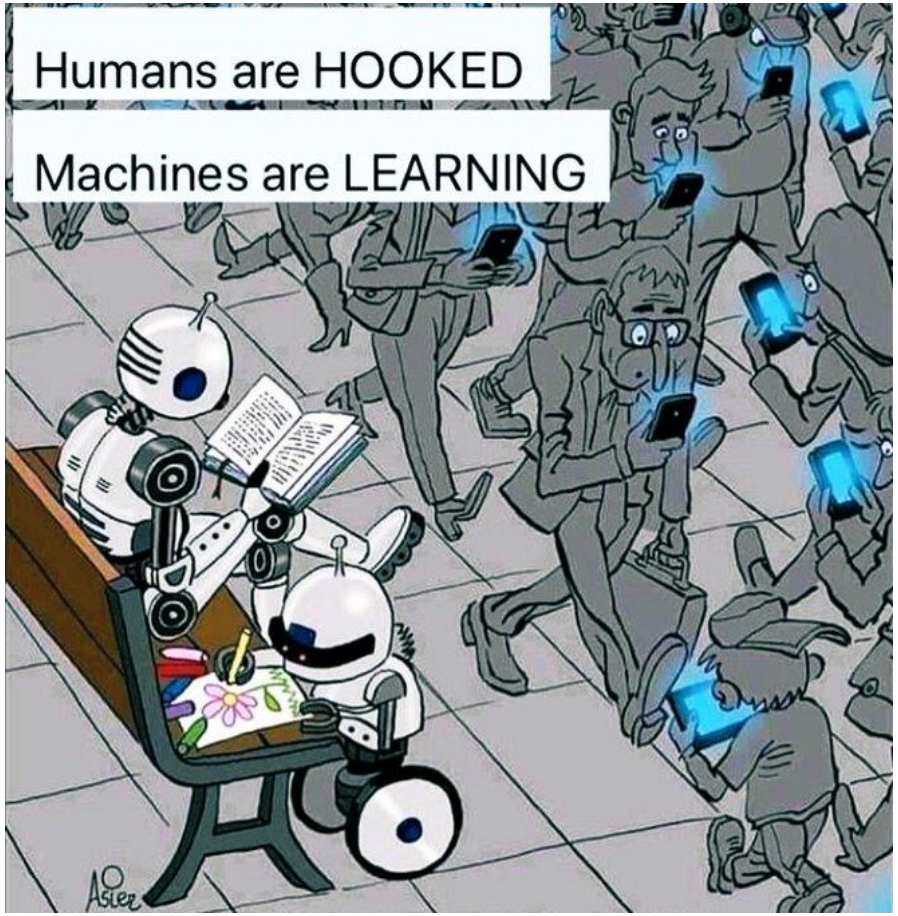
INTRODUCTION TO MACHINE LEARNING

DR. FARHAD RAZAVI

OUTLINE

- Why Machine Learning?
- What is Machine Learning?
- What is Artificial Intelligence and what is its relationship to Machine Learning?
- History of Machine Learning
- Why Python Programming?
- Things that will be covered in this course

WHY STUDYING MACHINE LEARNING?

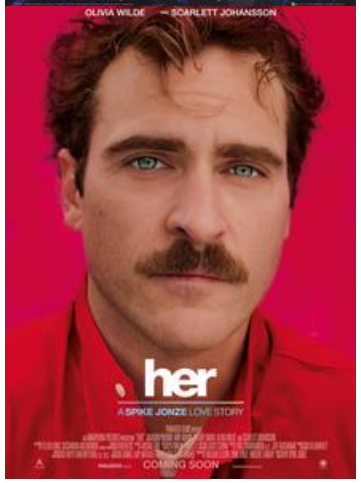


https://twitter.com/cappra/status/1274381140481257472

WHY STUDYING MACHINE LEARNING?

- Studying machine learning brings in better career opportunities.
- Machine Learning Engineers earn a pretty penny.
- Machine Learning Jobs are on the rise (check indeed.com!)
- CIO's Lament Lack of Machine Learning Skills.
- Machine learning is linked directly to Data Science.
- The presence of AI in our present and future makes learning ML a ubiquitous skillset that enables any engineer to excel in the cutting-edge technologies of tomorrow.

HUMAN SENTIMENTS TOWARD AI

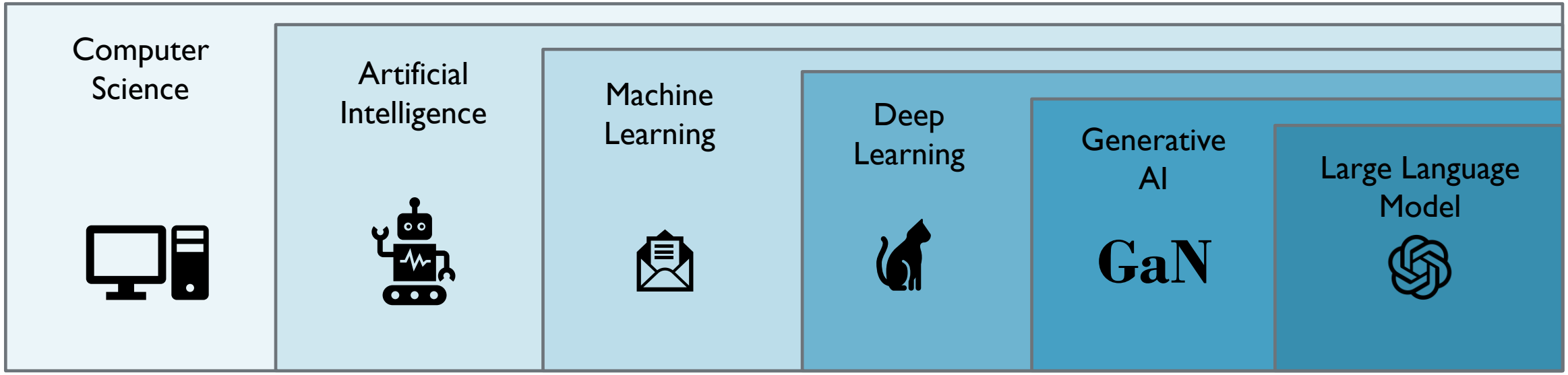


DEFINITION OF MACHINE LEARNING

Early Definition:

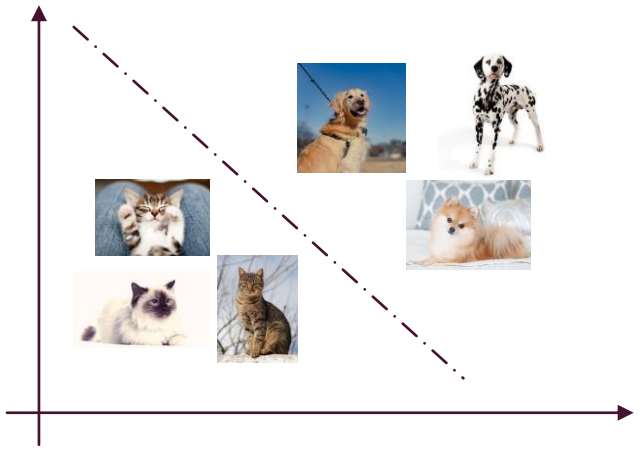
"Field of study that gives computers the ability to learn without being explicitly programmed."

- Arthur Samuel (1959)



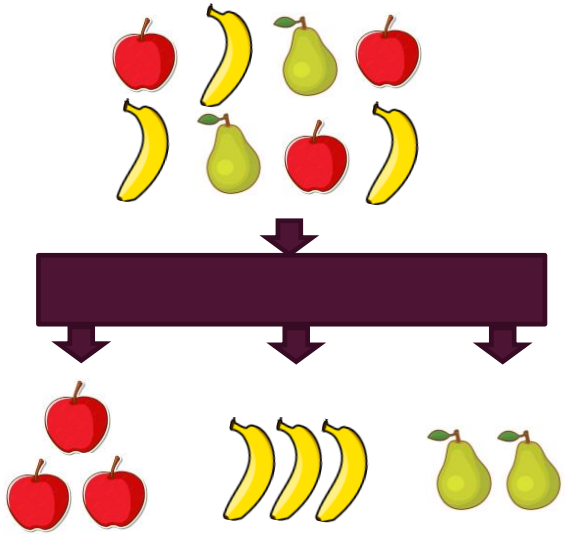
DIFFERENT TYPES OF MACHINE LEARNING

Supervised Learning



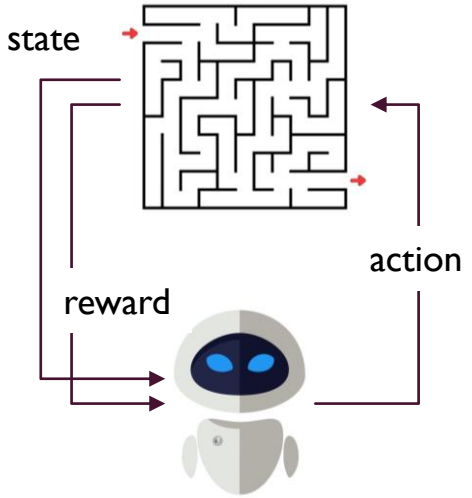
Task driven
(Classification/Regression)

Unsupervised Learning



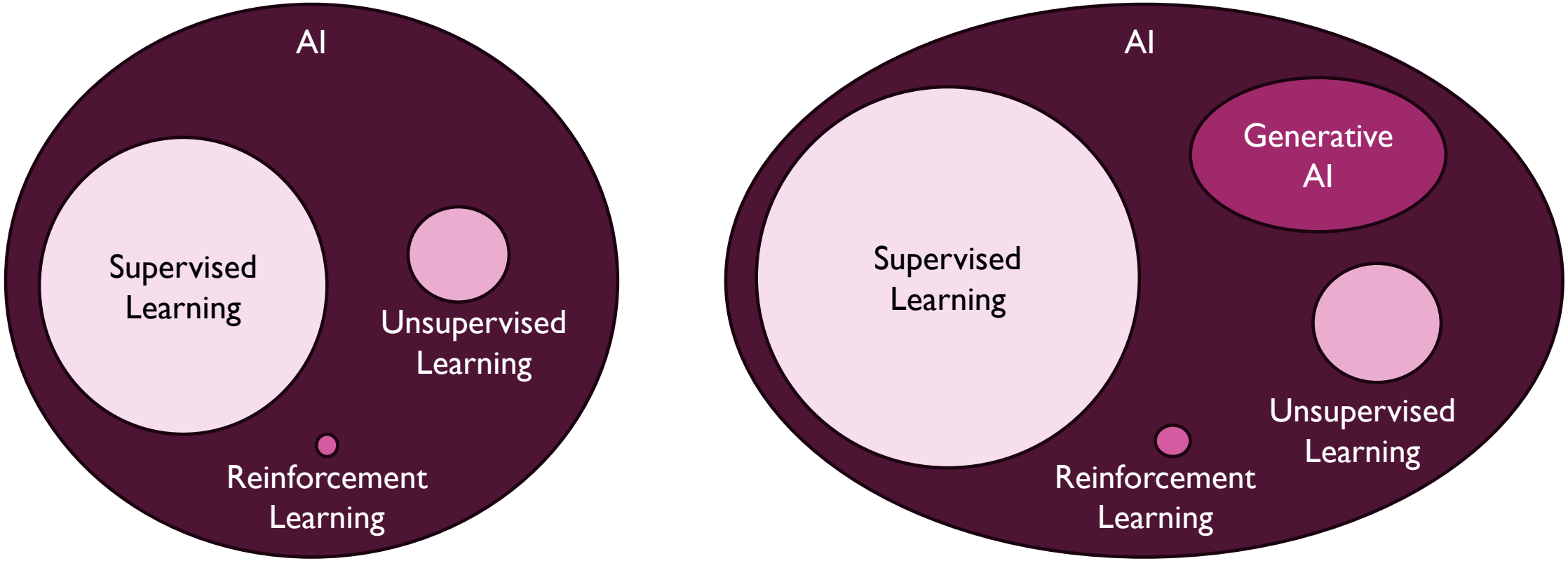
Data driven
Clustering

Reinforcement Learning



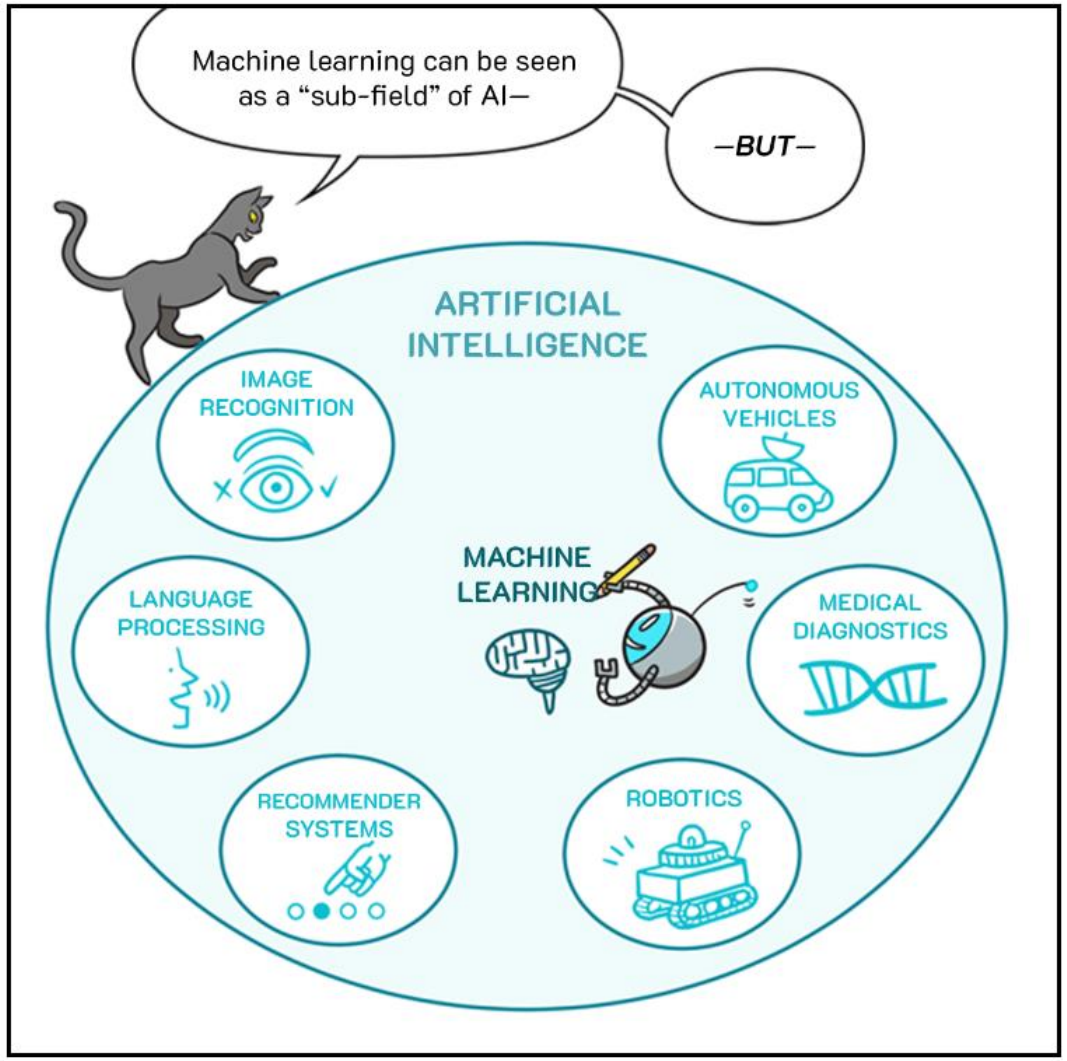
Algorithm learn to react
to an environment

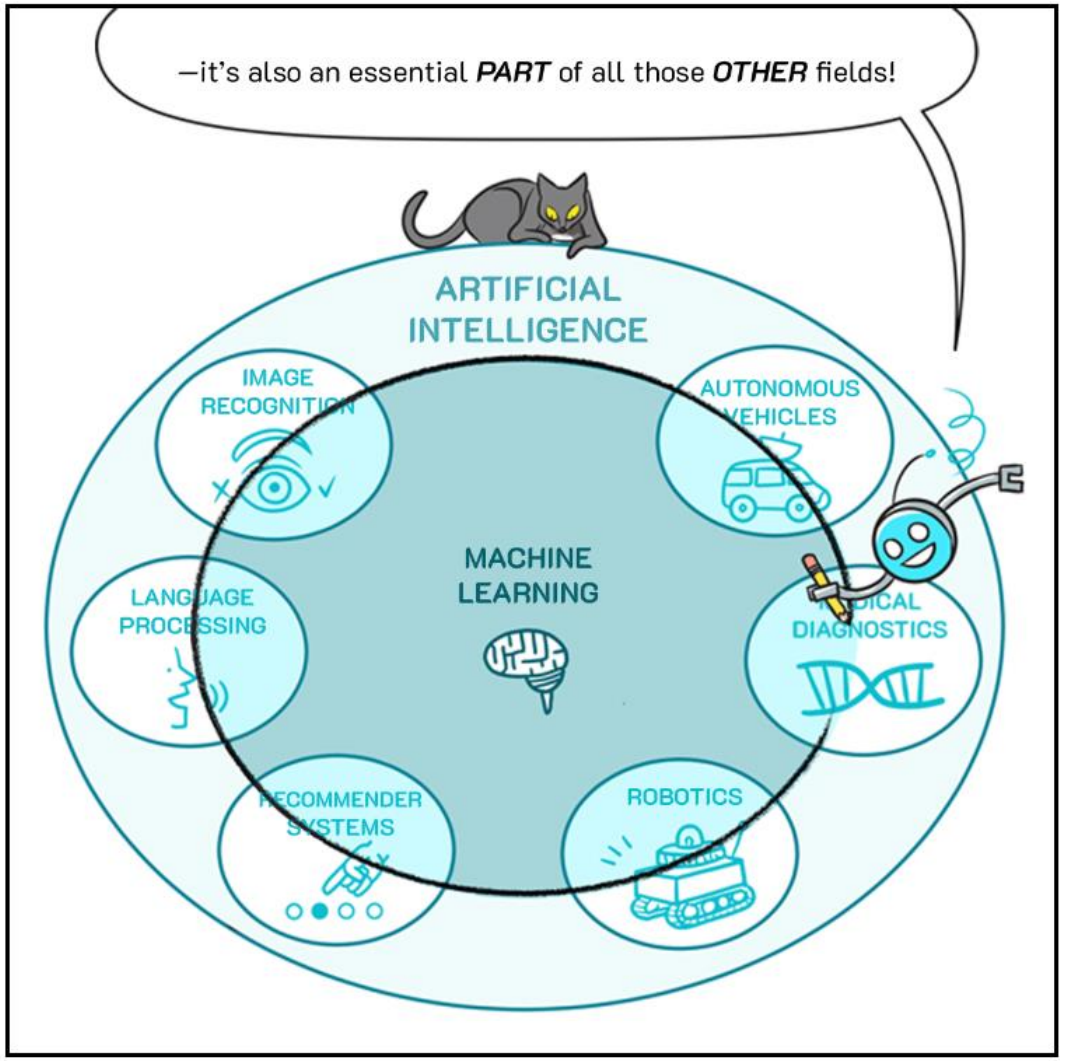
DIFFERENT TYPES OF MACHINE LEARNING (CONTINUED)



- Generative AI uses a blend of supervised learning (predicting the next word in a sentence, given the previous words) and unsupervised learning (figuring out the structure of the language without explicit instructions or labels).

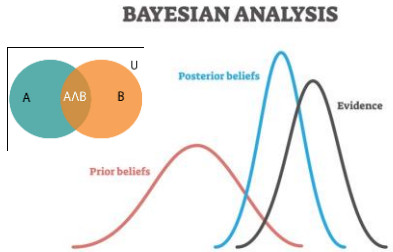
RELATIONSHIP BETWEEN AI AND MACHINE LEARNING

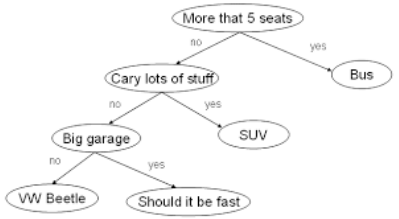


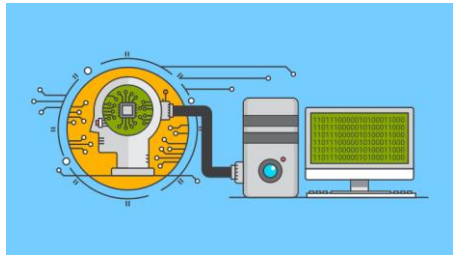


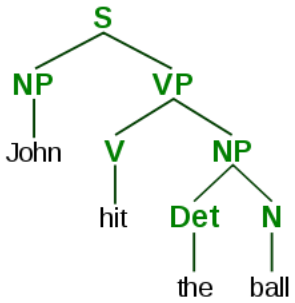
ARTIFICIAL INTELLIGENCE

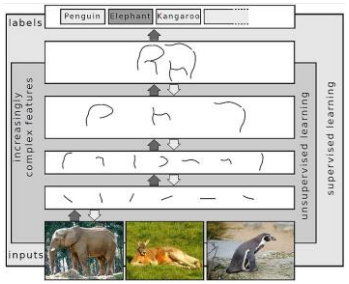
- AI is the study of intelligent agents, which refers to any system that perceives its environment and takes actions that maximize its chance of achieving its goals.
  - Reasoning and Problem Solving (probabilistic reasoning)
  - Knowledge Representation (ontology)
  - Planning
  - Learning (Machine Learning)
  - Natural Language Processing
  - Perception (vision, speech, …)
  - Motion and Manipulation (Robotics)
  - Social Intelligence











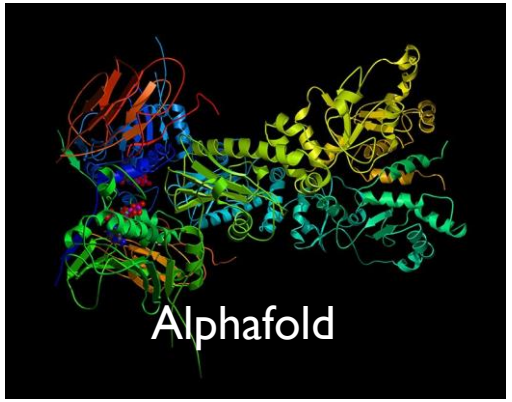
AGE OF AI


Self Driving


Natural Language Processing


Video Quality
NETFLIX


CHRIS UMÉ / METAPHYSIC
Deep Fake


Alphafold


Toonify!

AGE OF AI

TEXT DESCRIPTION

An astronaut Teddy bears A bowl of soup

mixing sparkling chemicals as mad scientists shopping for groceries working on new AI research

as a 1990s Saturday morning cartoon as digital art in a steampunk style

→

DALL·E 2

TEXT DESCRIPTION

An astronaut Teddy bears A bowl of soup

mixing sparkling chemicals as mad scientists shopping for groceries working on new AI research

as kids' crayon art on the moon in the 1980s underwater with 1990s technology

→

DALL·E 2

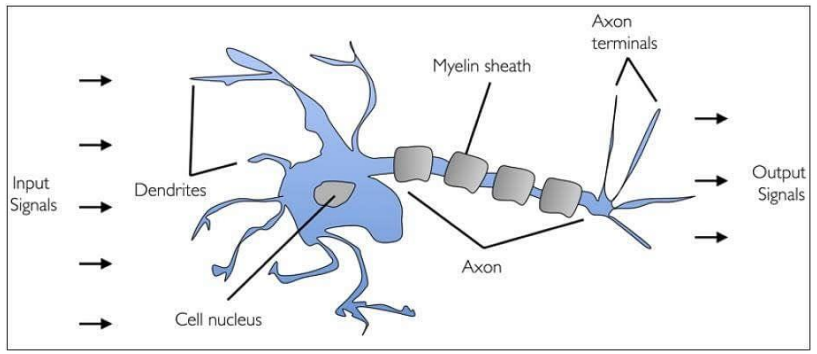
[Midjourney]

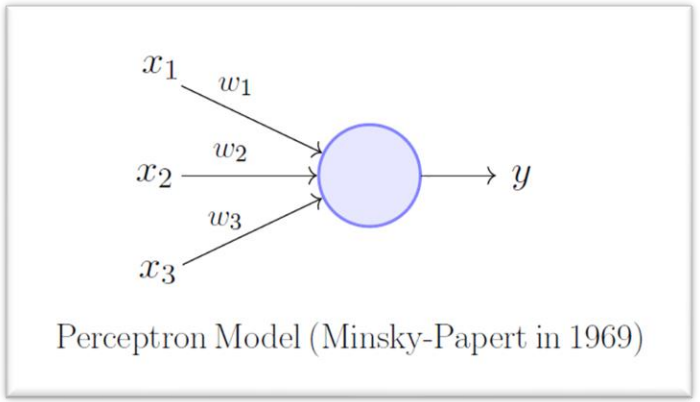
[Gencraft]

[iStock]

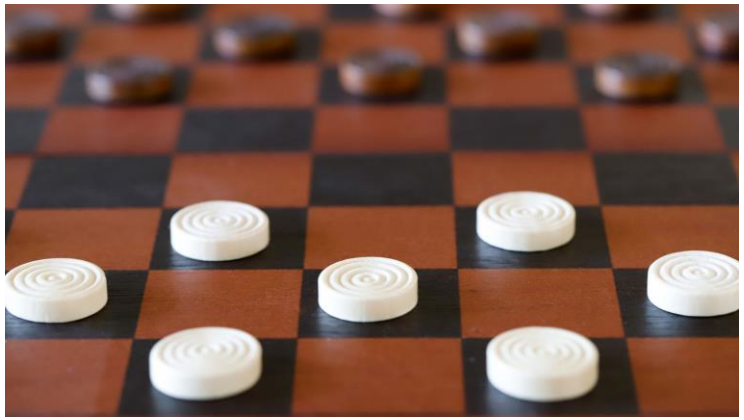
HISTORY OF MACHINE LEARNING

- **1958:** Frank Rosenblatt introduced the idea of perceptron (a form of neural network).
- **1959:** Arthur Samuel makes the first checkers program on IBM's first commercial computer IBM 701.



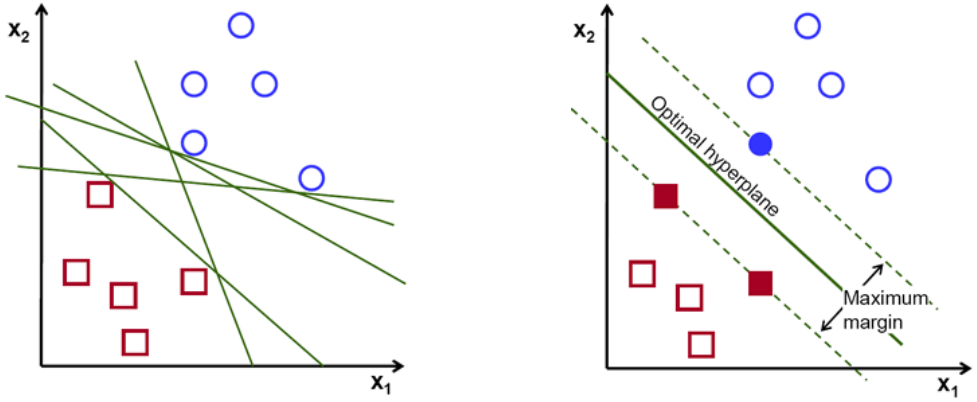


Perceptron Model (Minsky-Papert in 1969)

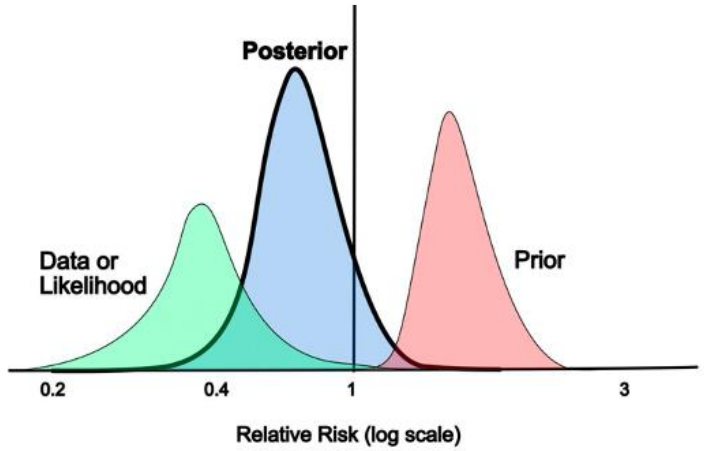


TIMELINE OF PROGRESS IN MACHINE LEARNING

- **1961**: Howard Raiffa and Robert Schlaifer, publish "Applied Statistical Decision Theory".
- **1963**: "Generalised Portrait Method (GPM)" was invented by Vladimir N. Vapnik and Alexey Ya. Chervonenkis.
  - Support Vector Machines (SVM) as a highly influential algorithm in Machine Learning is based on a nonlinear generalized version of GPM.



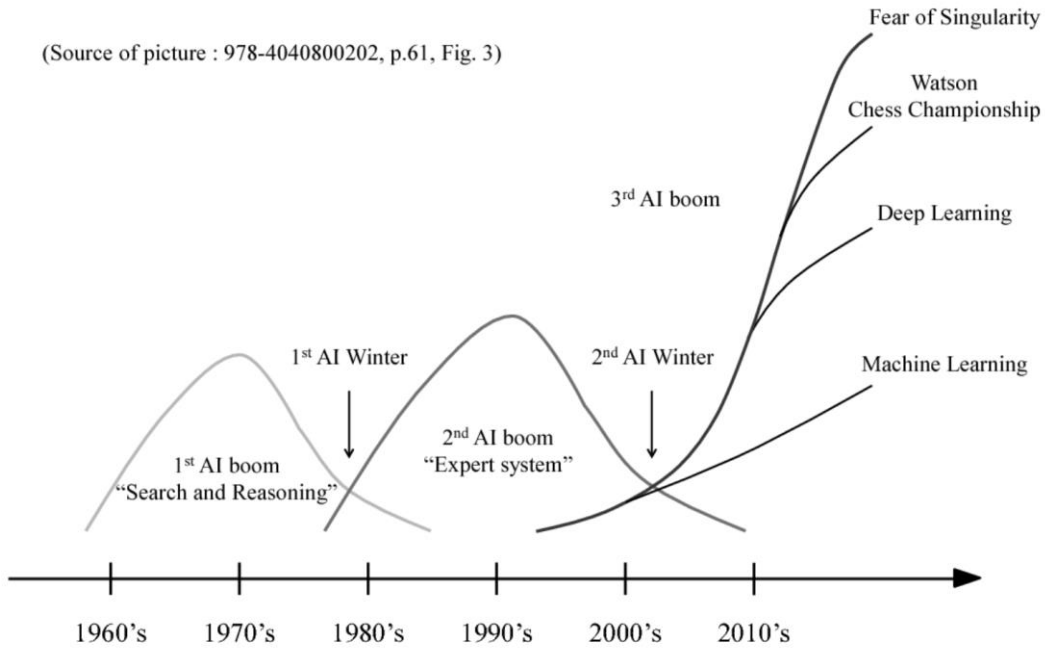
$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$



https://www.youtube.com/watch?v=aygSMgK3BEM

AI WINTER

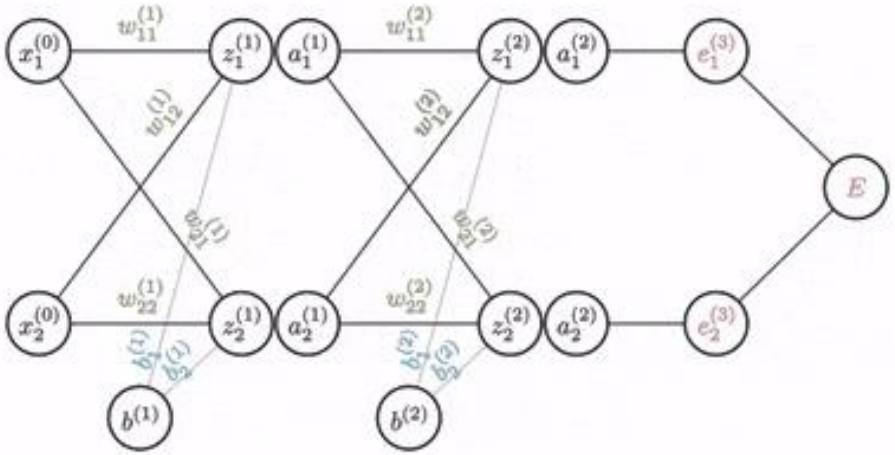
- Field of AI and Machine Learning did not have a smooth ride over the years.
  - 1966: failure of machine translation
  - 1970: abandonment of connectionism
  - Period of overlapping trends:
    - 1971–75: DARPA's frustration with the Speech Understanding Research program at Carnegie Mellon University
    - 1973: large decrease in AI research in the United Kingdom in response to the Lighthill report
    - 1973–74: DARPA's cutbacks to academic AI research in general
  - 1987: collapse of the LISP machine market
  - 1988: cancellation of new spending on AI by the Strategic Computing Initiative
  - 1993: resistance to new expert systems deployment and maintenance
  - 1990s: end of the Fifth-Generation computer project's original goals



BACK PROPAGATION

- **1980s:** Rediscovery of backpropagation causes a resurgence in machine learning research.

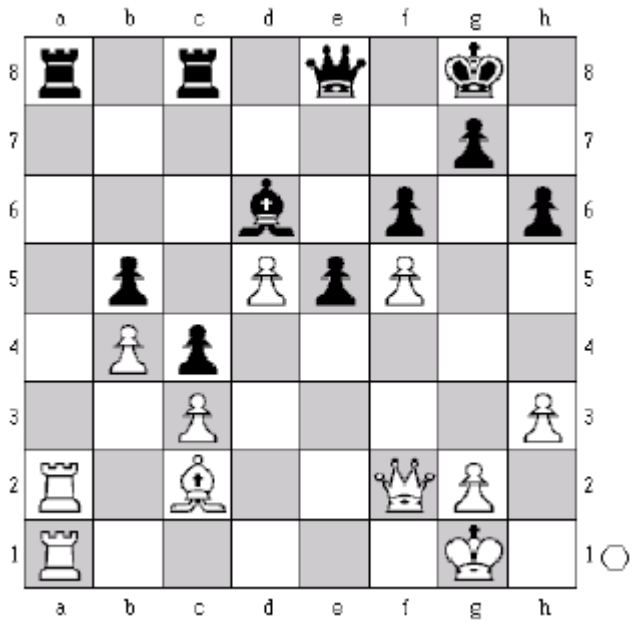
$$\frac{\partial E}{\partial w_{11}^{(2)}} = \frac{\partial e_1^{(3)}}{\partial a_1^{(2)}} \frac{\partial a_1^{(2)}}{\partial z_1^{(2)}} \frac{\partial z_1^{(2)}}{\partial w_{11}^{(2)}}$$



https://towardsdatascience.com/understanding-backpropagation-abcc509ca9d0

MAJOR ADVANCES IN ALL AREAS OF AI

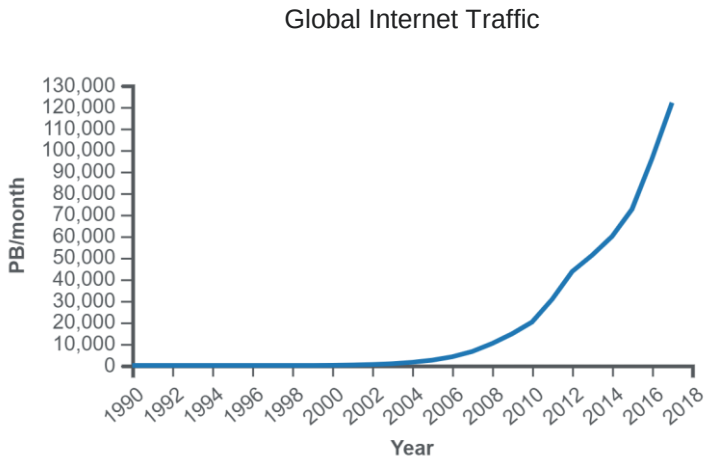
- **1990s**: Work on Machine learning shifts from a knowledge-driven approach to a data-driven approach.
  - Support-vector machines (SVMs) and recurrent neural networks (RNNs) become popular.
  - The fields of computational complexity via neural networks and super-Turing computation started.
  - In 1997 at the second try, Deep blue wins against world champion Garry Kasparov.

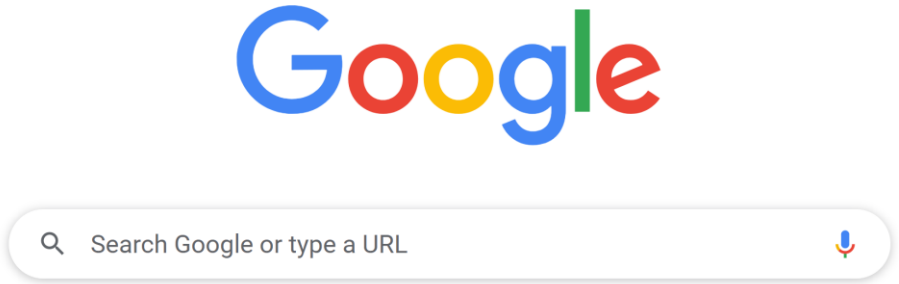


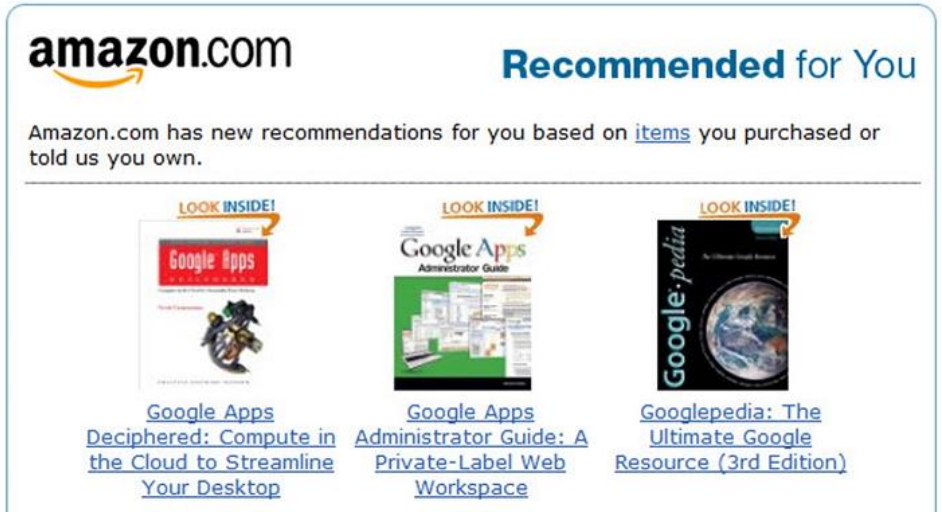
One of the two cabinets of Deep Blue

2000's

- Global wide-spread use of Internet.
- Products based on the Machine Learning started to have direct impact on people's life.
- Age of Internet AI started
  - Amazon
  - Google
  - Meta (Facebook)







BEATING THE GO MASTER

- **March 2016:** AlphaGo beat Lee Sedol in a five-game match, the first time a computer Go program has beaten a 9-dan professional without handicap.

AlphaGo

- Chess game tree complexity ($\log_{10}$) is in the order of 123.
- Go game tree complexity ($\log_{10}$) is in the order of 360. This means it is $10^{(360-123)}$ times harder than Chess! (one with 237 zeros in front of it!)
- The total number of atoms in the entire universe is approximated to be around 10^{80}.
- Most researchers were surprised as they witnessed this feat a decade sooner than what they expected.

BIG WAVES OF ARTIFICIAL INTELLIGENCE

- New engineering insights, well-curated big datasets, and hardware that can keep pace have all converged to make today's ML shine!

2010 Wave 1: Internet AI

Websites/apps, search, advertising, games/entertainment, e-commerce, social, internet lifestyle

2014 Wave 2: Business AI

Financial services, education, public services, medical, logistics, supply chain, back-office

2016 Wave 3: Perception AI

Security, retail, energy, IOT, smart homes, smart cities

2018 Wave 4: Autonomous AI

Agriculture, manufacturing (robotics), transportation (autonomous vehicle)

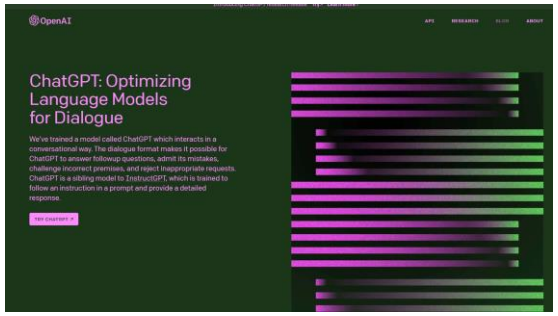
2020 Wave 5: Generative AI

ChatGPT, Dall-E (text, code, image, audio, music … generation)

AI STATE OF THE ART

Generative Adversarial Network (GAN)

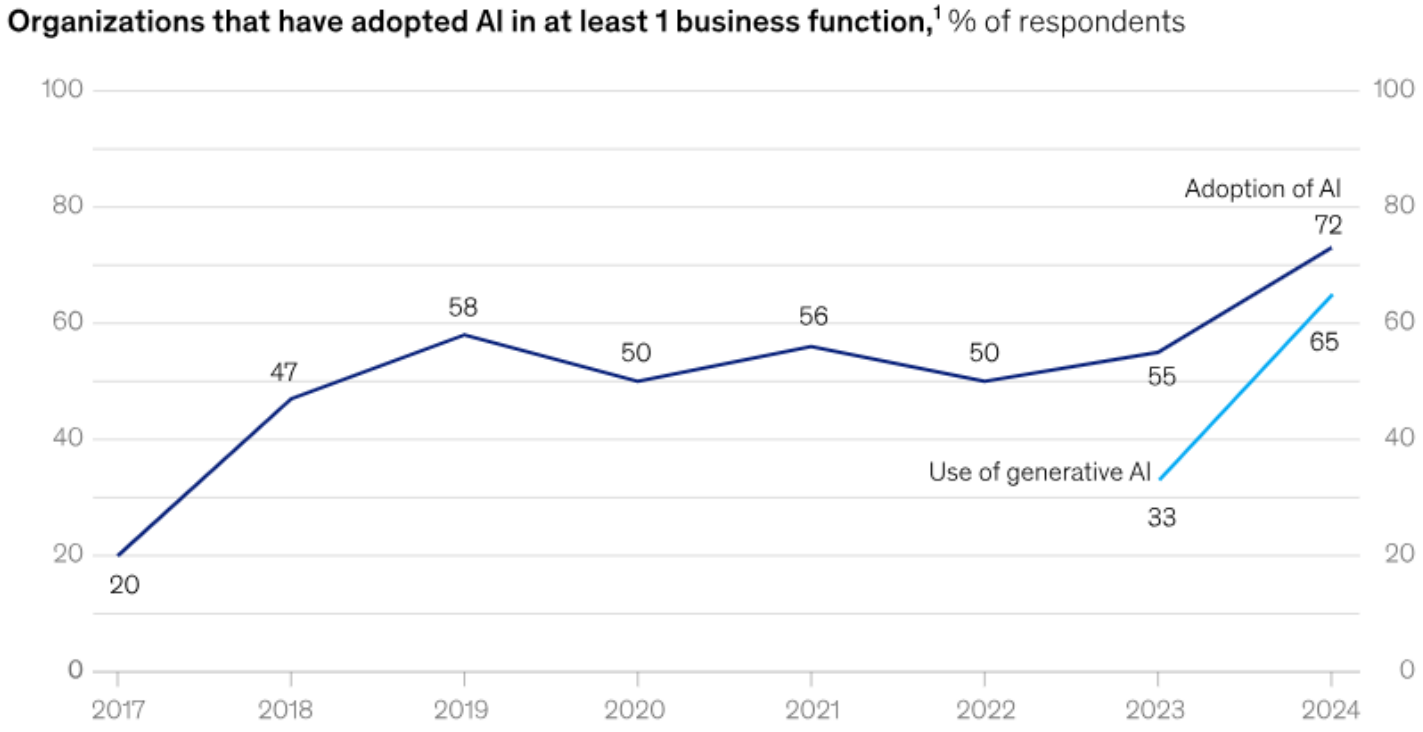
Age of Large Language Models (LLMs)



- The current wave of AI innovations goes beyond the predictive AI of the 2010s.
- It is unlocking creative output (eg writing, design, coding), enabling better functionality (eg contextual search and summarization), upgrading experiences (eg human-like chatbots), and turbo-charging decision-making (eg smart assistants).

AI MAKING MEANINGFUL IMPACT

- AI adoption worldwide has increased dramatically from 2023 after years of little meaningful change.



WHAT CAN AI DO?

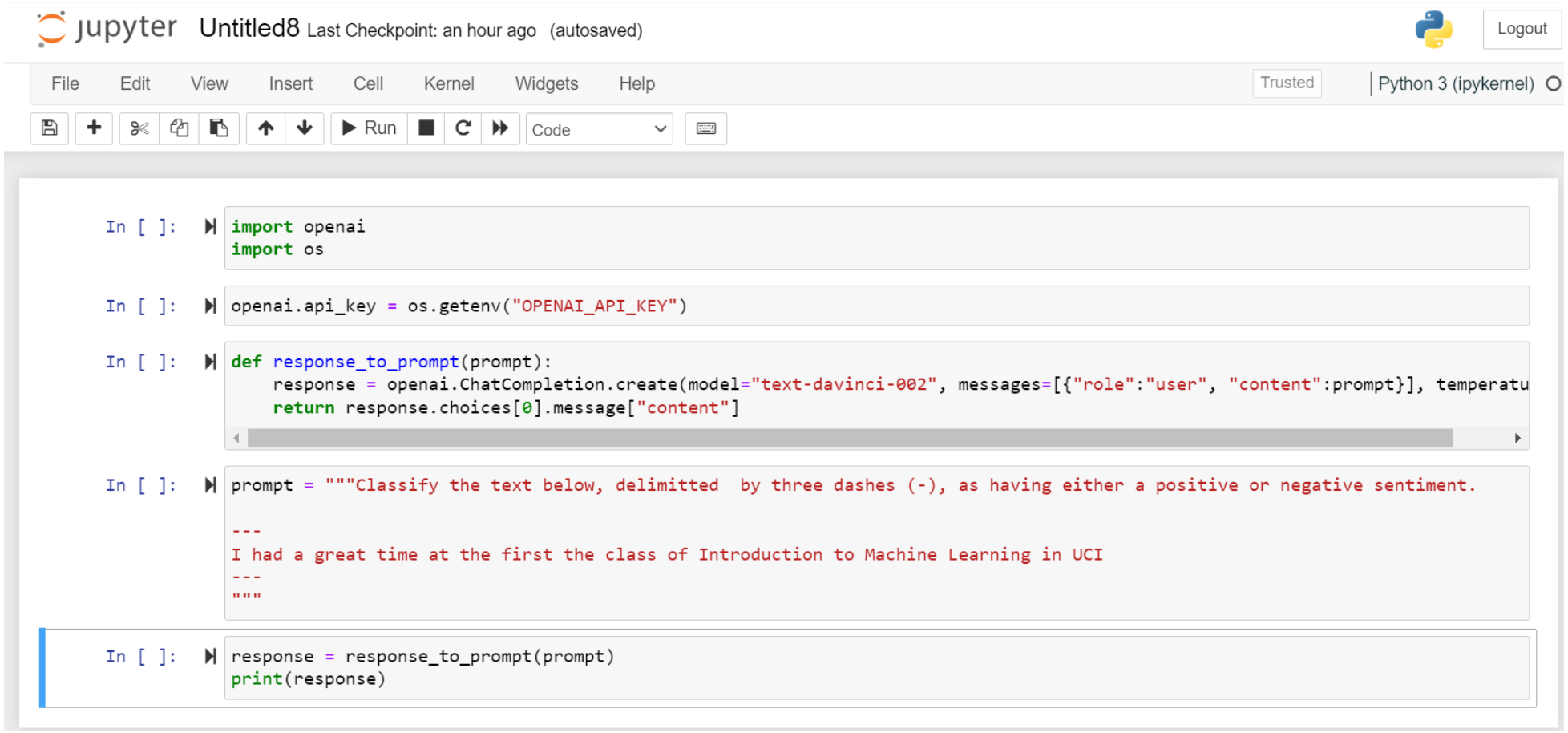
Quiz: Which of the following can be done at present?

- ✓ Play a decent game of Jeopardy?
- ✓ Win against any human at chess?
- ✓ Win against the best humans at Go?
- ✓ Play a decent game of table tennis?
- ✓ Grab a particular cup and put it on a shelf?
- ✗ Unload any dishwasher in any home?
- ✓ Drive safely along the highway?
- ✗ Drive safely along Broadway street in New York?
- ✓ Buy a week's worth of groceries on the web?
- ✗ Discover and prove a new mathematical theorem on their own?
- ✗ Perform a surgical operation on their own?
- ✓ Translate spoken Chinese into spoken English in real time?
- ✗ Write an intentionally funny story?

PYTHON PROGRAMMING LANGUAGE

- Python is a general-purpose programming language.
- Python is high level, interpreted language (in contrast to complied or machine level languages).
- It has easy syntax and dynamic semantics. It makes it easy for even a beginner.
- Due to the huge computing power that is available nowadays, the focus from speed in program execution is shifted to program readability and ease of development.
- It is an open-source language and thus free.
- It has a huge library and a great supporting community.
- It is portable. It is operating system agnostic (OS, Win, Linux).
- It is an object-oriented language.

POWER OF PYTHON PROGRAMMING!



TOPICS TO BE COVERED

- Introduction to Machine Learning
- Python Programming Language and Jupyter
- Supervised Learning and Linear Regression
- Cost Function and Gradient Descent
- Data Visualization, Cleaning and Regularization
- Logistic Regression and Classification
- k-Nearest Neighbor Classification
- Naïve Bayes and Probabilistic Classification
- Artificial Neural Networks
- TensorFlow Implementation for Neural Networks
- Bias and Variance
- Image Processing and Pattern Recognition
- Unsupervised Learning and Clustering
- k-Means Clustering
- Dimensionality Reduction and PCA
- Anomaly Detection
- Generative Models and LLM's

GRADING CRITERIA

- Midterm 20%
- Class Participation and Quizzes* 10%
- Homework 20%
- Project 20%
- Final Exam 30%

* Class participation does not mean a mandatory presence at the class at all sessions. You might be asked questions occasionally or assigned some small pertaining tasks to the course. The emphasize will be on the participation and engagement and not the right or wrong answers. If that criterion is satisfied, the whole class will be awarded the 5% full credit. The remaining 5% will be based on your individual score on the quizzes.

My office hours:

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Monday from 5:30-6:30 pm

TA for the class:

Yongfan Liu yongfal@uci.edu

Tuesday 11:30am-12:30pm