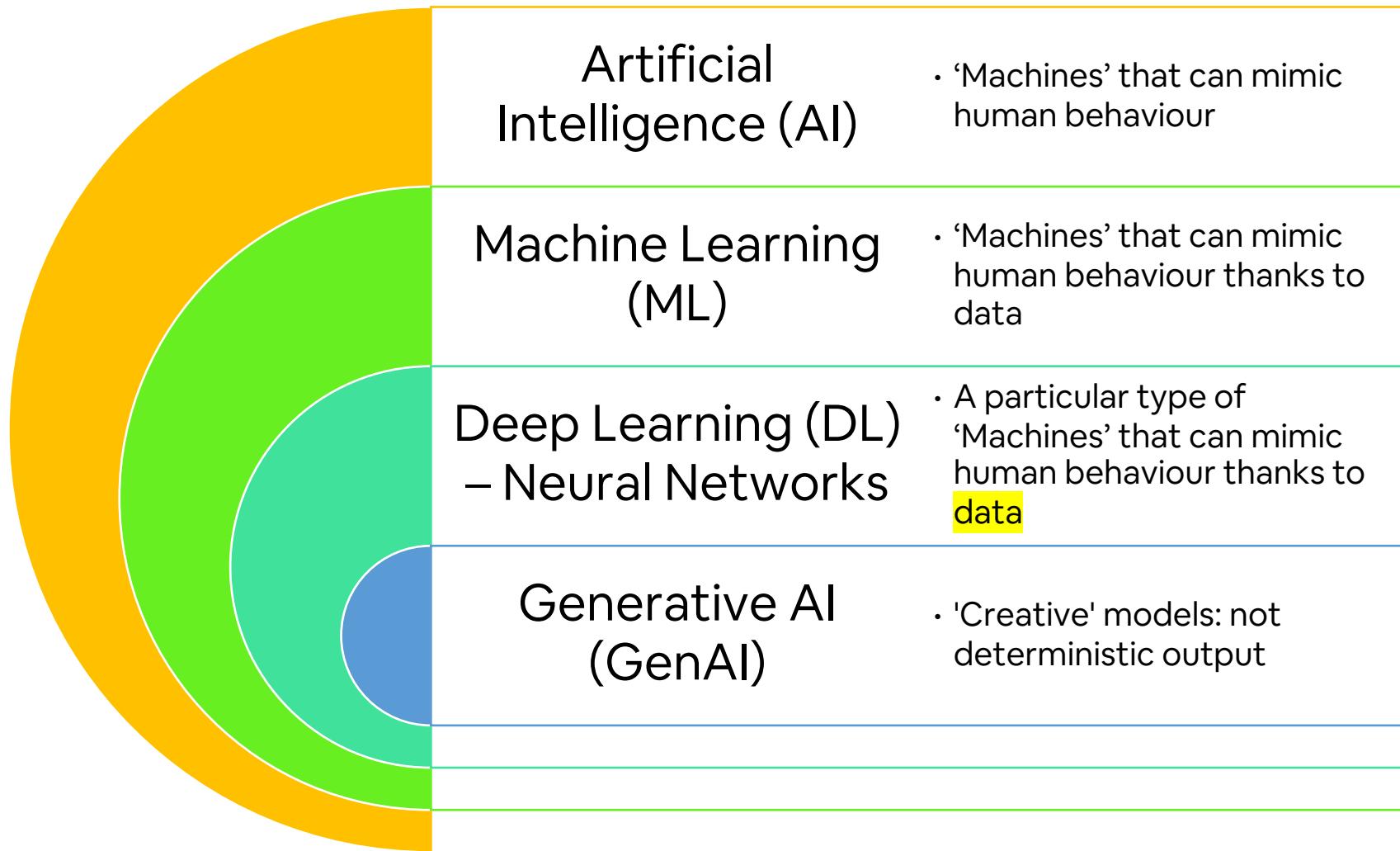


A mostly complete chart of Neural Networks

©2016 Fjodor van Veen - asimovinstitute.org

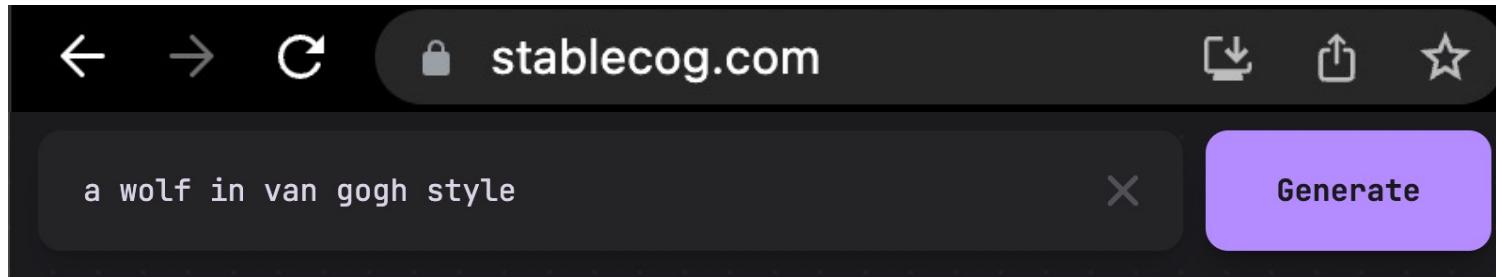


The keywords



Generative AI

Example: 1. text to image

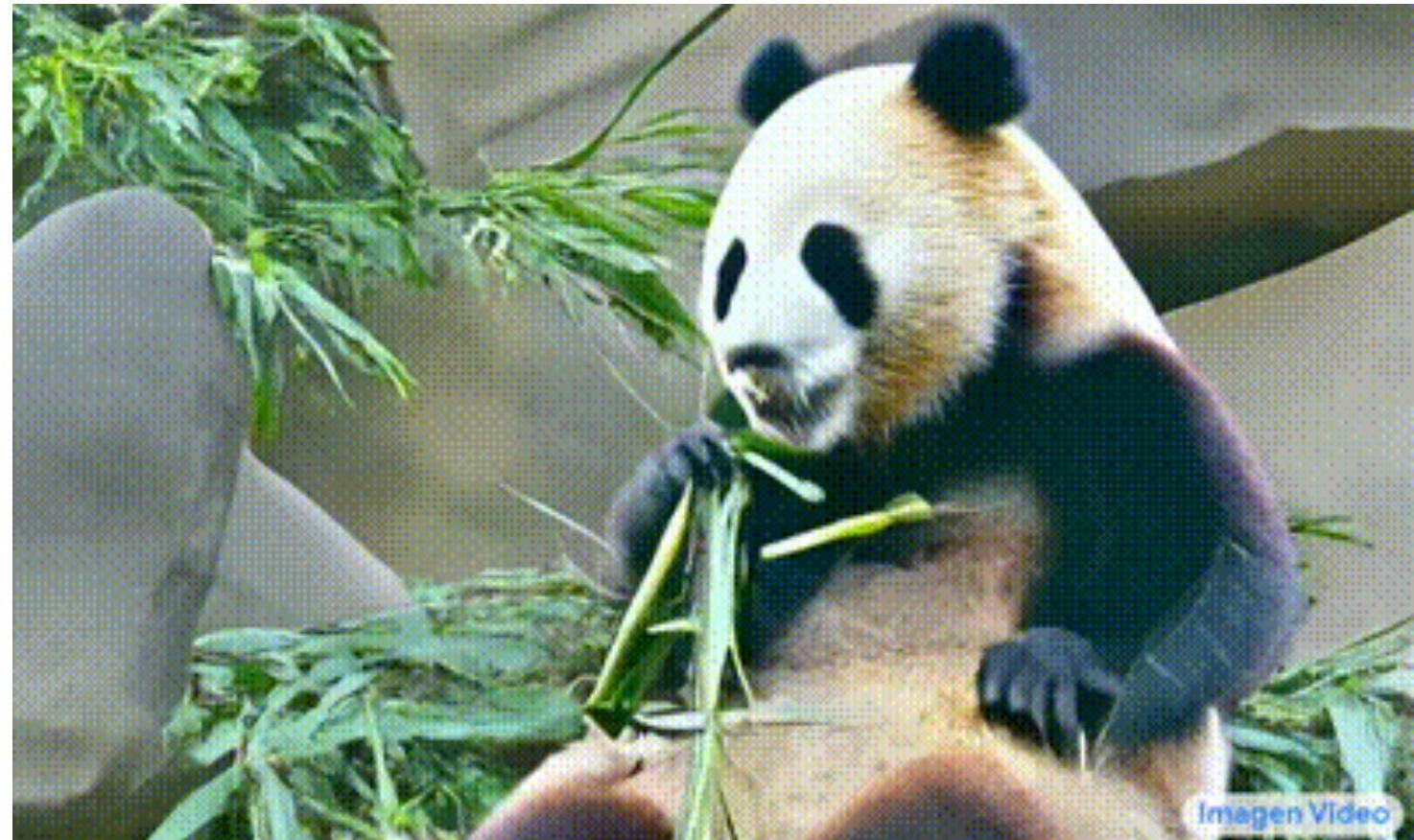




Generative AI

Example: text to video

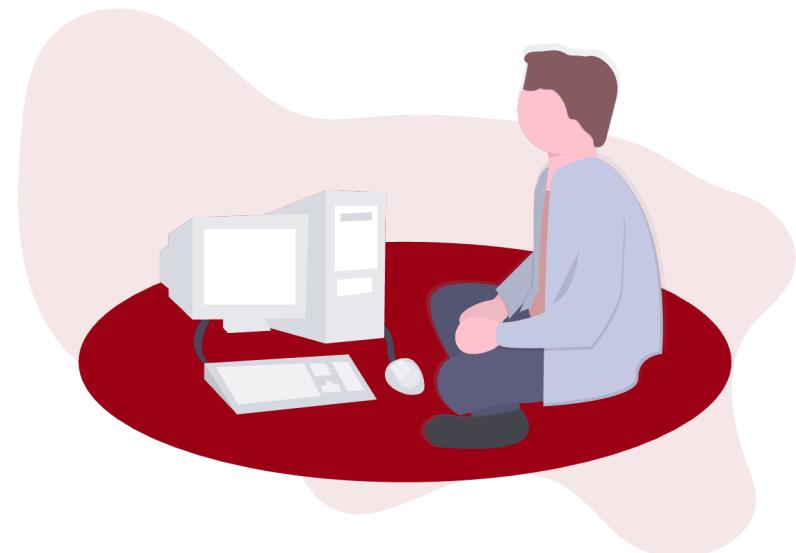
‘A panda eating
bamboo under a rock’



[2025 Question]

‘Is Machine Learning a new
thing? It started with
ChatGPT?’

Well, actually...





Yoshua Bengio



Geoffrey Hinton



Yann LeCun

2018 Turing Awards Recipients
(and on Nobel prize recipient!)



Yoshua Bengio



Geoffrey Hinton



Yann LeCun

2018 Turing Awards Recipients (and on Nobel prize recipient!)

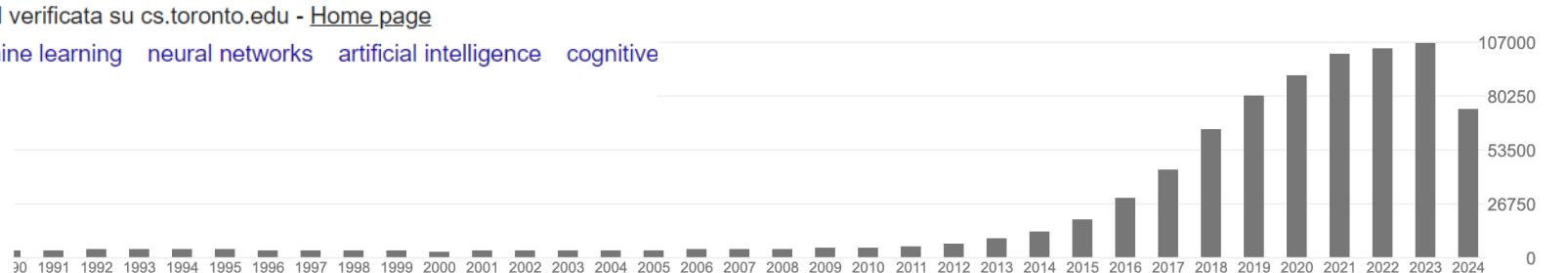


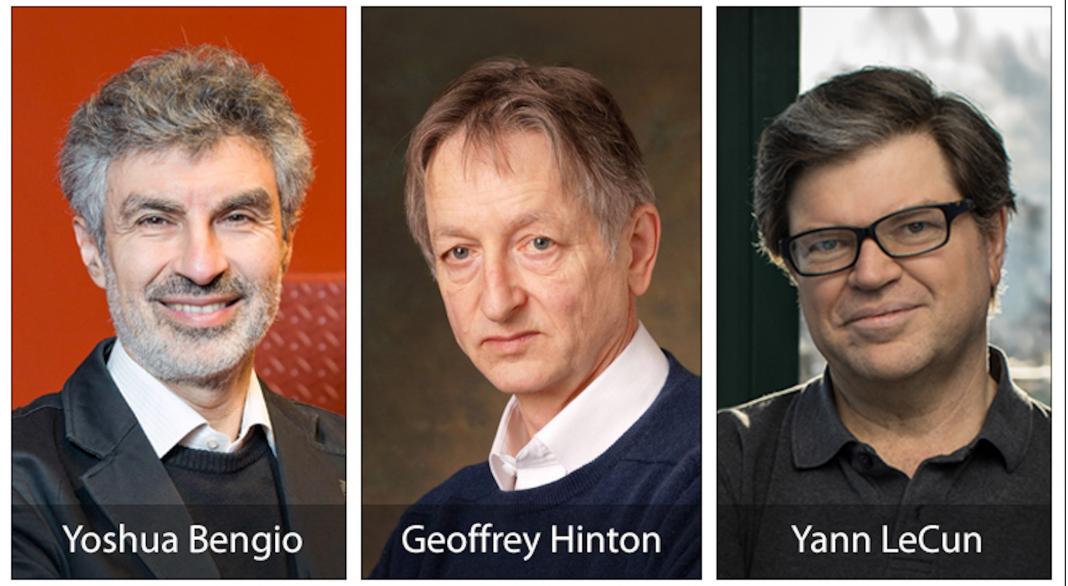
Geoffrey Hinton

Emeritus Prof. Comp Sci, U.Toronto & Engineering Fellow, Google
Email verificata su cs.toronto.edu - [Home page](#)

[machine learning](#) [neural networks](#) [artificial intelligence](#) [cognitive](#)

Citazioni per anno





Why now?

2018 Turing Awards Recipients (and on Nobel prize recipient!)

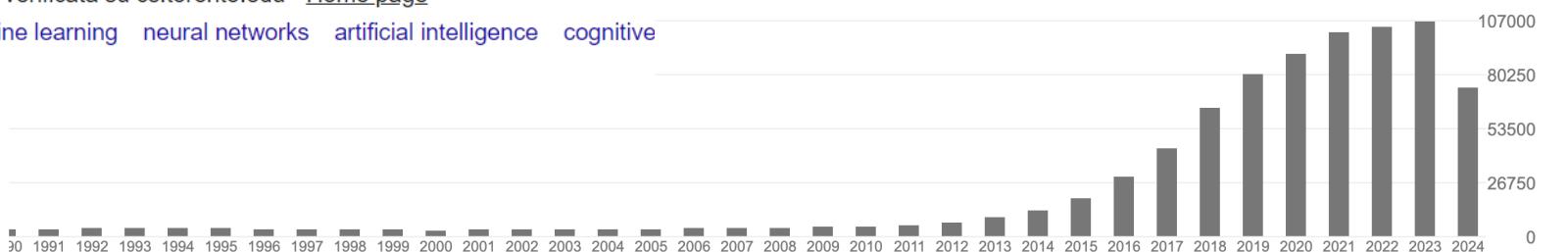


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[machine learning](#) [neural networks](#) [artificial intelligence](#) [cognitive](#)

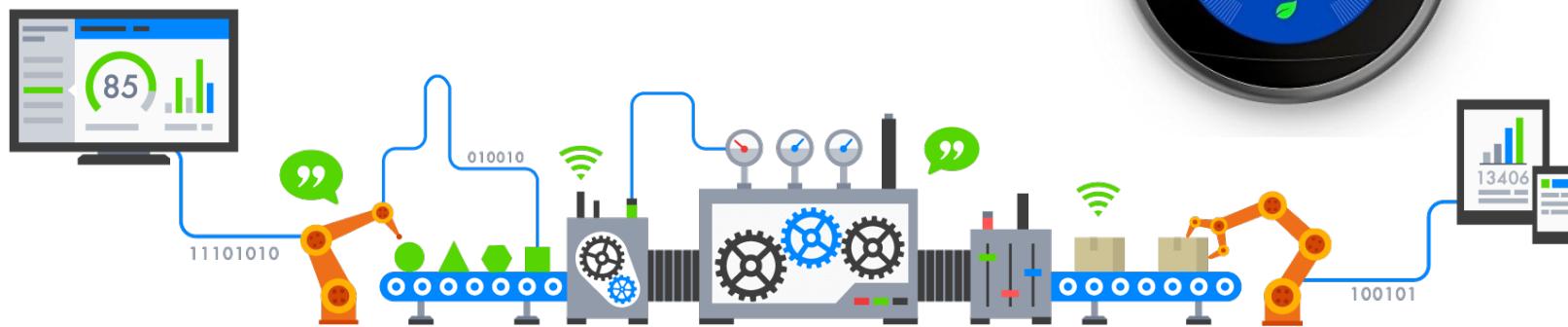
Citazioni per anno



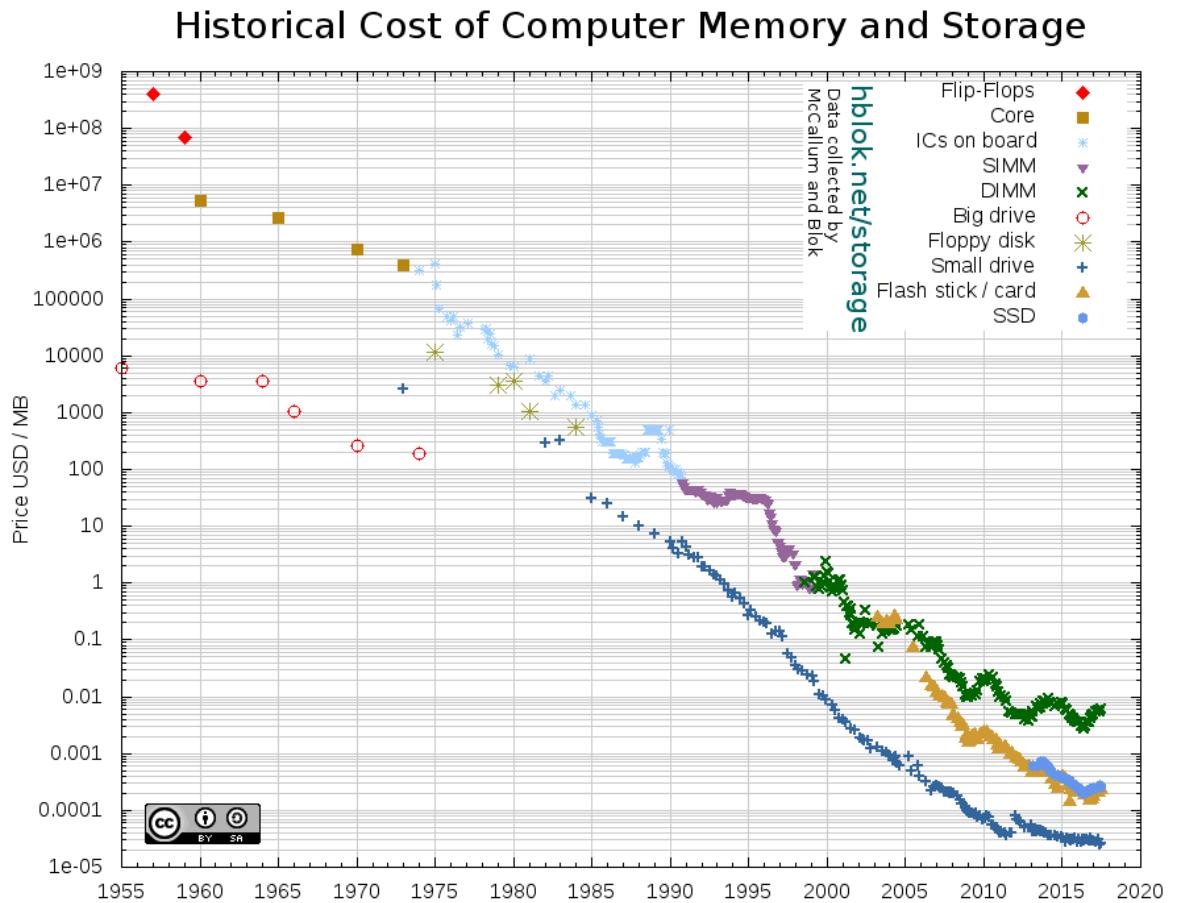
1. Data



IMAGENET



2. Hardware





NVIDIA Corporation (NVDA) ☆

NasdaqGS - NasdaqGS Real Time Price. Currency in USD

455.72 **-6.69** **(-1.45%)**

455.30 **-0.42** **(-0.09%)**

At close: September 8 04:00PM EDT

After hours: 07:59PM EDT

Indicators Comparison Events Date Range 1D 5D 1M 3M 6M YTD 1Y 2Y 5Y Max Interval 1W Line Draw Settings Share Reset

NVDA 190.31

yahoo!finance

Recently Viewed

Symbol Last Price

NVDA **455.72**

-6.69 **(-1.45%)**

Cryptocurrencies

Symbol Last Price

BTC-USD **25,869.82**

+62.18 **(+0.24%)**

ETH-USD **1,634.09**

+6.51 **(+0.40%)**

USDT-U... **1.00**

-0.00 **(-0.00%)**

BNB-USD **214.89**

+0.85 **(+0.40%)**

XRP-USD **0.5040**

+0.0021 **(+0.417%)**

Trending Tickers

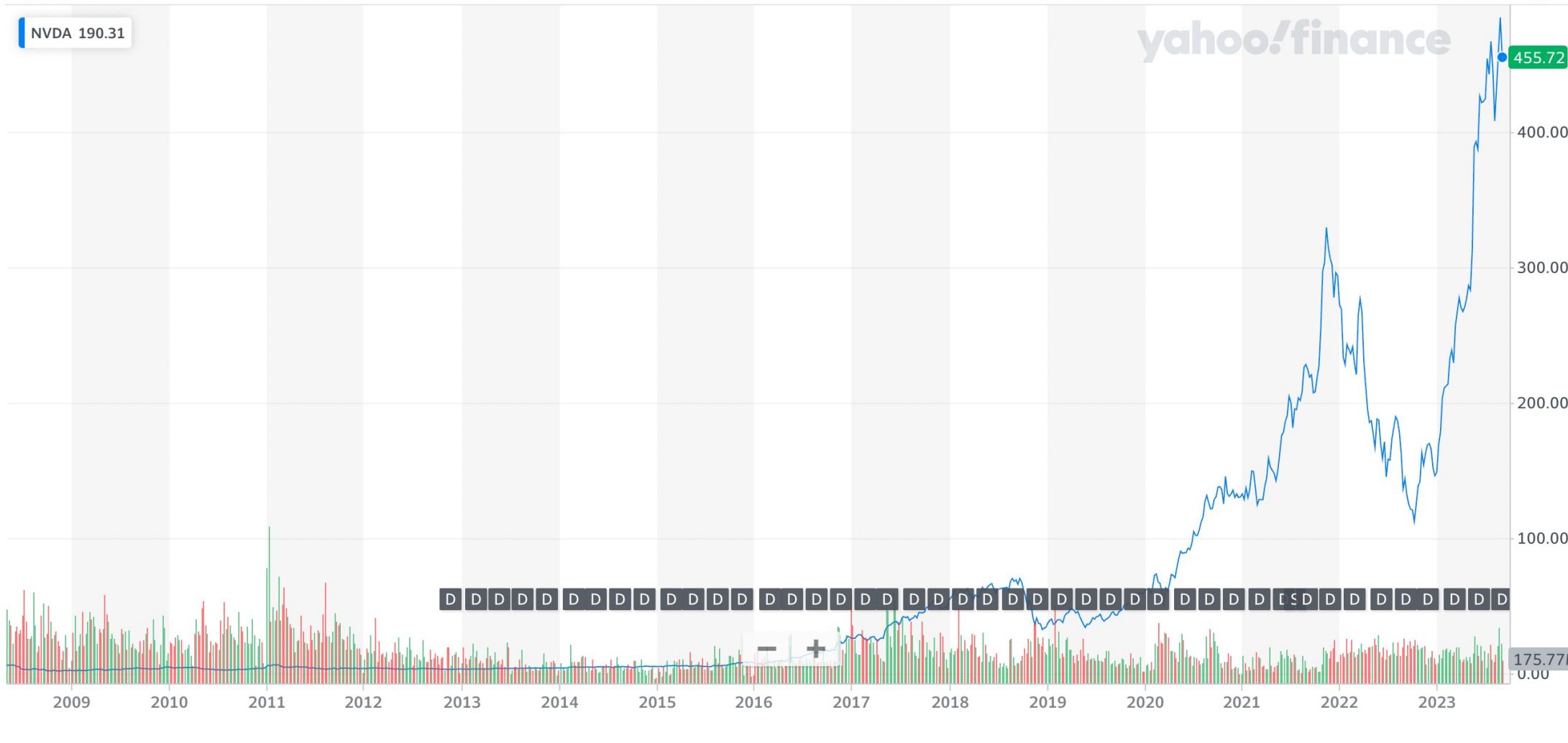
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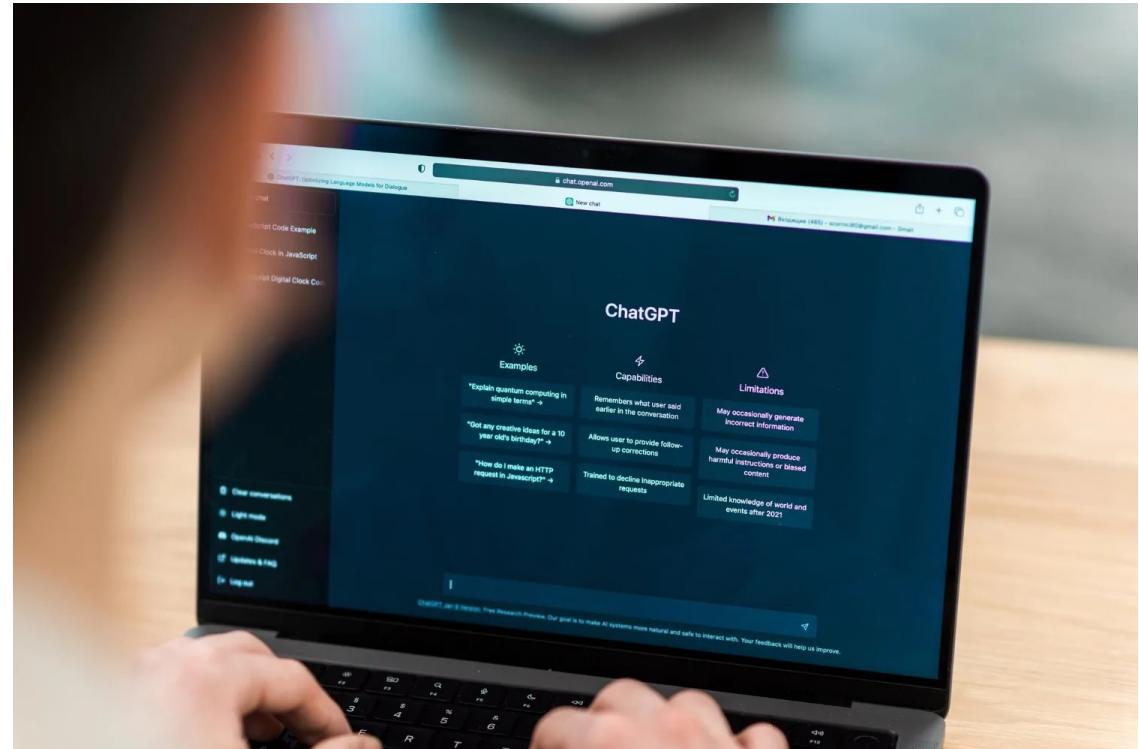
3. Software and Community



paperswithcode.com



The Rise of Deep Learning



Is everything
'solved' then? Is
AI just a 'simple'
and positive
thing?



Attitudes towards AI/Machine Learning



From the web

The overly skeptical

‘It is just a thing for Amazon, Apple, Google and Facebook... I pass’ – ‘AI will have a negative impact on humanity’

Attitudes towards AI/Machine Learning



From the web

The overly skeptical

‘It is just a thing for Amazon, Apple, Google and Facebook... I pass’ – ‘AI will have a negative impact on humanity’



From the web

The overly excited

‘This is the best thing ever! I’m going to plug AI in my system/product and it is done’ – ‘AI will save humanity’

Attitudes towards AI/Machine Learning



From the web

The overly skeptical

‘It is just a thing for Amazon, Apple, Google and Facebook... I pass’ – ‘AI will have a negative impact on humanity’



Both views are wrong!
There are many aspects to
be considered when
developing and ‘judging’ AI

‘This is the best thing ever! I’m going to plug AI in my system/product and it is done’ – ‘AI will save humanity’

#1 Without data, no ML

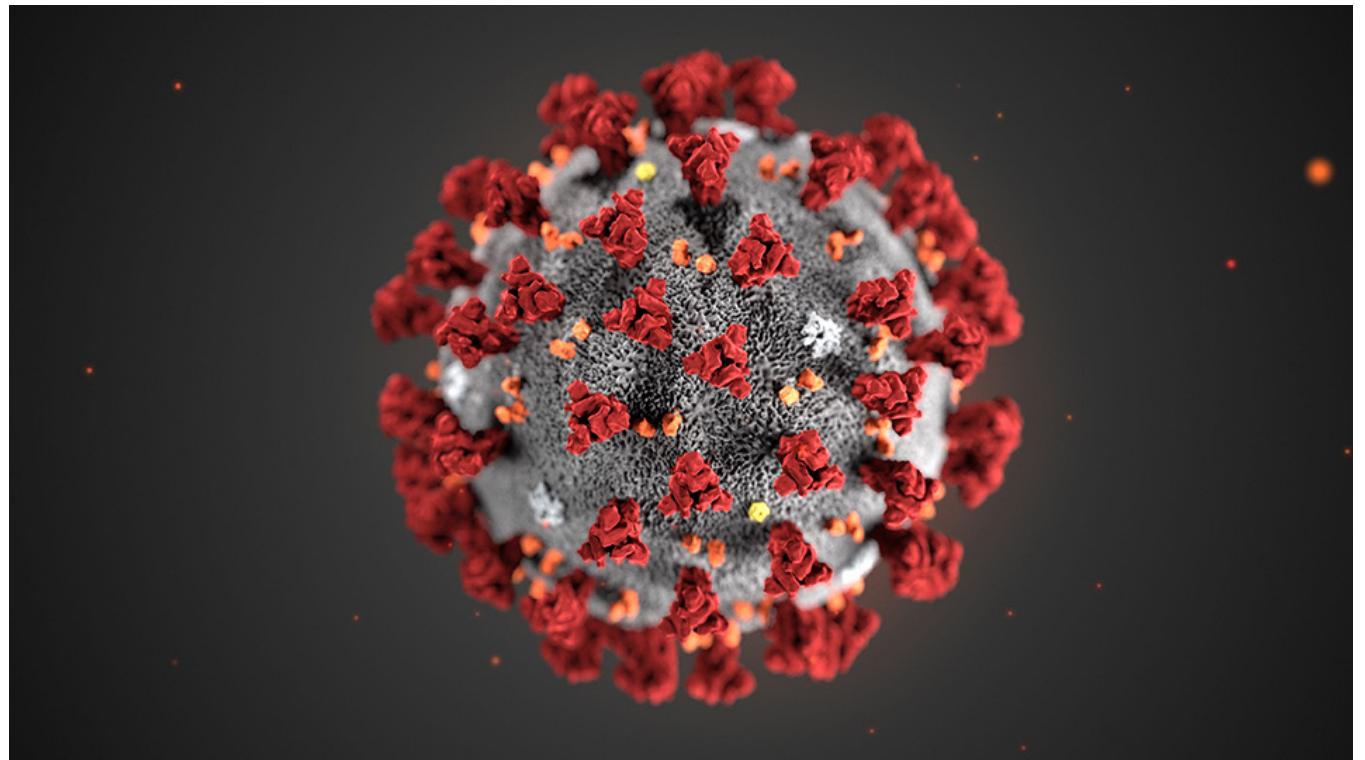
Machine Learning is not black magic, but it is a science based on the availability of data

Without data (or a data strategy) there is no way to implement a Machine Learning solution!



From the web

#2 Some phenomena are ‘unpredictable’



#2 Some phenomena are ‘unpredictable’

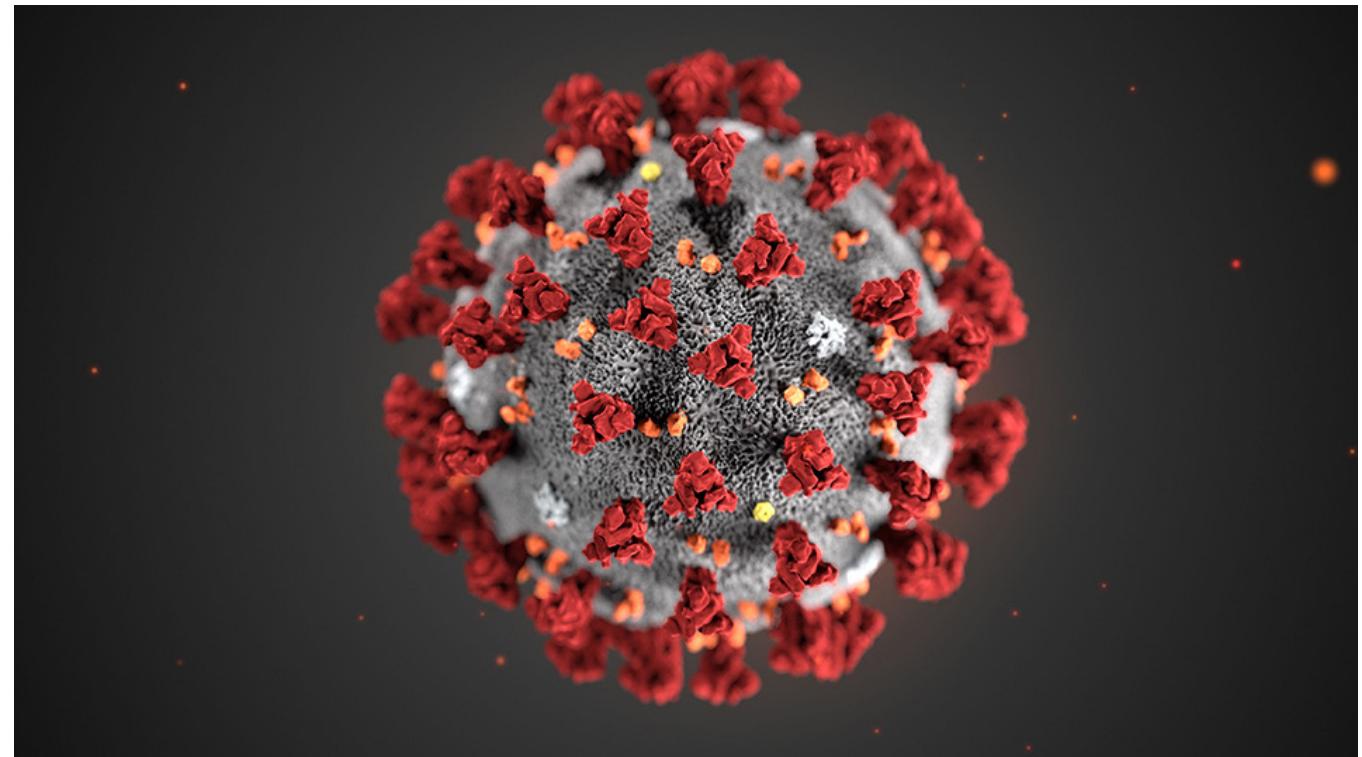
≡ **WIRED**

GREGORY BARBER

BUSINESS 05.19.2020 06:00 AM

Why Didn't Artificial Intelligence Save Us From Covid-19?

Wikipedia



#2 Some phenomena are ‘unpredictable’

≡ WIRE

GREGORY BARBER

BUSINESS 05.19.2020 06:00 AM

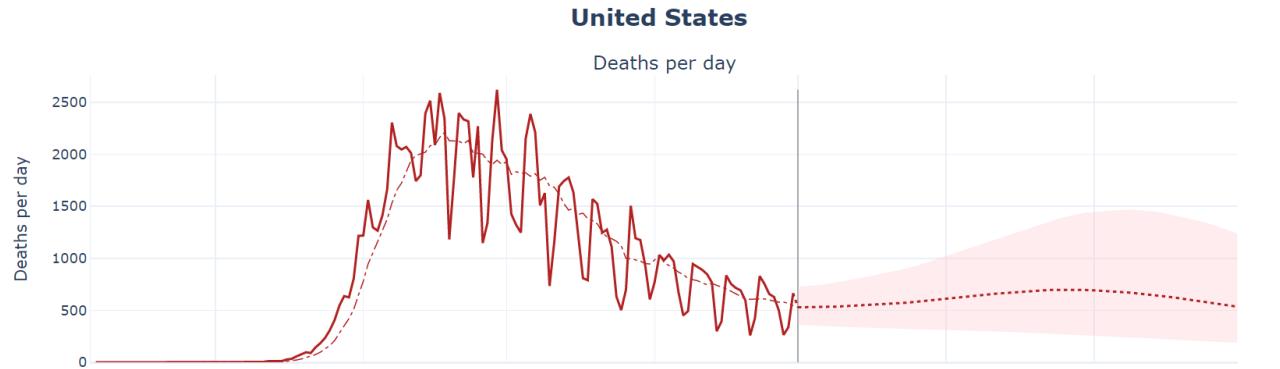
Why Didn't Artificial Intelligence Save Us From Covid-19?

Wikipedia

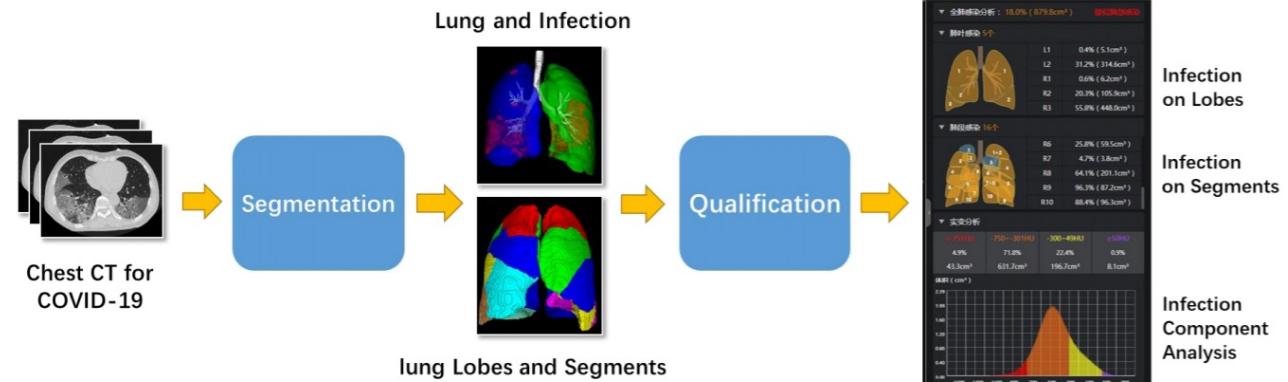
Machine learning using intrinsic genomic signatures for rapid classification of novel pathogens: COVID-19 case study

Gurjit S. Randhawa, Maximilian P. M. Soltysiak, Hadi El Roz, Camila P. E. de Souza, Kathleen A. Hill, Lila Kari

Published: April 24, 2020 • <https://doi.org/10.1371/journal.pone.0232391>



<https://covid19-projections.com/>

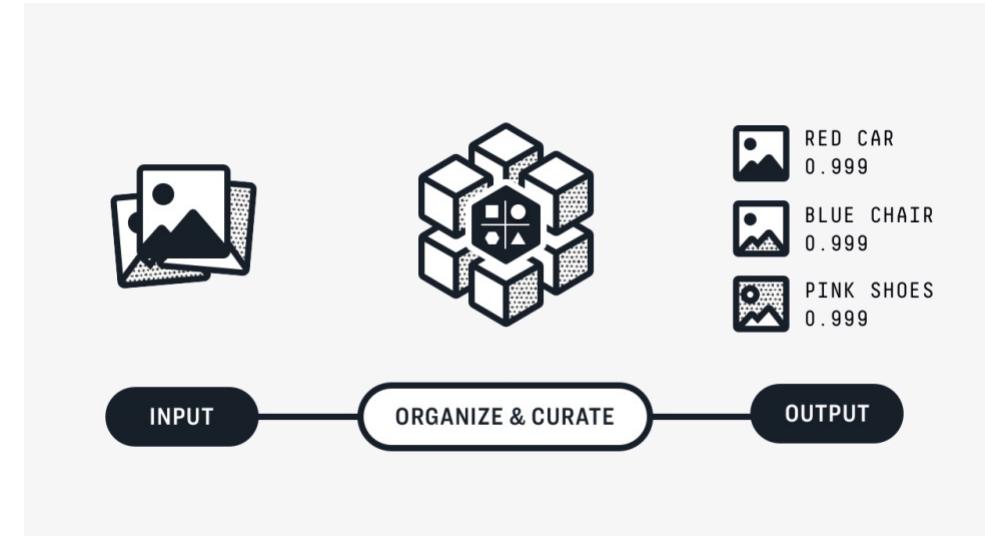


<https://arxiv.org/abs/2003.04655>

#3 Are Machine Learning systems able to generalize? Or they can just understand/predict what they have seen in the past?



The following example was inspired by Prof. Pietro Perona of CalTech



GENERAL FACE NSFW COLOR

MORE MODELS ▾



General

VIEW DOCS

LANGUAGE

Italian (it)

PREDICTED CONCEPT

PROBABILITY

mucca (bovina) 0.999

agricoltura (azienda commerciale) 0.998

bestiame 0.995

latte 0.994

bovini da carne 0.994

pascolo 0.994

bos taurus 0.994

fattoria 0.993

campo di fieno 0.993

erba (botanica) 0.991

campo 0.990

area rurale 0.990

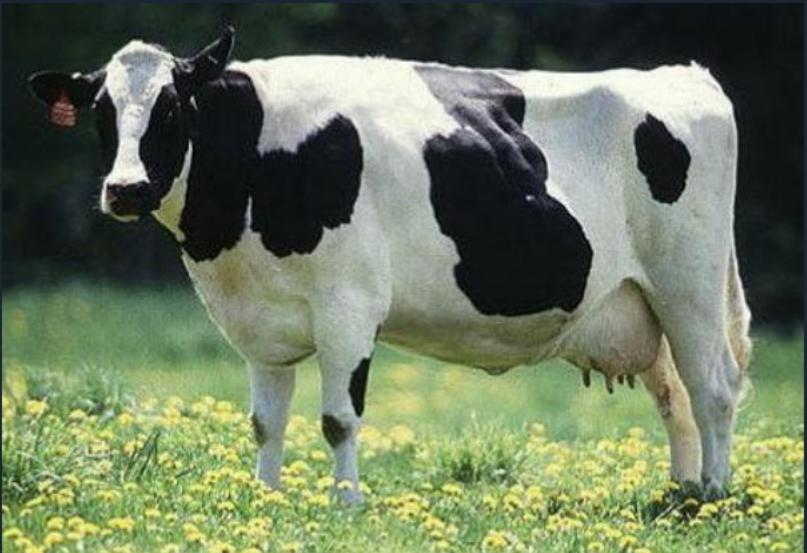


TRY YOUR OWN IMAGE OR VIDEO



GENERAL FACE NSFW COLOR

MORE MODELS ▾



General

VIEW DOCS

LANGUAGE

Italian (it)

PREDICTED CONCEPT

PROBABILITY

mucca (bovina) 1.000**latte** 0.999**agricoltura (azienda commerciale)** 0.999**bestiame** 0.998**fattoria** 0.998**bovini da carne** 0.998**caseificio** 0.998**bos taurus** 0.997**campo di fieno** 0.994**pascolo** 0.994**erba (botanica)** 0.994**mammalia** 0.991

TRY YOUR OWN IMAGE OR VIDEO



GENERAL FACE NSFW COLOR

MORE MODELS ▾

VIEW DOCS



General

LANGUAGE

Italian (it)

PREDICTED CONCEPT

nessuna persona

0.992

spiaggia

0.990

Acque

0.985

sabbia

0.981

mare

0.979

viaggiare

0.978

costa

0.971

estate

0.952

cielo

0.945

all'aperto

0.942



TRY YOUR OWN IMAGE OR VIDEO



GENERAL FACE NSFW COLOR

MORE MODELS ▾



General

VIEW DOCS

LANGUAGE

Italian (it)

PREDICTED CONCEPT

mucca (bovina) 0.994

mammalia 0.991

erba (botanica) 0.990

pascolo 0.986

agricoltura (azienda commerciale) 0.983

area rurale 0.981

bestiame 0.979

campo 0.978

campo di fieno 0.978

bos taurus 0.977

terreni agricoli (paese) 0.971

fattoria 0.965



TRY YOUR OWN IMAGE OR VIDEO



#4 In many (most) areas/tasks effective Machine Learning is not plug-and-play



- Machine Learning solutions require a development process.
- Domain expertise is fundamental in many areas/tasks

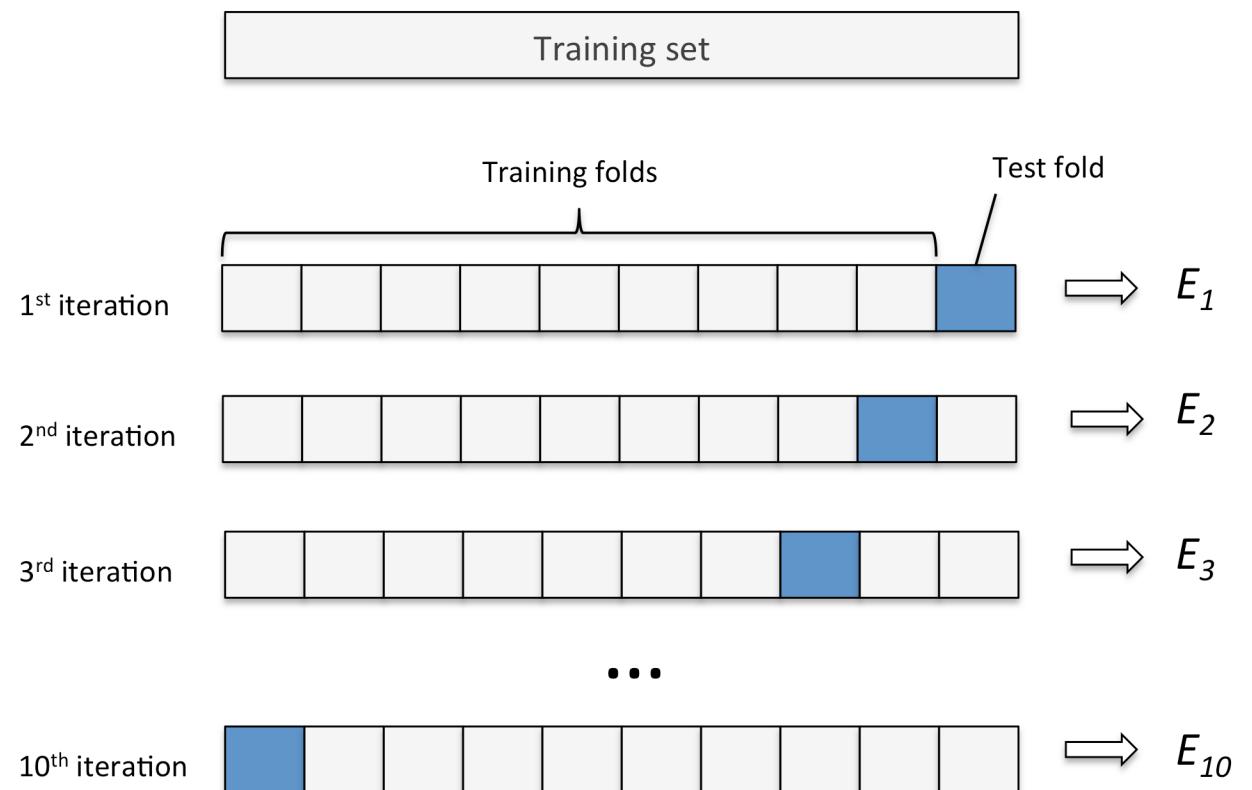
Data-based

Hybrid

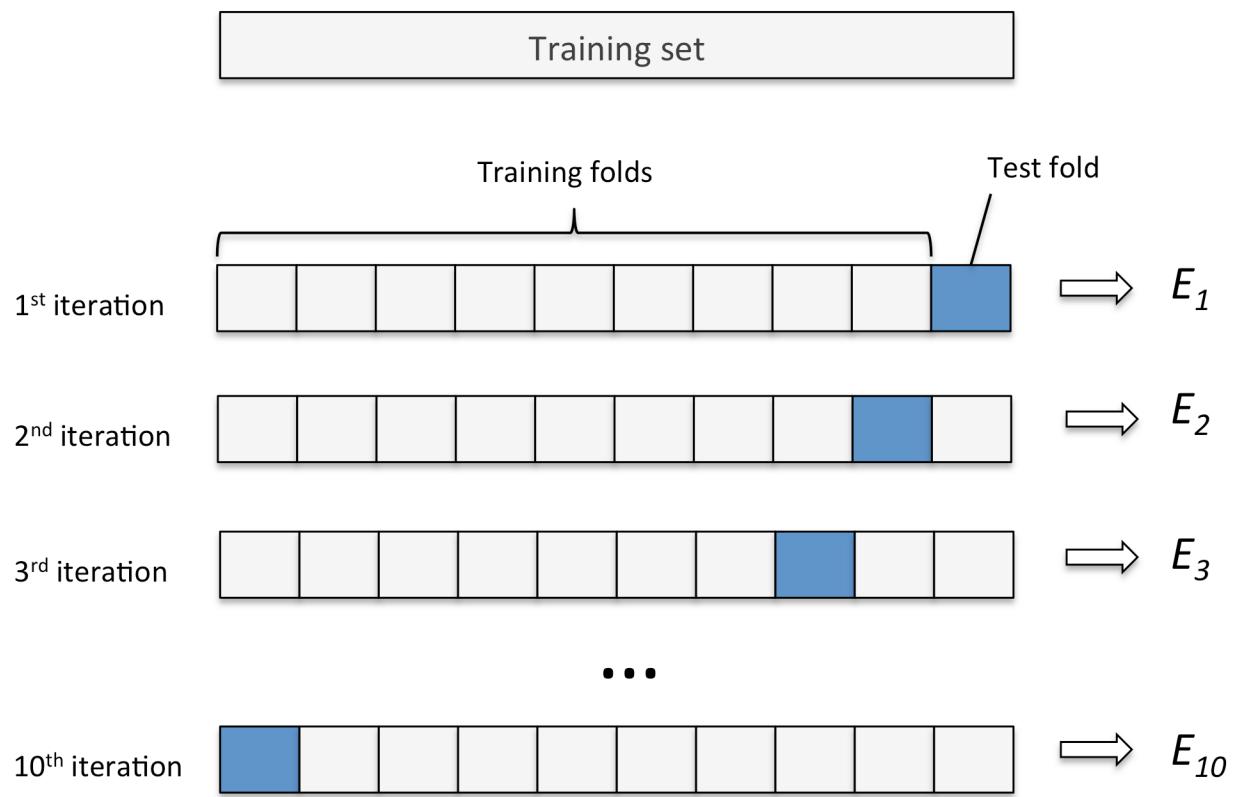
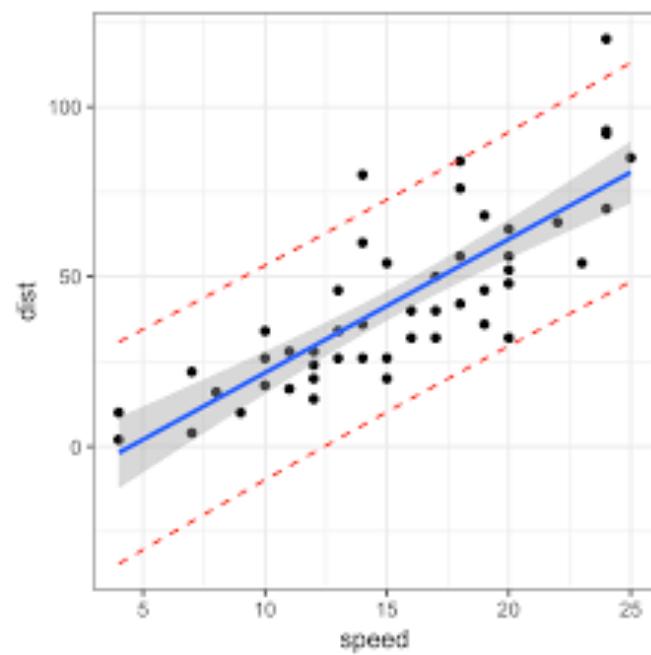
Physics-based

#5 There is no a-priori
knowledge on Machine
Learning performances

#5 There is no a-priori knowledge on Machine Learning performances



#5 There is no a-priori knowledge on Machine Learning performances

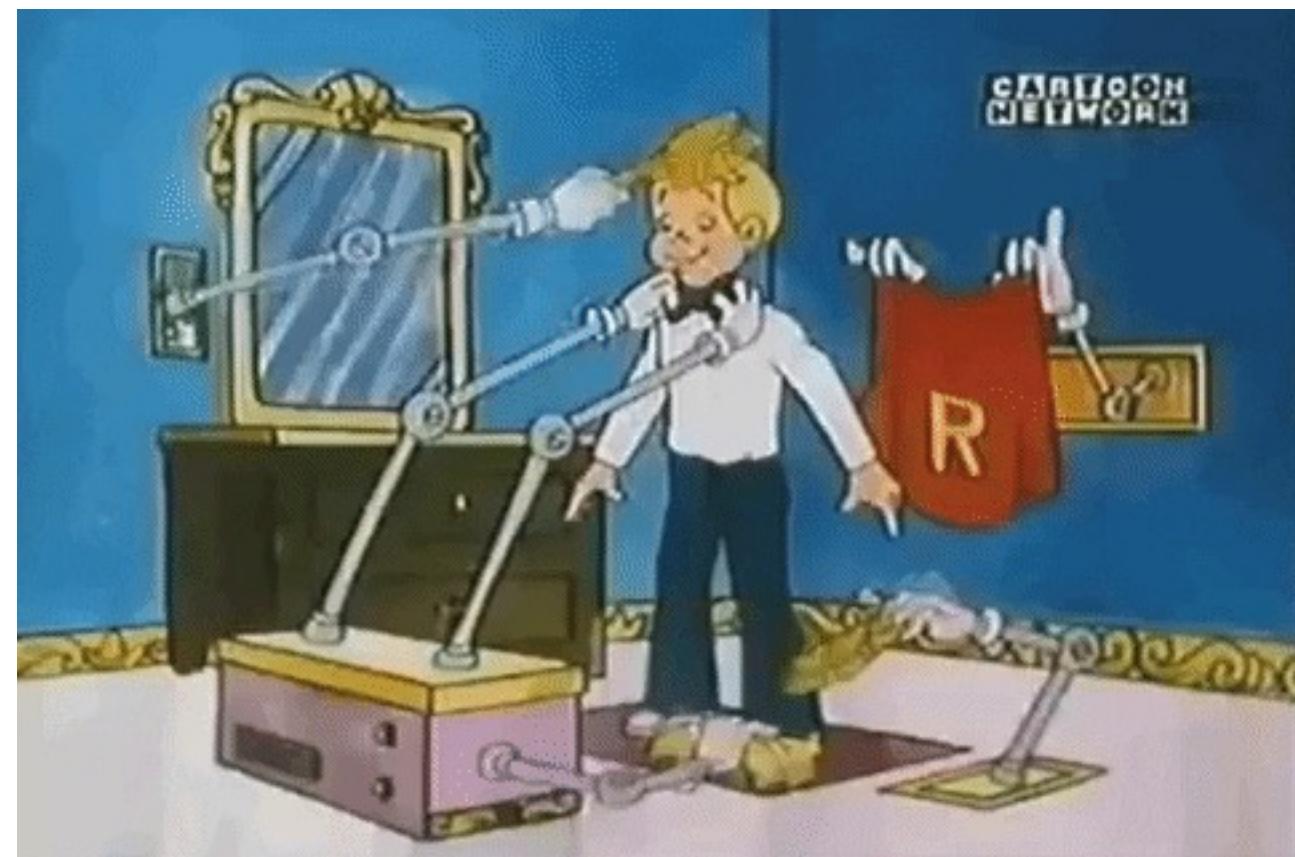
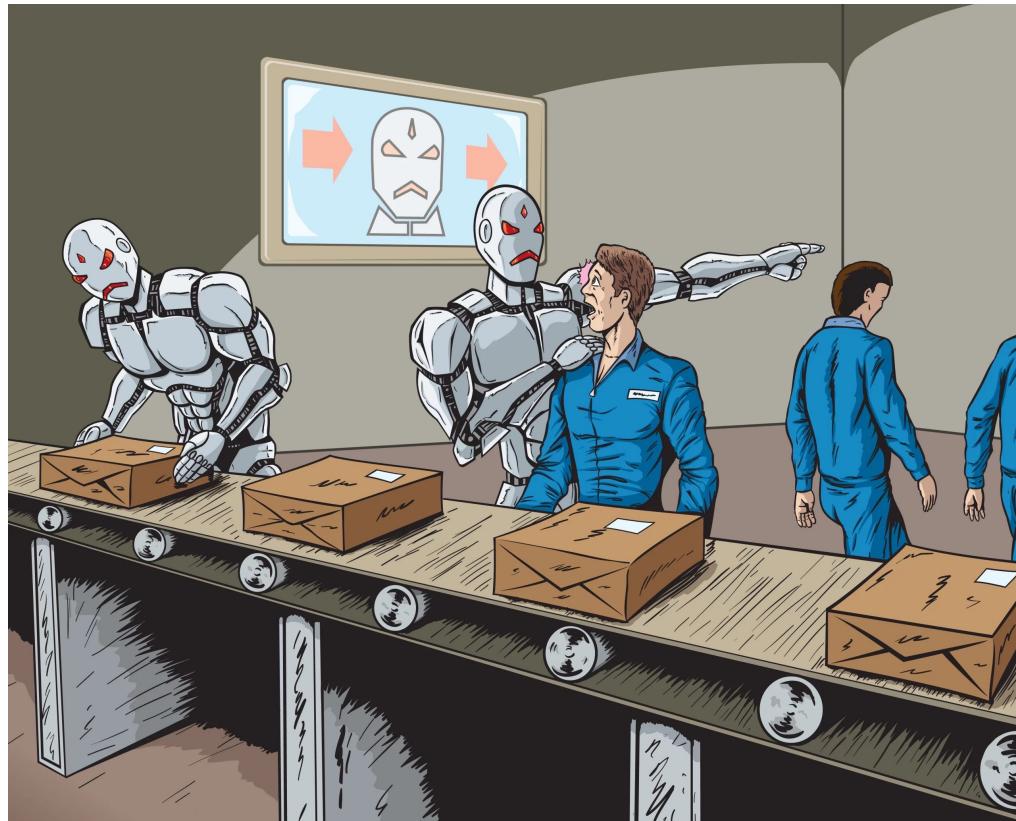


#5 There is no a-priori knowledge on Machine Learning performances...

Especially when dealing with 'private' (ie. company-specific) data!



#6 We will lose all our jobs because of AI



#6 We will lose all our jobs because of AI

ChatGPT Is Passing the Tests Required for Medical Licenses and Business Degrees

GPT-3 would have received a B to B- on an MBA Wharton final exam.



By [Chloe Xiang](#)

24 January 2023, 1:46am [f](#) [t](#) [s](#)



#6 We will lose all our jobs because of AI

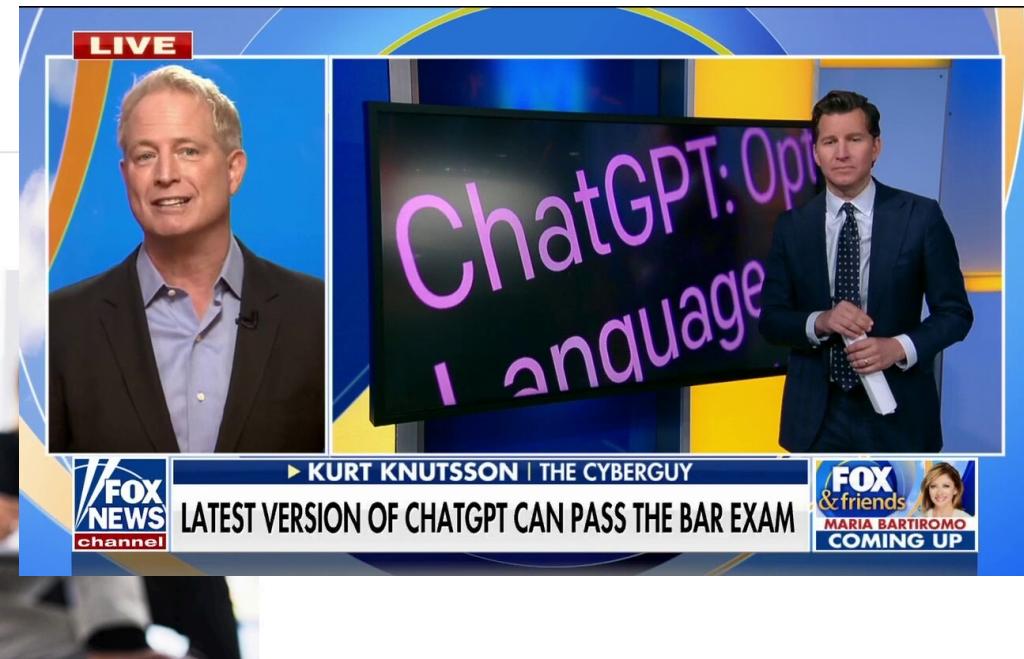
ChatGPT Is Passing the Tests Required for Medical Licenses and Business Degrees

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24 January 2023, 1:46am [f](#) [t](#) [n](#)

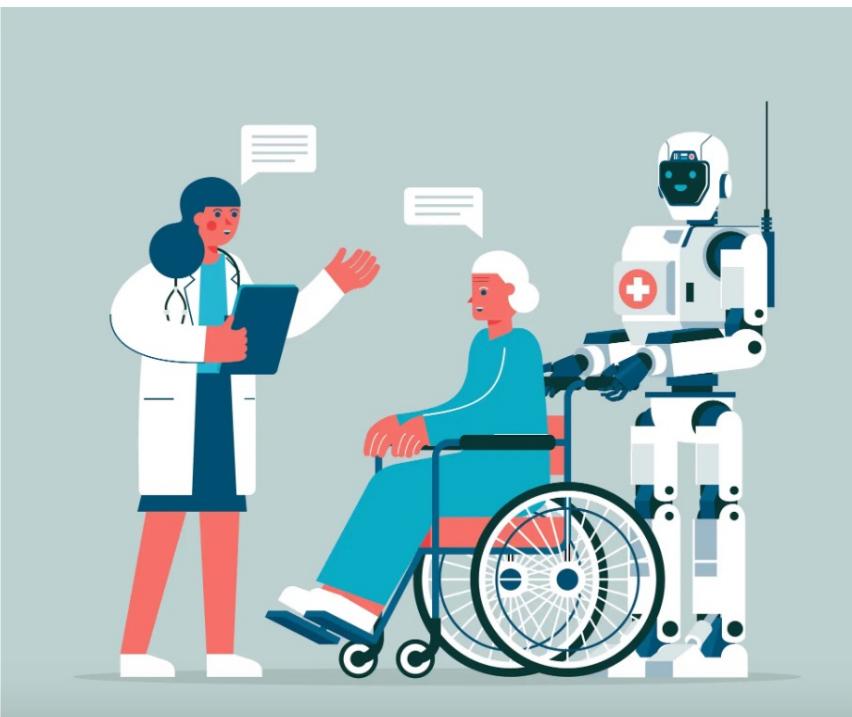


#6 We will lose all our jobs because of AI

HOME > TECH

Medical experts prefer ChatGPT to a real physician 78.6% of the time — because it has more time for questions

Aaron Mok and Hilary Brueck May 2, 2023, 10:00 AM CEST



ChatGPT Is Passing the Tests Required for Medical Licenses and Business Degrees

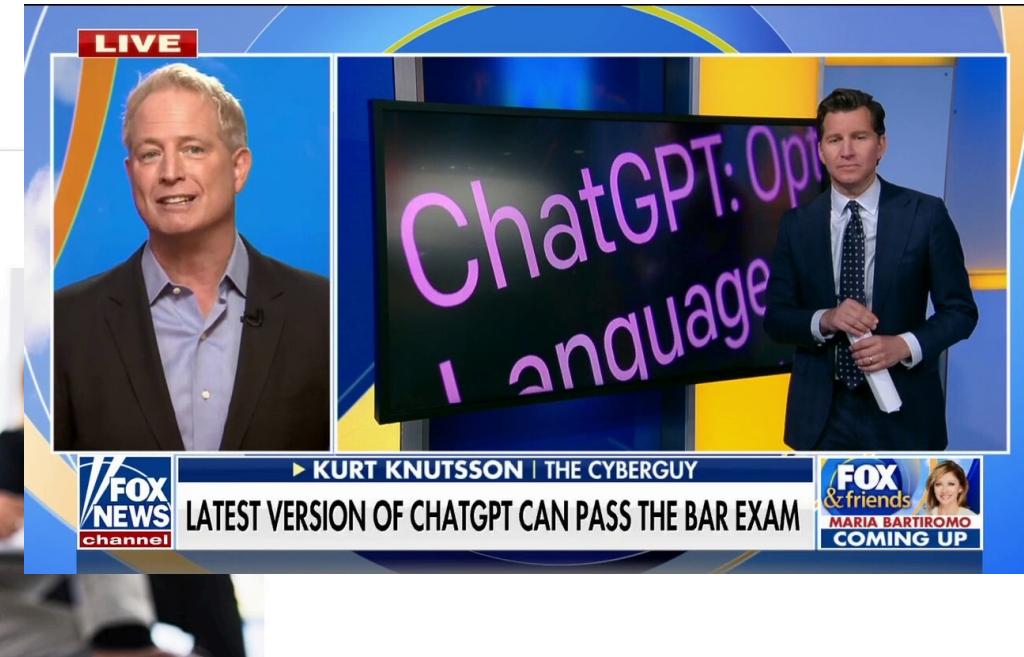
GPT-3 would have received a B to B- on an MBA

Wharton final exam.



By [Chloe Xiang](#)

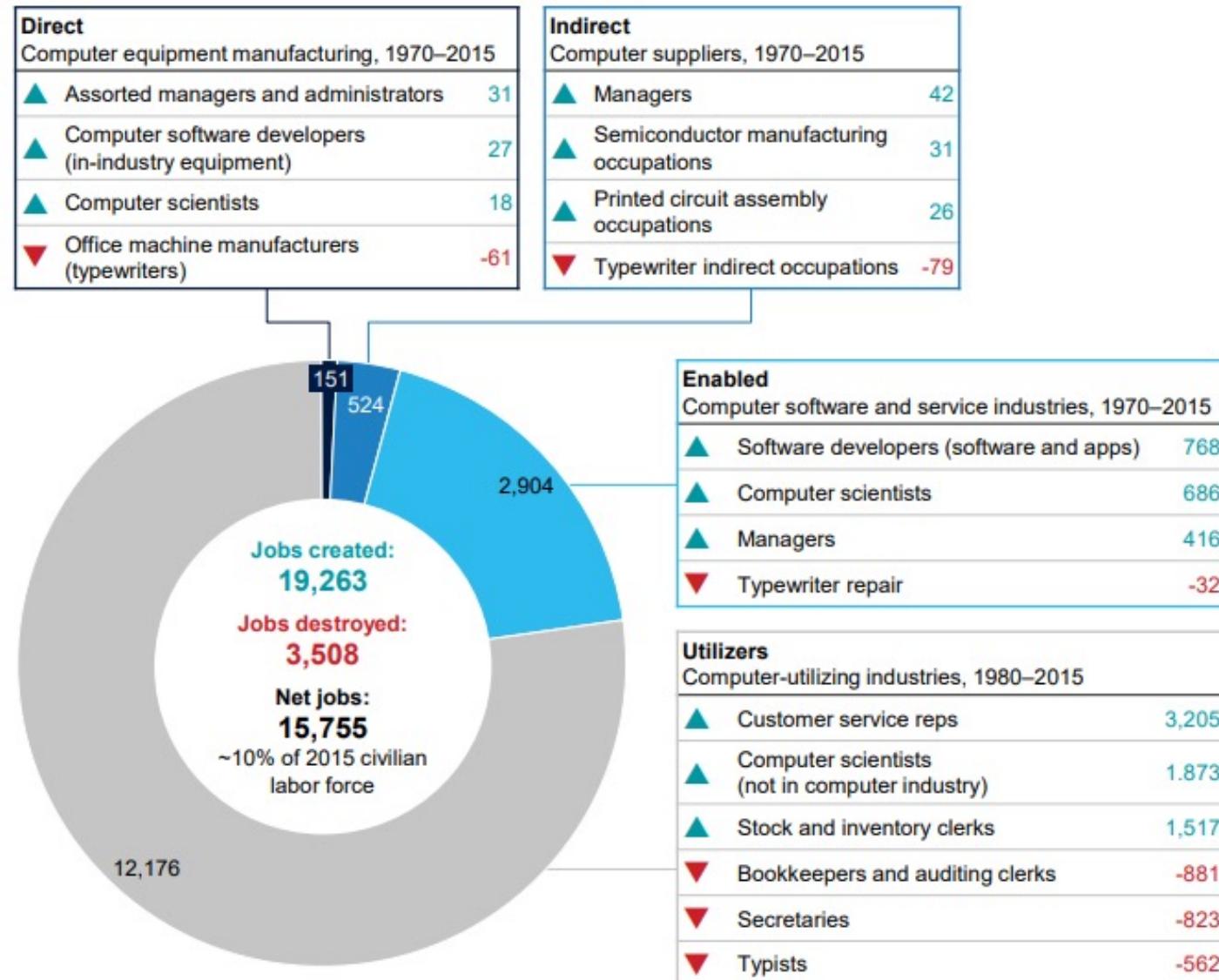
24 January 2023, 1:46am [f](#) [t](#) [s](#)



#6 We will lose all our jobs because of AI

Most likely AI will replace jobs (accordingly also to major analysts, such as PwC or McKinsey)

Example: Personal computers
Total US jobs created and destroyed by personal computers (examples listed are not comprehensive)
Thousands



#7 Deep Fakes



#7 Deep Fakes

Original (Amini)



Synthesized (Obama)



#8 Fairness

Women less likely to be shown ads for high-paid jobs on Google, study shows

theguardian



DYLAN FUGETT

Prior Offense

1 attempted burglary

Subsequent Offenses

3 drug possessions

BERNARD PARKER

Prior Offense

1 resisting arrest
without violence

Subsequent Offenses

None

LOW RISK

3

HIGH RISK

10

**For all these
aspects, a starting
course in Machine
Learning should
make sense...**



Course Outline

Course Outline (tentative)

The goal of the course is to provide an overview of the most common algorithms in ML. The course also aims at providing programming experiences on basic ML tasks.

We will cover:

- Basics of Statistics
- Supervised Learning Approaches (Regression & Classification)
- Unsupervised Learning Approaches (Anomaly Detection & Clustering)
- Elements of Neural Networks
- Elements of eXplainable Artificial Intelligence & Fairness

Supervised Learning



Setup: Observation of the environment

Data: (x, y)

Task: learn a map from inputs x to outputs y

Supervised Learning

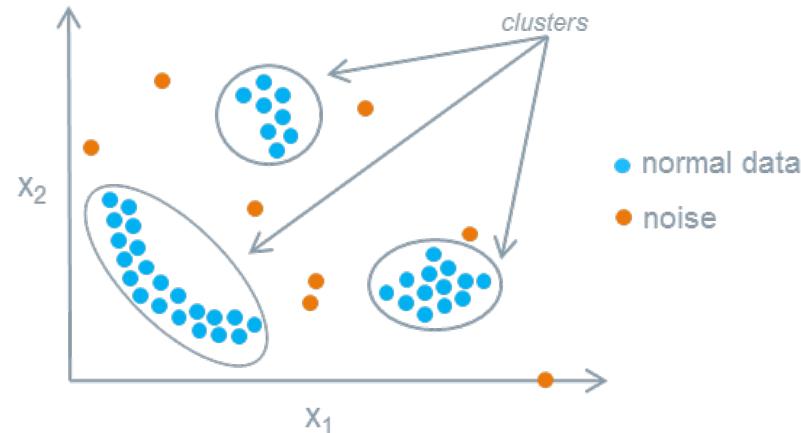


Setup: Observation of the environment

Data: (x, y)

Task: learn a map from inputs x to outputs y

Unsupervised Learning



Setup: Observation of the environment

Data: x (no labels)

Task: learn patterns in input data

Supervised Learning

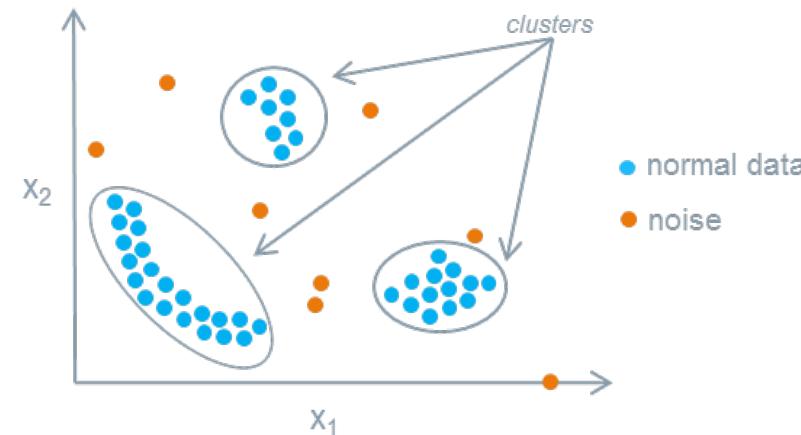


Setup: Observation of the environment

Data: (x, y)

Task: learn a map from inputs x to outputs y

Unsupervised Learning



Setup: Observation of the environment

Data: x (no labels)

Task: learn patterns in input data

Reinforcement Learning

(there is a Master class)



Setup: Observation of the environment

Data: (x, y)

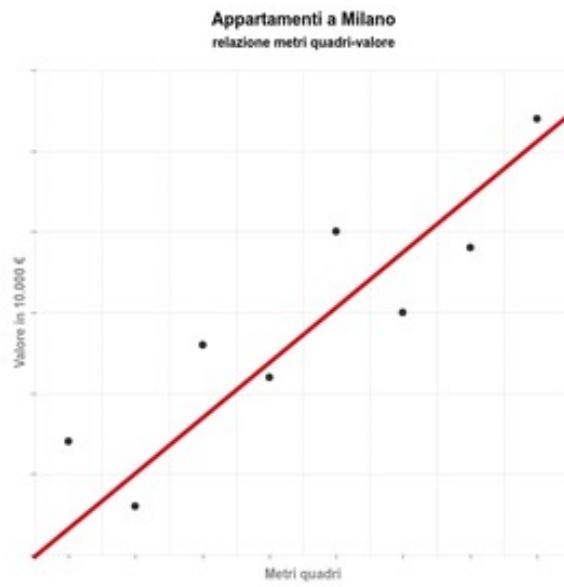
Task: learn a map from inputs x to outputs y

Setup: Interaction with the environment

Data: $(\text{state}, \text{action}, \text{rewards})$

Task: learn policies that maximize rewards

Machine Learning Approaches

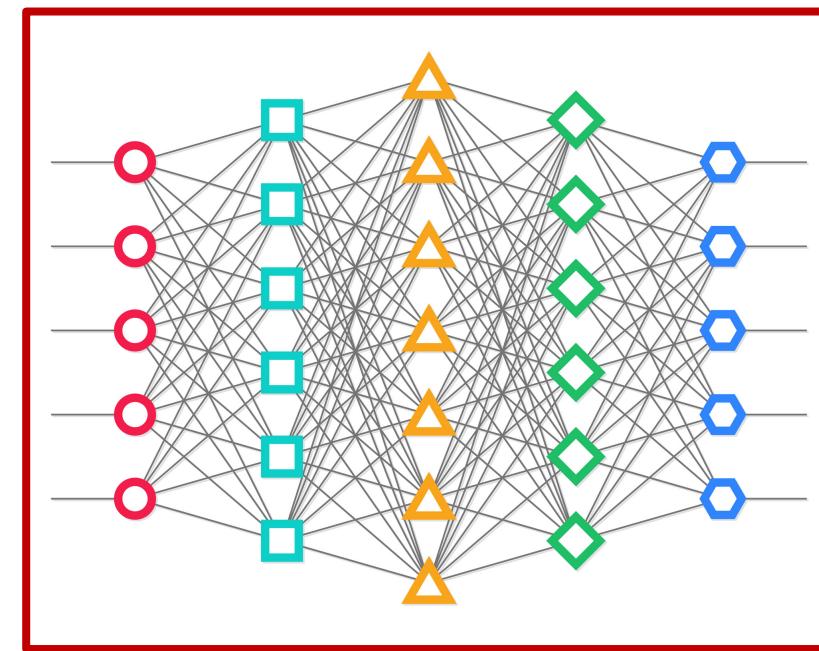
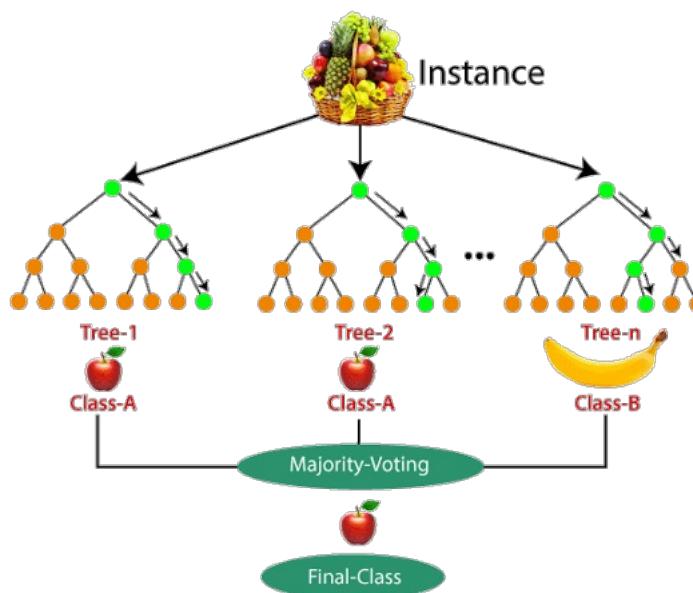
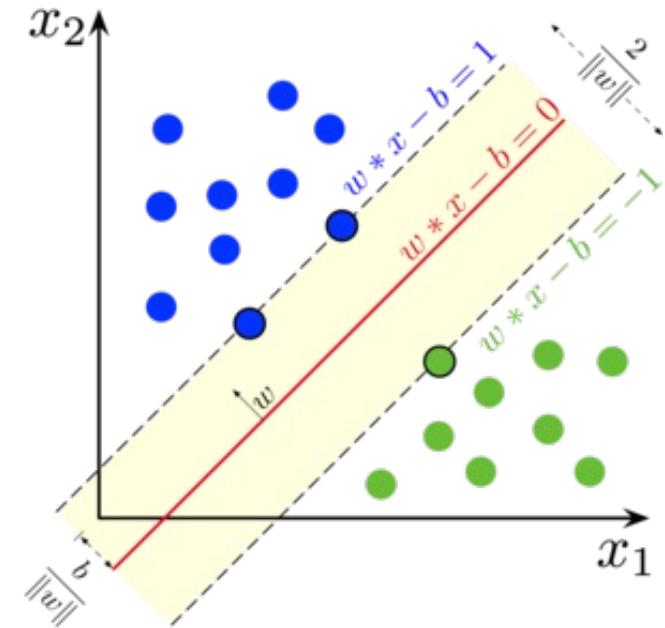


La regressione lineare

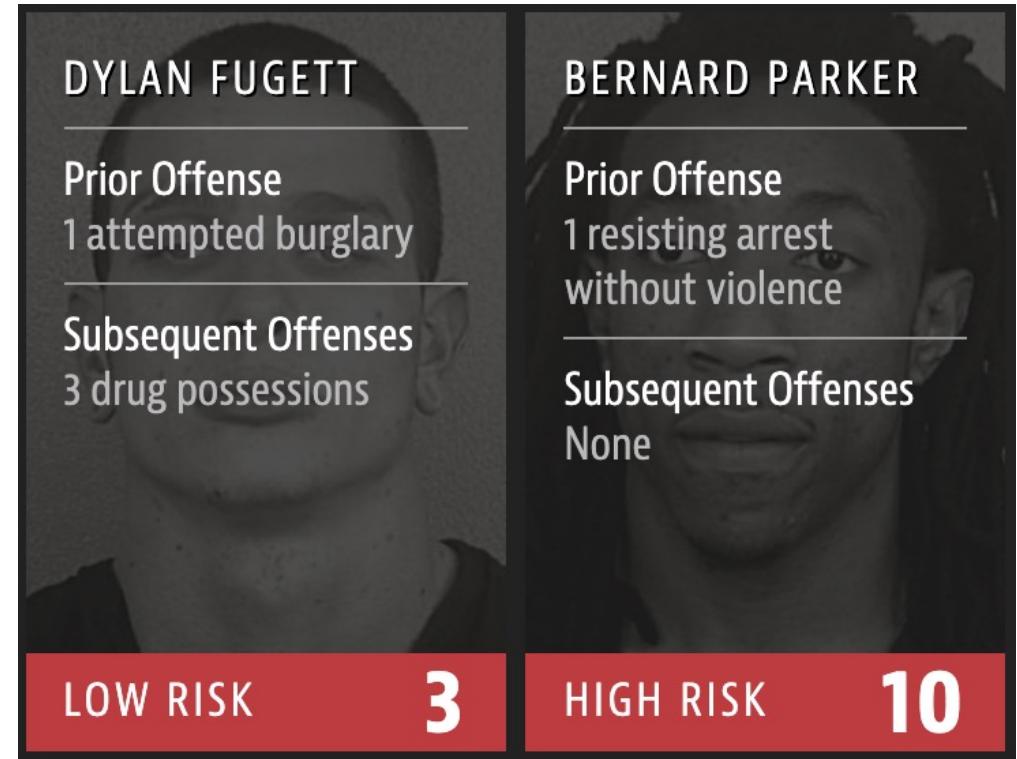
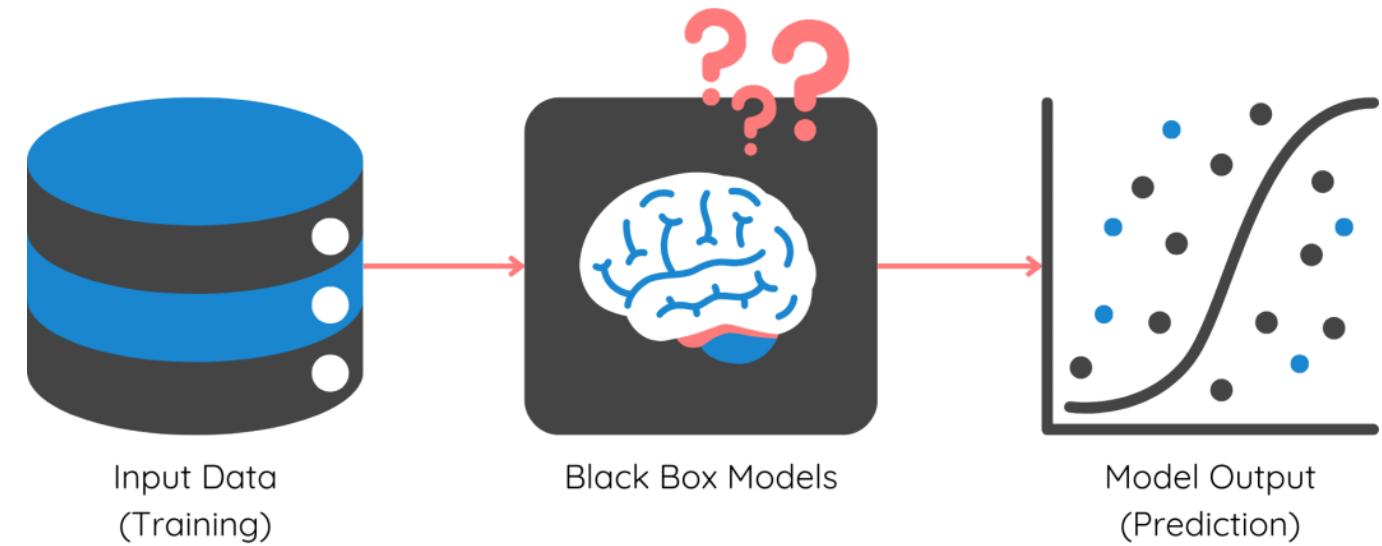
$$y = b + wx$$

BIAS
↓
PREDIZIONE

PROPRIETÀ
↑
PESO



Beyond accuracy





Course Outline and Calendar 1/4

WEEK 01

2025-02-24 Monday - Lecture 01: Course introduction & Motivation & Taxonomy of ML
2025-02-27 Thursday - Lecture 02: Introduction to Statistics for Machine Learning
2025-02-28 Friday - Lecture 03 (Lab 01): Introduction to Python

WEEK 02

2025-03-01 Monday - Lecture 04: Data Visualization, GIT
2025-03-04 Thursday - Lecture 05: Principal Component Analysis
2025-03-05 Friday - Lecture 06 (Lab 02): Elaborate and Visualize data

WEEK 03

2025-03-10 Monday - Lecture 07: Supervised Learning, linear regression, training vs testing
2025-03-13 Thursday - Lecture 08: Overfitting and Ridge Regression, crossvalidation
2025-03-14 Friday - Lecture 09 (Lab 03): Linear Regression and Ridge Regression

WEEK 04

2025-03-17 Monday - Lecture 10: Ridge Regression vs LASSO, gradient descent
2025-03-20 Thursday - Lecture 11: Classification, Logistic Regression
2025-03-21 Friday - Lecture 12 (Lab 04): Regularization & Classification

Course Outline and Calendar 2/4

WEEK 05

2025-03-24 Monday - Lecture 13: Multiclass Classification and Softmax Regression, Introduction to performance metrics: accuracy, precision, recall, F1-score / Handling unbalanced data

2025-03-27 Thursday - Lecture 14: Decision trees, overfitting and pruning

2025-03-28 Friday - Lecture 15 (Lab 05): Decision Trees

WEEK 06

2025-03-31 Monday - Lecture 16: Ensemble Methods: Bagging, Random Forests, bootstrap aggregating

2025-04-03 Thursday - Lecture 17: AdaBoost, XGBoost, Catboost

2025-04-04 Friday - Lecture 18 (Lab 06): Ensemble approaches

WEEK 07

2025-03-17 Monday - Lecture 19: Support Vector Machines (SVM), Linear and kernel-based approaches, Concept of the margin and kernel trick

2025-04-10 Thursday - Lecture 20: Unsupervised Learning: K-Means Clustering. Evaluating clustering performance.

2025-04-11 Friday - Lecture 21 (Lab 07): SVM and Clustering

Course Outline and Calendar 3/4

WEEK 08

2025-04-14 Monday - Lecture 22: Anomaly Detection

2025-04-17 Thursday - Lecture 23: Introduction to Neural Networks, Activation functions (ReLU, sigmoid, softmax), Perceptrons

WEEK 09

2025-04-24 Thursday - Lecture 24: Training of NN #01

WEEK 10

2025-04-28 Monday - Lecture 25: Training of NN #02

WEEK 11

2025-05-05 Monday - Lecture 26: CNN

2025-05-08 Thursday - Lecture 27: Autoencoders

2025-05-09 Friday - Lecture 28 (Lab 08): NN #01

WEEK 12

2025-05-13 Monday - Lecture 29: RNN

2025-05-15 Thursday - No Lecture

2025-05-16 Friday - Lecture 30 (Lab 09): NN #02

Course Outline and Calendar 4/4

WEEK 13

2025-05-19 Monday - No Lecture

2025-05-22 Thursday - No Lecture

2025-05-23 Friday - No Lecture

WEEK 14

2025-05-26 Monday - Lecture 31: XAI #01

2025-05-29 Thursday - Lecture 32: XAI #02

2025-05-30 Friday - Lecture 33 (Lab 10): XAI

WEEK 15

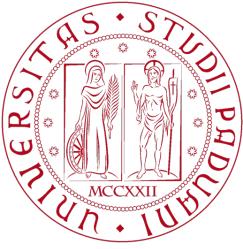
2025-06-05 Thursday - Lecture 34: Fairness in ML

2025-06-06 Friday - Lecture 35: Real-world Applications and MLOps

WEEK 16

2025-06-09 Monday - Lecture 36: What's next

2025-06-12 Thursday - FREE



UNIVERSITÀ
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DI PADOVA

Machine Learning

2024/2025

AMCO
ARTIFICIAL INTELLIGENCE, MACHINE
LEARNING AND CONTROL RESEARCH GROUP

Thank you!

Gian Antonio Susto

