Machine Learning and Pattern Recognition (AI3011)

Dr. Siddharth
Tuesday/Thursday (2201)
2-3.30 PM

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This Course

- Deals with the **design**, **analysis**, and **methodology** of algorithms to recognize patterns in **real-world** data (audio, visual, text, financial, etc.)

- There are hundreds of algorithms under the Machine Learning umbrella (and many more come out each month!). The **goal** is not to study them all but rather to gain a strong understanding of fundamentals with the ability to undertake real-world projects.

Course Information

Course website will be up when the project list is ready.

Announcements, grades, and links: eLearning

Discussions: eLearning

Course Information

Office Hours

Instructor (Dr. Siddharth): Thursday, 4-4.45 PM (2411)

TFs (Mr. Rajiv and Ms. Poonam): Wednesday, 2-3 PM (2416)

TFs (Mr. Pushpendra and Mr. Viraj): Friday, 3-4 PM (2416)

Course Information

Grading

Quiz 1 (Week 5): 10%

Project (midterm evaluation): 20%

Quiz 2 (Week 9): 10%

Quiz 3 (Week 15): 10%

Project (final evaluation): 35%

Lab Evaluation: 15%

Course Information

Lectures

- Lectures will be delivered **in-person**. Each lecture will be 90 minutes in duration. The initial 50-60 minutes will be used to go over the course material and the remaining will be utilized for showing real-time demos of the concepts discussed in the class.

- During lecture, **please do not** work on your laptops/phones.

- Students are **highly encouraged** to ask questions during/after the presentation.

Course Information

Labs

- In-person labs every week will serve two purposes. First, each lab will have an **assignment** component in which the students will code (using Python) the solution to a problem relevant to the course material.

- Second, the labs will be used for **discussing** the project ideas that the student groups are pursuing for the course.

Course Information

- At least 70% attendance is **mandatory** in both lectures and labs to be eligible to pass the course.

- The use of Generative AI platforms like ChatGPT, Google Bard, GitHub Copilot, etc. is **absolutely not permitted** for any kind of code generation/debugging/evaluation/analysis.

- However, such Generative AI platforms may be used for other applications not related to programming such as referring to different sources, examining which algorithms are apt for a problem, etc.

Course Information

Project

- In groups of two or three students (four is a crowd!).
- Must be inspired by a **real-world problem** that you face at Plaksha.
- Work with the instructor and TFs in the first three weeks to define the problem statement.
- Evaluation will be based on the merit of
  - Problem Statement
  - Background Survey
  - Data collection/understanding of the dataset used
  - Development of the ML solution
  - Understanding of the fundamental ML concepts used in the project
  - [Bonus] Efficacy and deployability of the solution at Plaksha University
- Students **must submit** their whole software code for plagiarism check.

Course Information

Project

- A website will be up with the following information for each project
  - Abstract
  - Presentation (in PDF format)
  - Video Summary (less than 5 minutes in length)
  - Code

- Students can use their project to show potential employers that they have "hands-on" ML experience. The project must be exclusively for this course.

- The website will always be publicly accessible. Thus, **make sure** to not have any plagiarized material in your project.

Course Information

Recommended readings and resources

- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition by Aurélien Géron Released September 2019 Publisher(s): O'Reilly Media, Inc. ISBN: 9781492032649

- Machine Learning course videos by Andrew Ng (https://www.youtube.com/playlist?list=PLoROMvodv4rMiGQp3WXShtMGgzqpfVfbU)

(other readings/resources may be provided throughout the course)

Introduction to Machine Learning

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What is Machine Learning?

- "***Learning*** is any process by which a system improves performance by experience."

- "***Machine Learning*** is concerned with computer programs that automatically improve their performance through experience."

Herbert A. Simon
Turing Award, 1975
Nobel Prize in Economics, 1978

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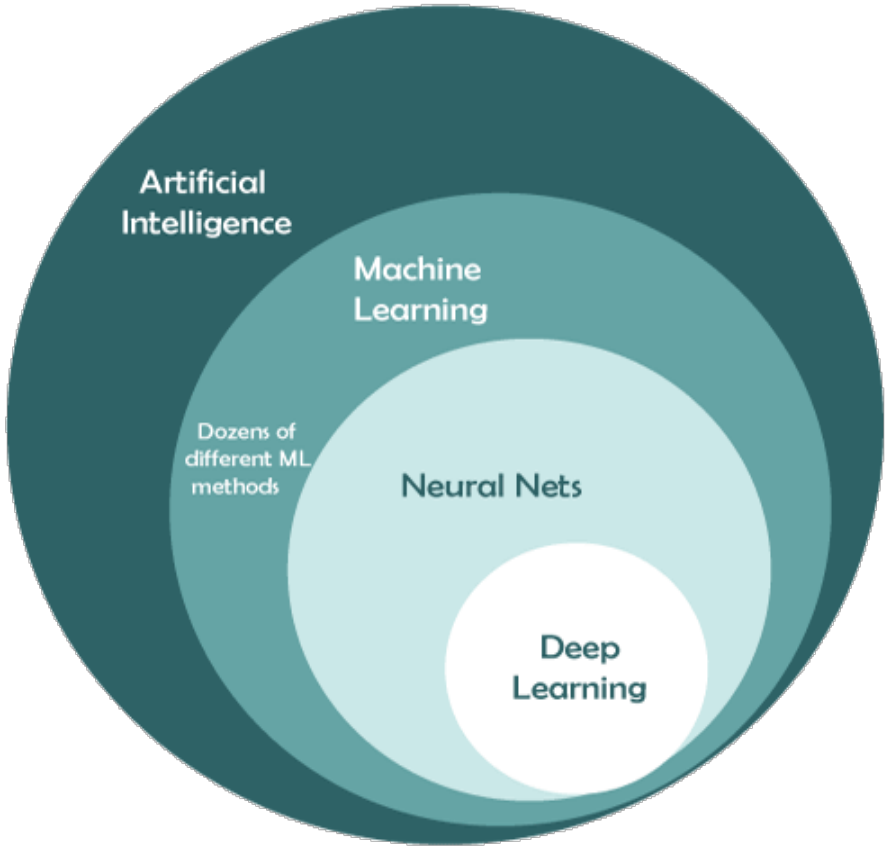
What is Machine Learning?

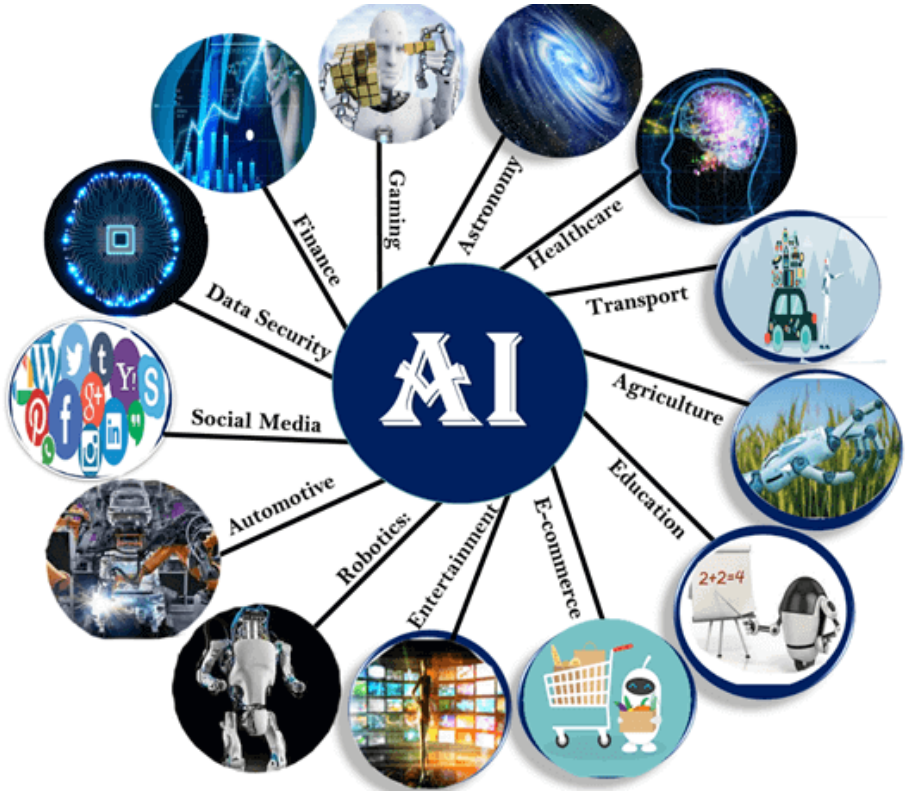
Machine Learning is a branch of Artificial Intelligence (AI) that allows machines to **learn automatically.**



Graphic courtesy:
https://www.javatpoint.com/deep-learning-vs-machine-learning-vs-artificial-intelligence

So, what is Artificial Intelligence?

AI is the "simulation" (i.e., artificial process) of human intelligence processes by machines. It has many (many!) applications:

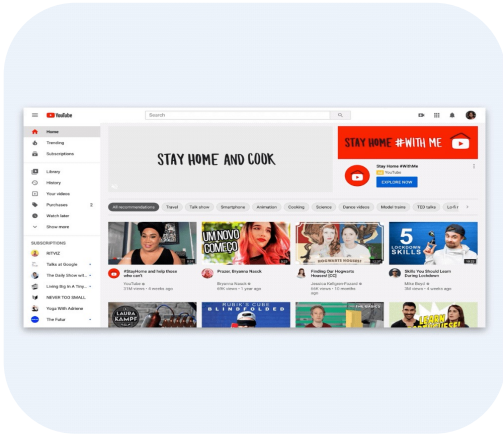


Graphic courtesy:
https://www.javatpoint.com/application-of-ai

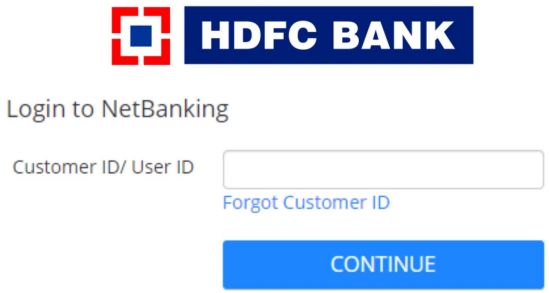
AI applications right here in this classroom!

Virtual Assistants

Health Insights



YouTube Recommendations



Data Security

Navigation

Auto-tracking Cameras

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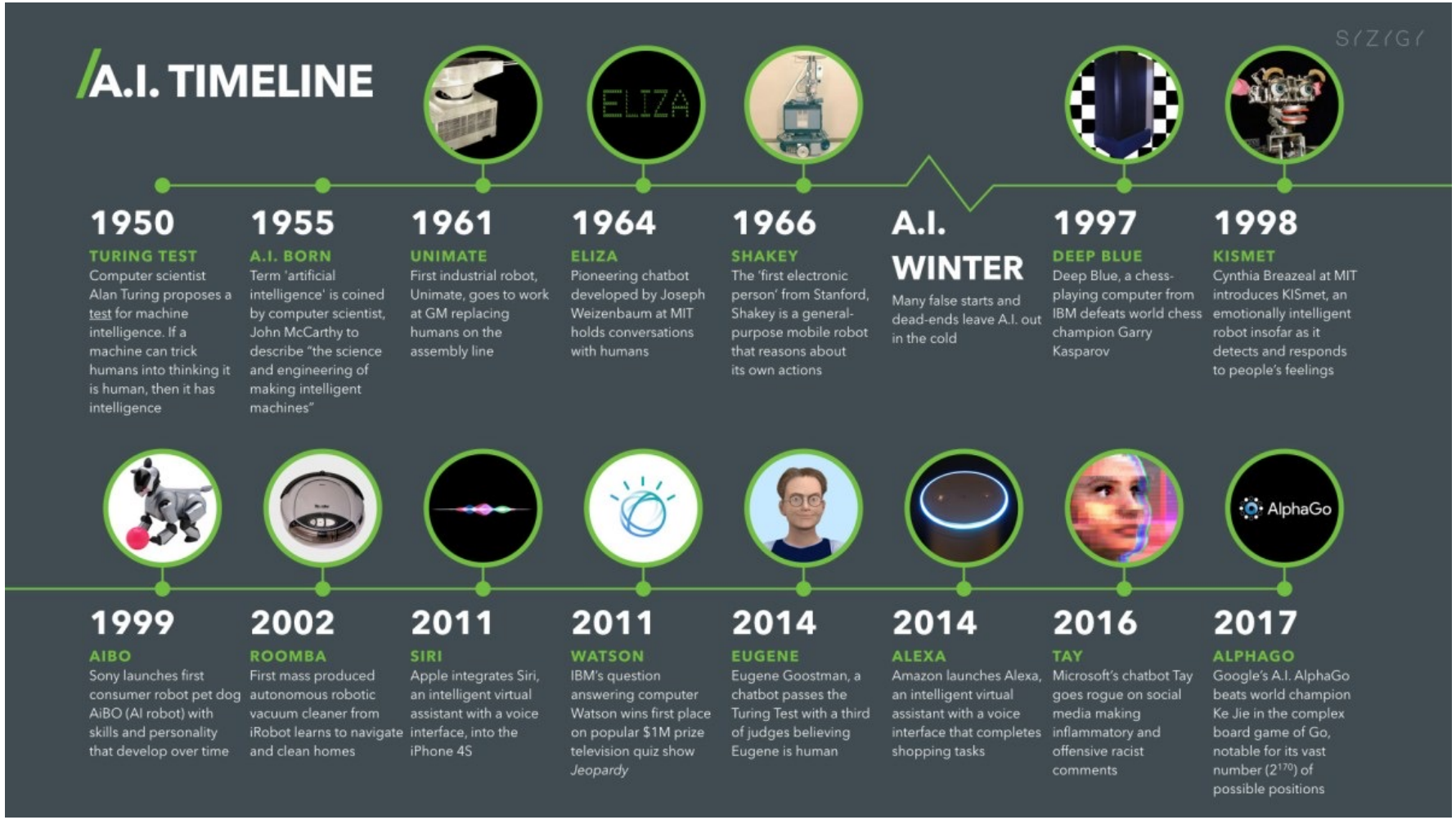
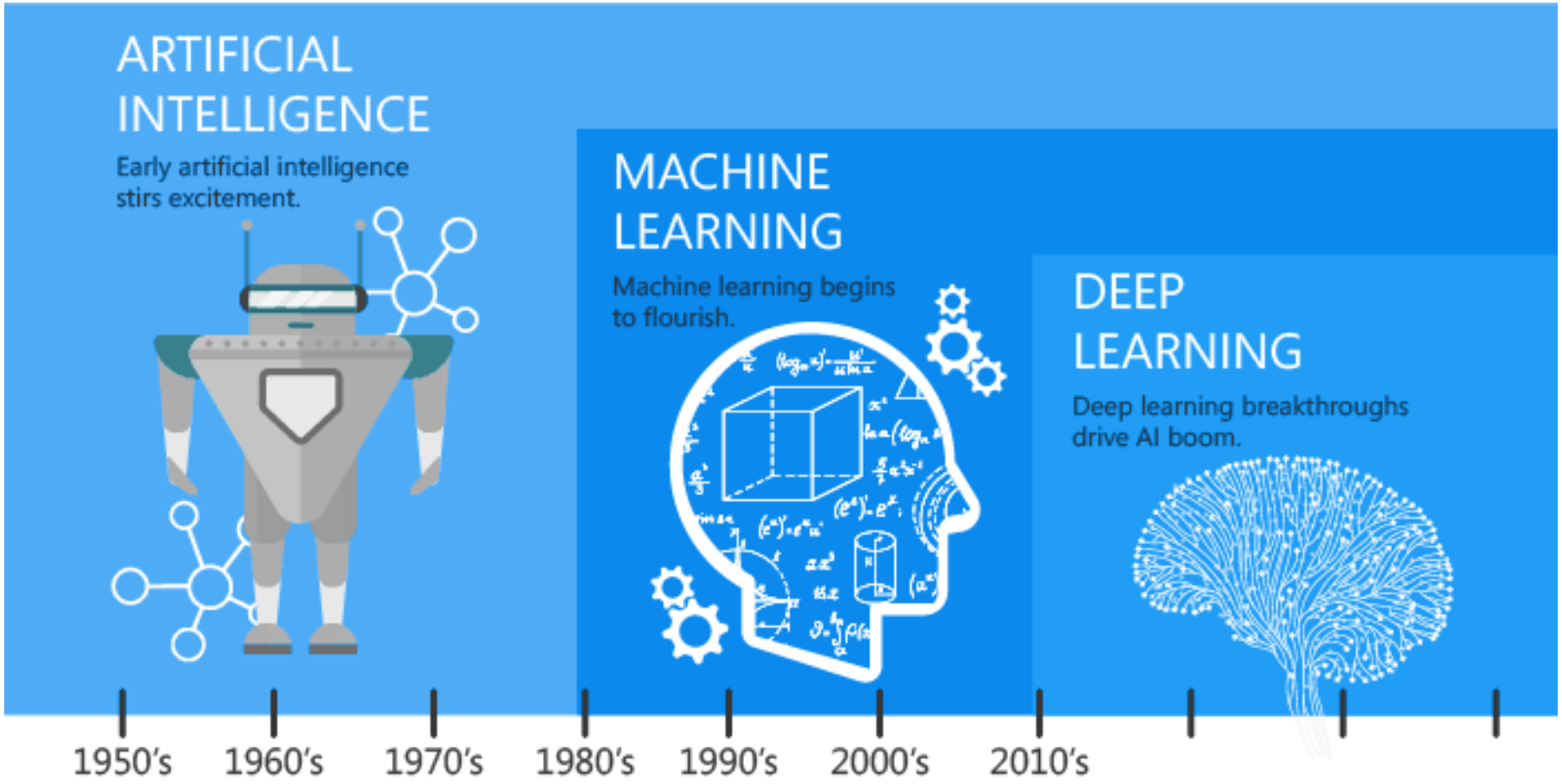
Intro to ML → Features Extraction → Features Clustering → Features Dim Reduction → Features Classification → ML Systems Challenges → ML Real-world Applications → Intro to NNs → Multi-layer NNs → "Deep" NNs → Other ML Methods

History of AI



Graphic courtesy:
https://digitalwellbeing.org/artificial-intelligence-timeline-infographic-from-eliza-to-tay-and-beyond/

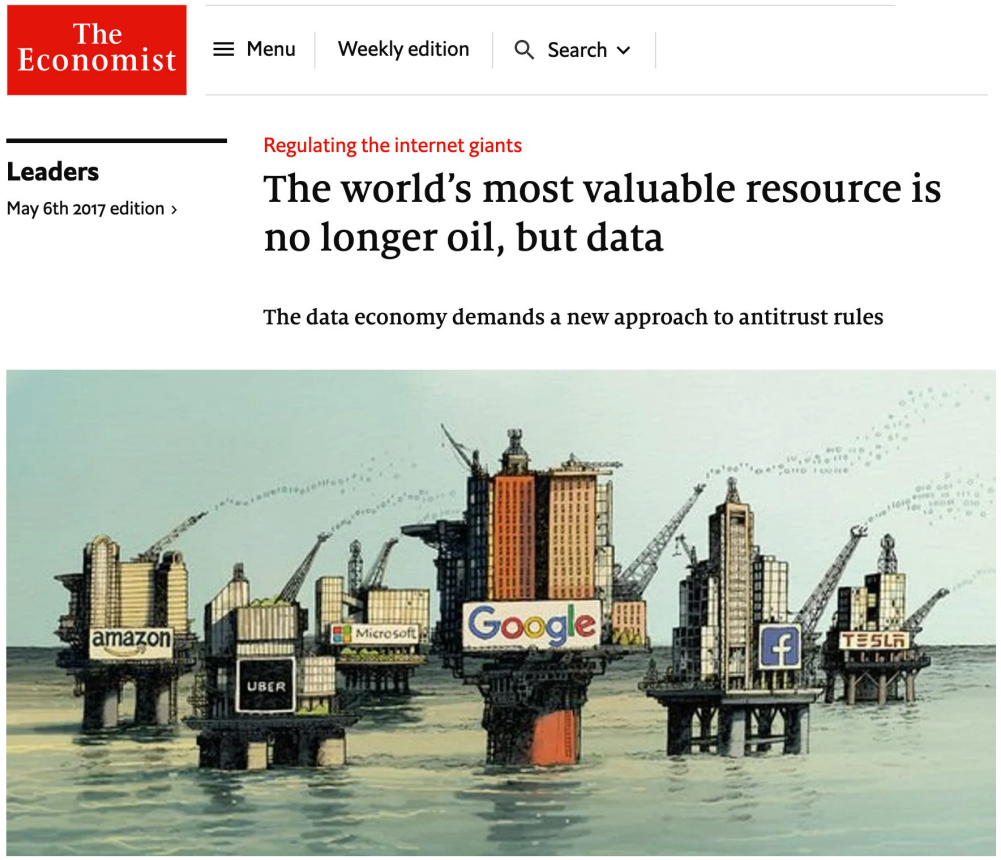
History of AI



Since an early flush of optimism in the 1950's, smaller subsets of artificial intelligence - first machine learning, then deep learning, a subset of machine learning - have created ever larger disruptions.

Graphic courtesy: https://www.linkedin.com/pulse/artificial-intelligence-ai-vs-machine-learning-deep-natarajan-siva/

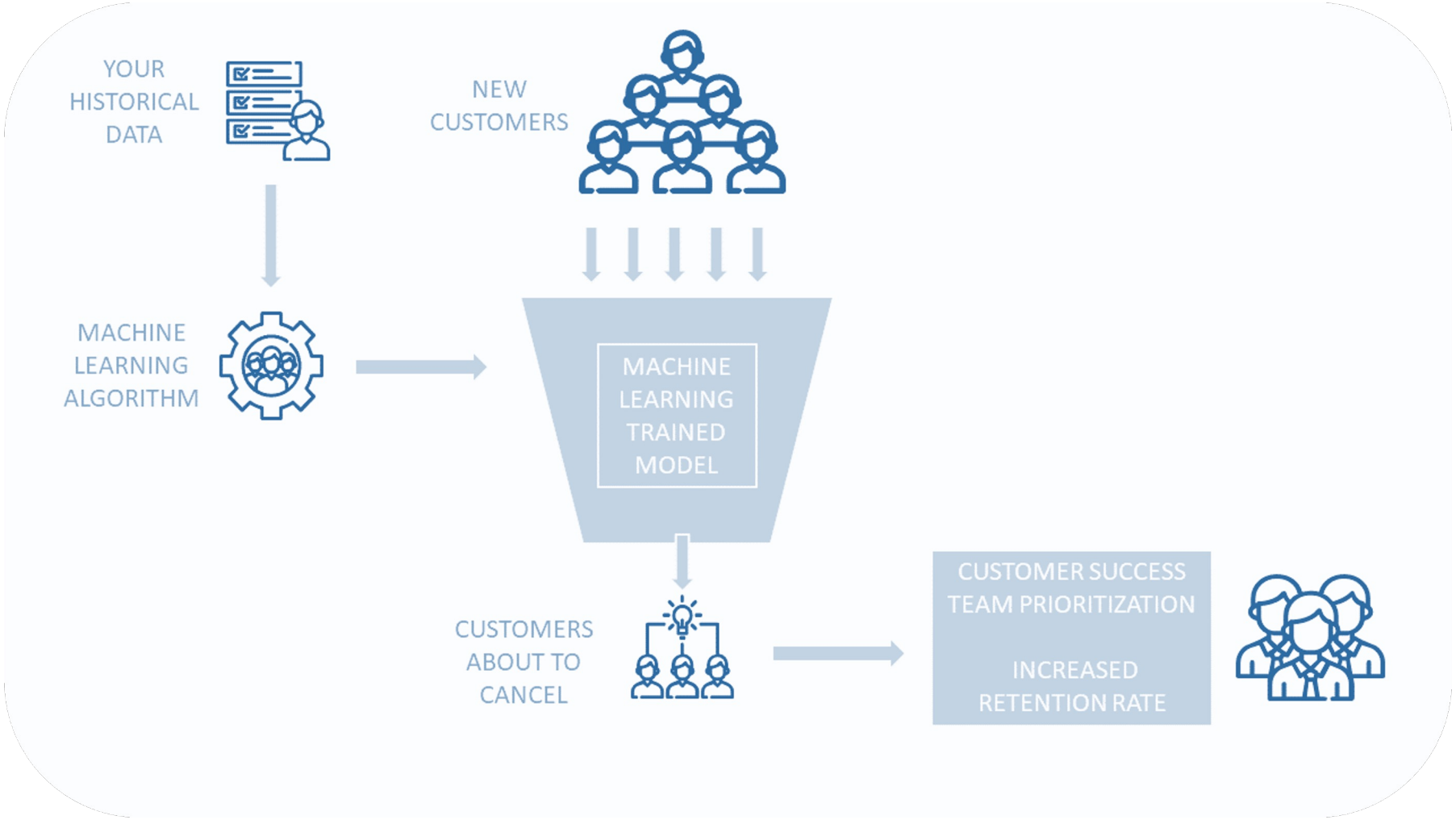
Why use ML?



Graphic courtesy: https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data

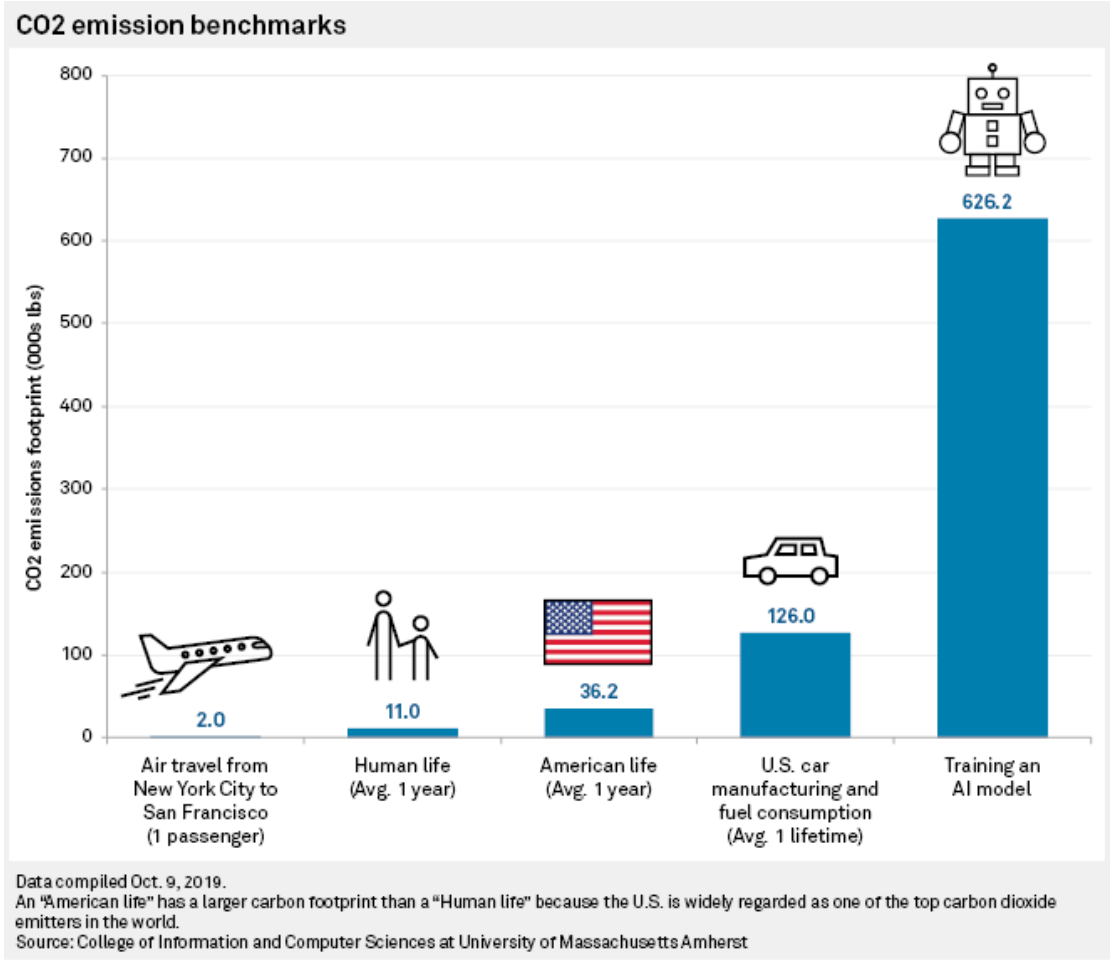
- Data is the **lifeblood** of all business.
- **Data-driven decisions** are key to the success and failure of any business.
- ML is presently amongst the most effective ways to **recognize patterns** in data.
- These patterns could then be used to generate insights that drive **decision-making.**

Example



Graphic courtesy:
https://graphite-note.com/popular-applications-of-machine-learning-in-business

Unfortunately, nothing comes for free!



- What if I told you that the AI model on the left has 213 million parameters while GPT-2 has 1.5 billion parameters!
- Now, consider that GPT-3 has 175 billion parameters!!
- Now, consider that GPT-4 has an estimated 100 trillion parameters!!!
- Finally, consider all the other models being trained simultaneously around the world!!!!

Data here, data there, data is everywhere!

Graphic courtesy:
https://www.corporatecomplianceinsights.com/data-data-data-everywhere/

- It's not just businesses that leverage data for decision-making. For example:
- Doctors may use insights from biomedical imaging data to diagnose patients.
- An autonomous vehicle may use insights from camera data to drive itself.
- Investors may use insights from stock data to take buy/sell decisions.

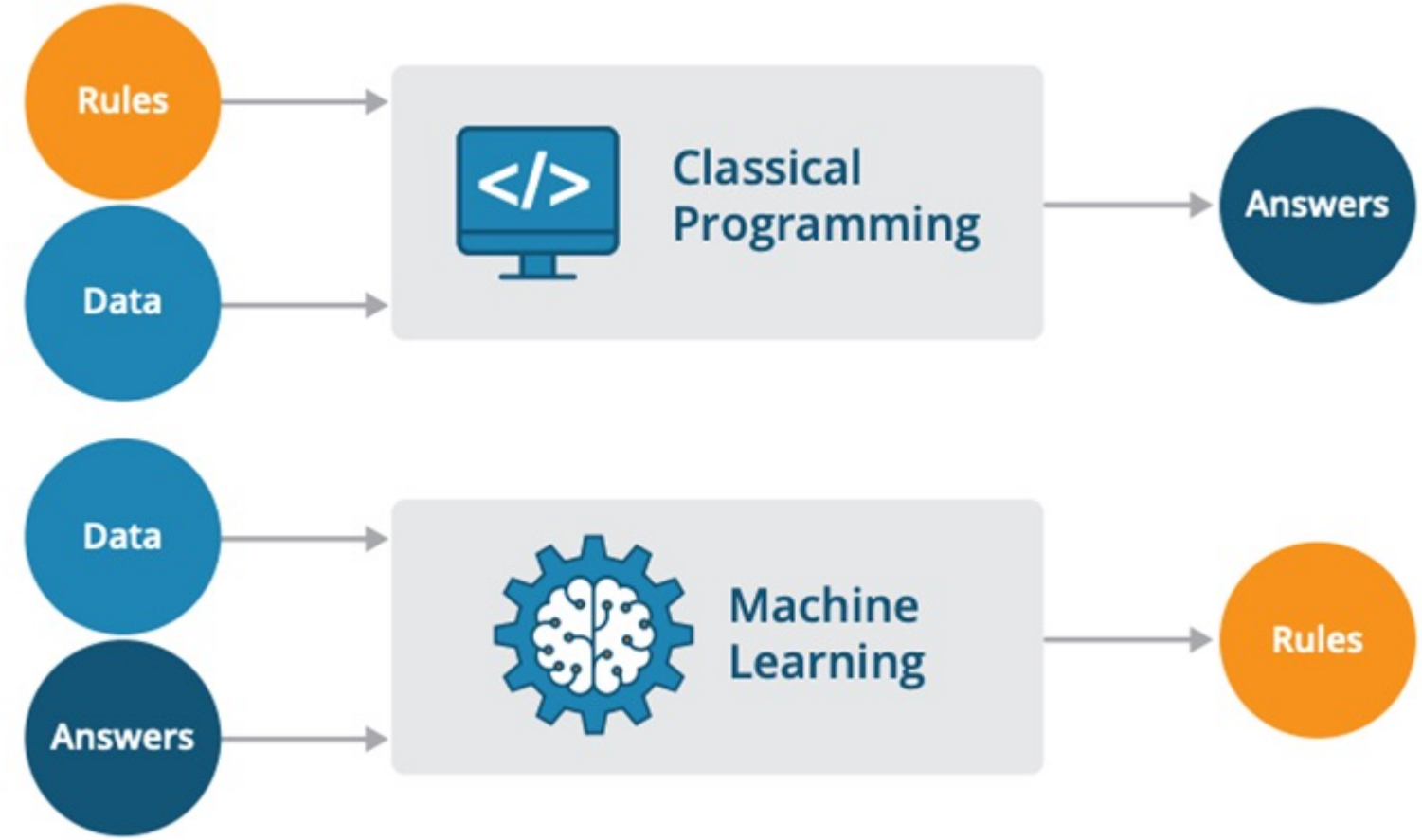
But, can't programming already do this?!

```python
class Solution:
    def maxProfit(self, prices: List[int], fee: int) -> int:
        n = len(prices)
        if n<2:
            return 0

        buy = [0] * n
        sell = [0] * n
        buy[0] = -prices[0] - fee

        for i in range(1,n):
            buy[i] = max(buy[i-1], sell[i-1] - prices[i] - fee)
            sell[i] = max(sell[i-1], buy[i-1] + prices[i])
        return sell[-1]
```

A simple program to buy/sell stocks

Graphic courtesy:
https://medium.com/algorithms-and-leetcode/best-time-to-buy-sell-stocks-on-leetcode-the-ultimate-guide-ce420259b323

Classical Programming vs. ML

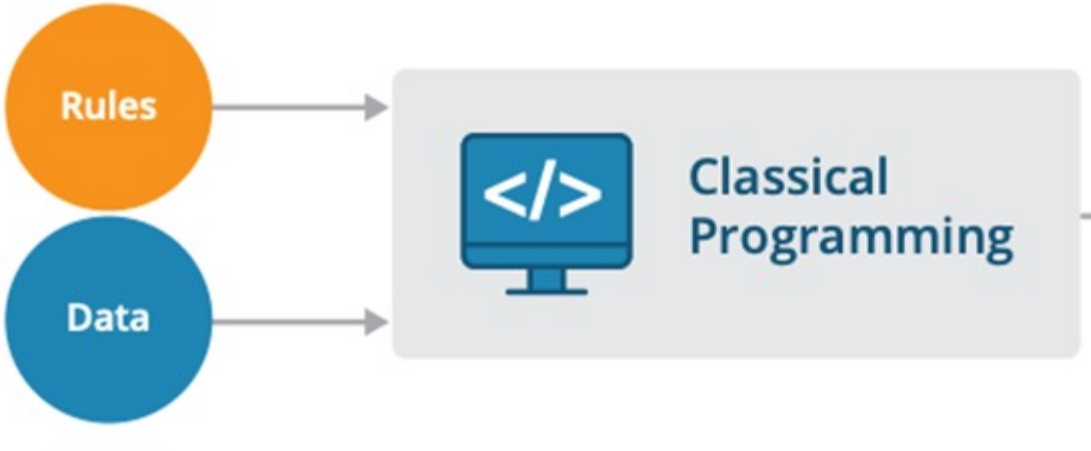


Graphic courtesy:
https://sravya-tech-usage.medium.com/traditional-programming-vs-machine-learning-e9bbed5e491c

Classical Programming vs. ML

Problem: How to program the rules that distinguish between Red and Green apples?

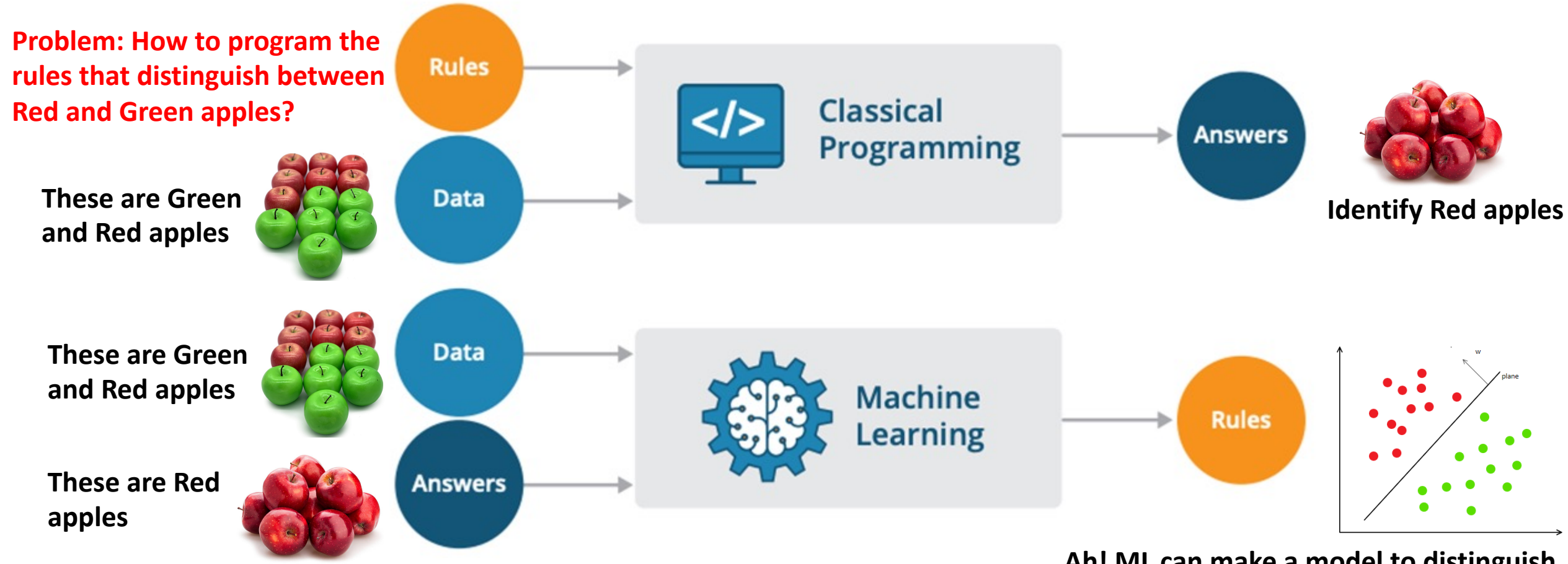
These are Green and Red apples



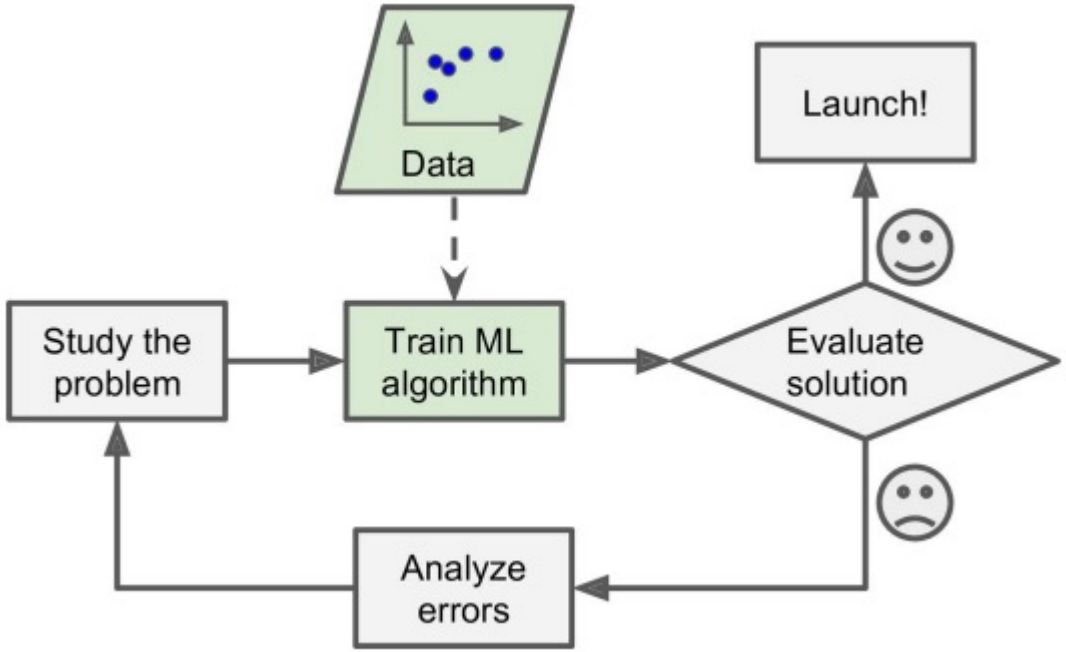
Identify Red apples

Classical Programming vs. ML

Problem: How to program the rules that distinguish between Red and Green apples?

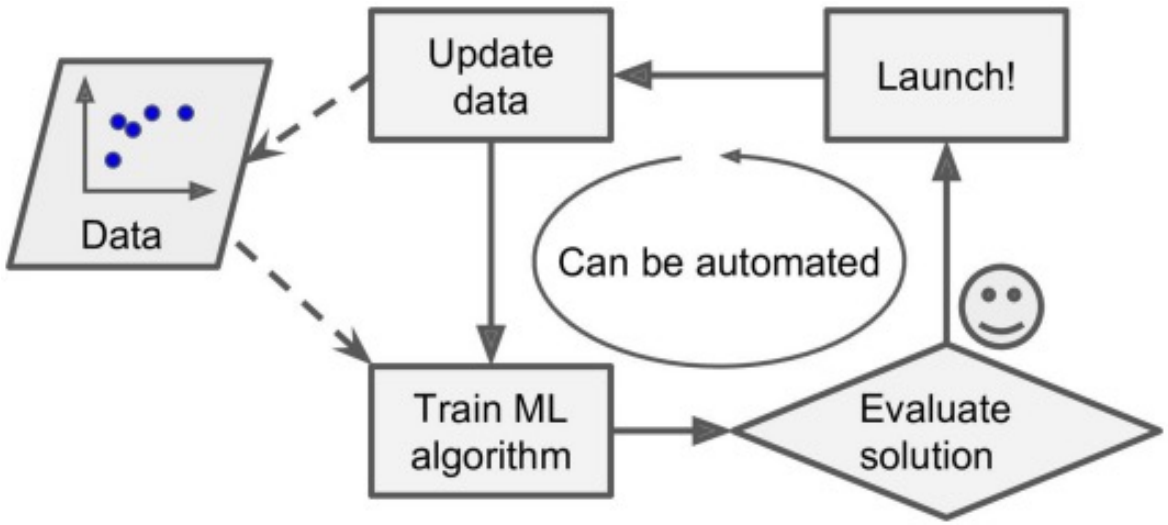


Advantages of the ML approach



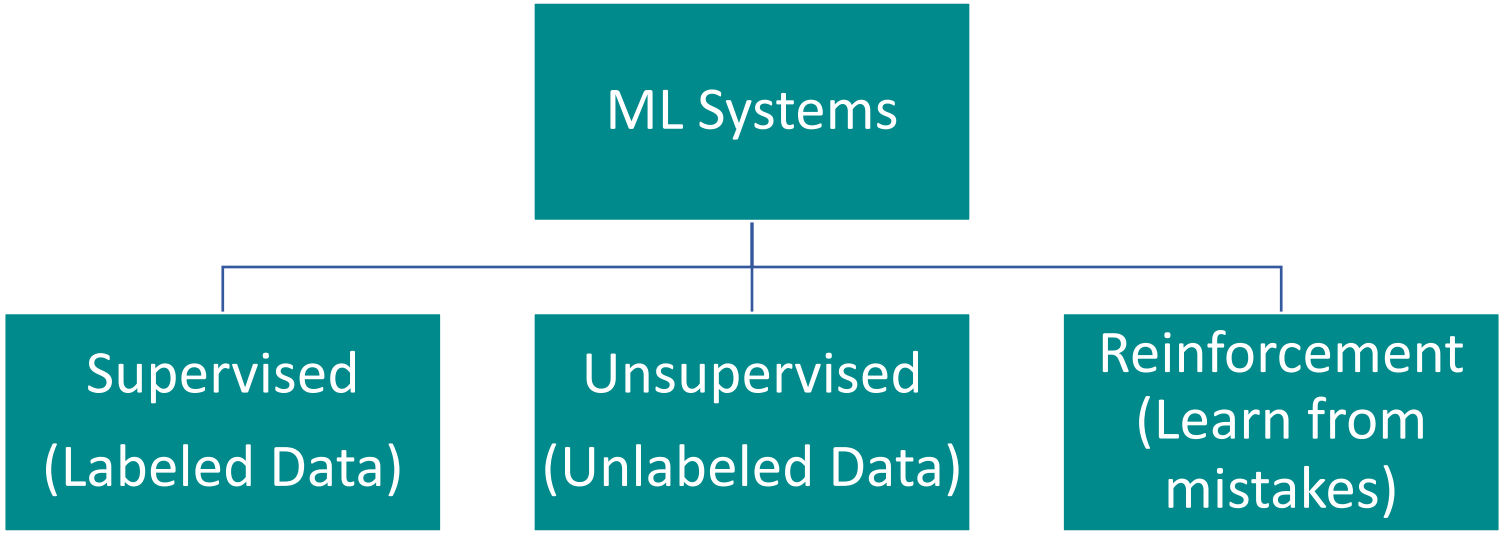
- Unlike classical programming, ML approach **does not need** a long list of complex rules (conditions) to program.
- Has the capability of **adjusting itself** as new data comes in without the need to introduce additional complex rules to the program.

Advantages of the ML approach

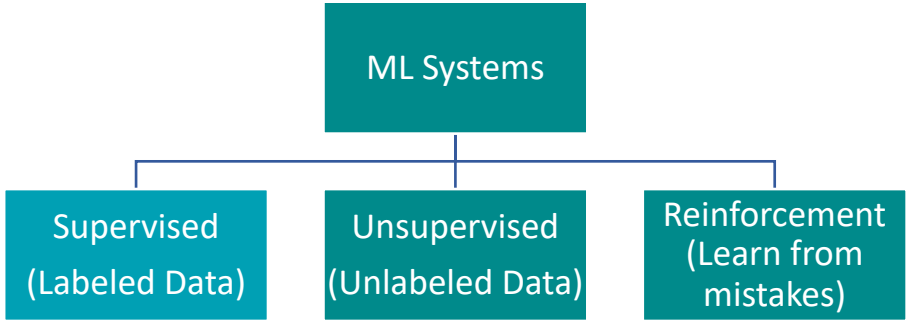


- ML model can be **automated** even as new data comes in.
- Great for problems that otherwise require lots of hand-tuning/a long list of complex rules in classical programming.
- Works well for complex problems for which there is no solution at all through rules-based classical programming.

Types of ML Systems



I. Supervised Learning



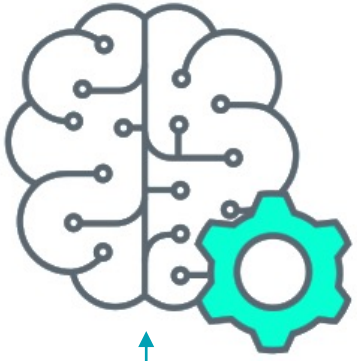
Input Data (Labeled)

These are apples

These are bananas

These are oranges

ML Model

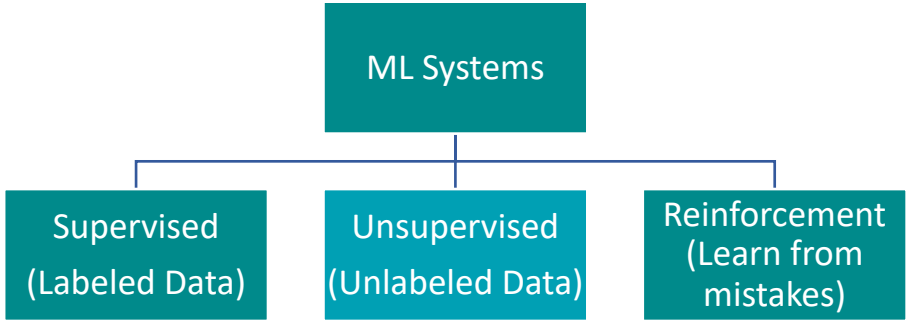


What is this?

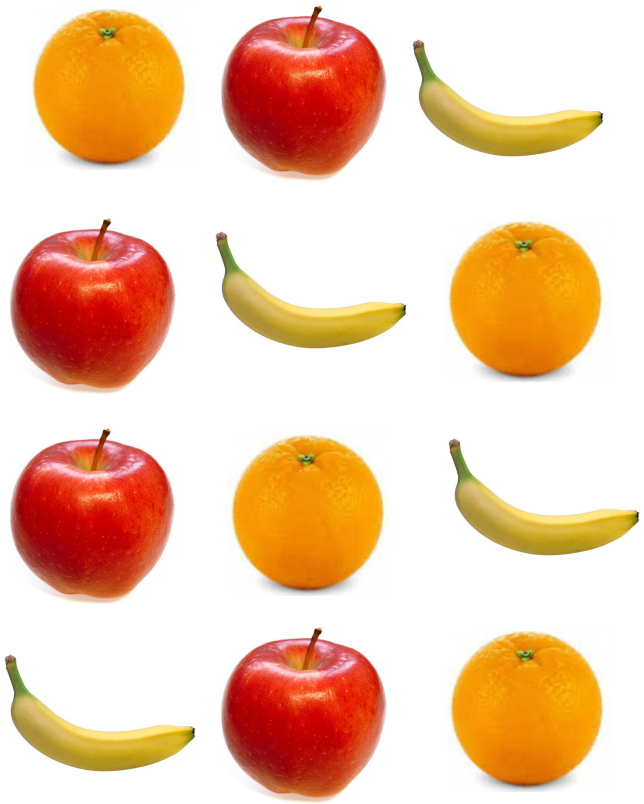
Prediction

It is an orange!

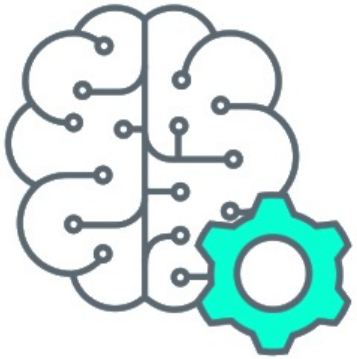
II. Unsupervised Learning



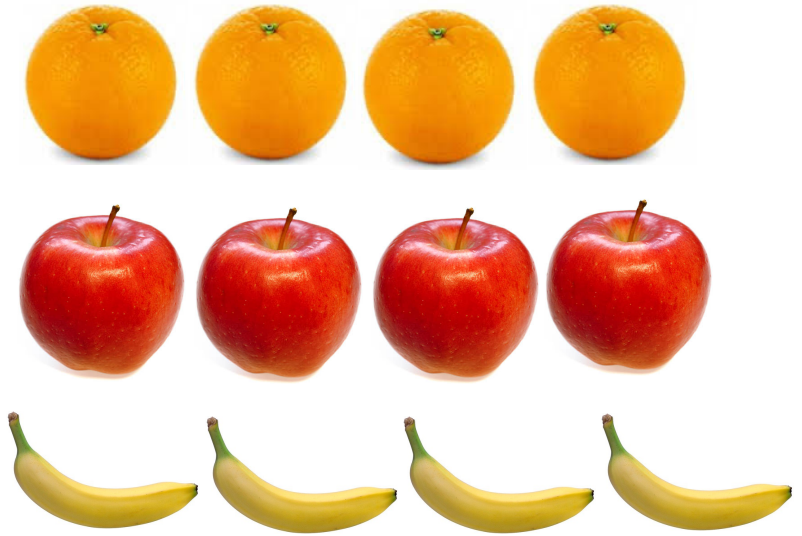
Input Data (Unlabeled)



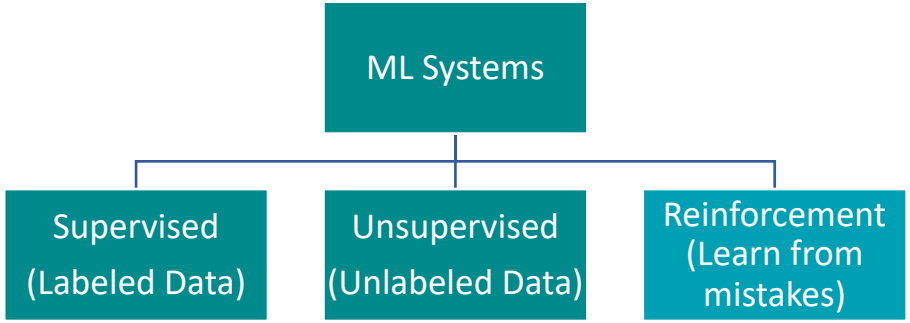
ML Model

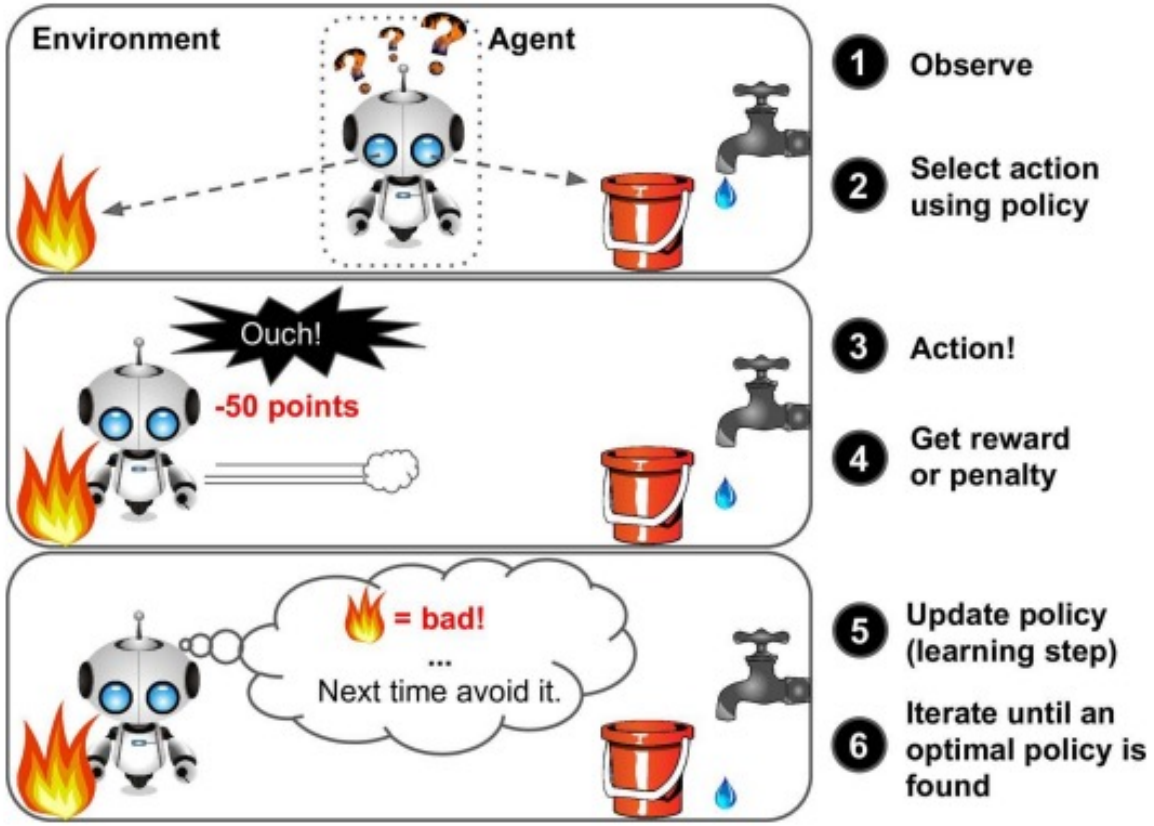


Clustering



III. Reinforcement Learning





Summary

This lecture

- Intro and History of ML
- How is ML different from Traditional Programming?
- Types of ML Systems

Next lecture

- To start building ML models, we need to extract features. What are features in ML?
- How to preprocess features before we start building ML models?

Questions?


Intro to ML
Features Extraction
Features Clustering
Features Dim Reduction
Features Classification
ML Systems Challenges
ML Real-world Applications
Intro to NNs
Multi-layer NNs
“Deep” NNs
Other ML Methods

QR Code for Attendance