TEECE 1/1L – ECE Elective 1/1L

M1: Introduction to Machine Learning

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Outline

Introduction to Machine Learning

- What is Machine Learning?
- Typical ML Applications
- Significant Advancements in AI
- Why Machine Learning?
- Types of Learning Problems
- Machine Learning Methods

What is Machine Learning?

Machine learning is the science of programming computers so they can *learn from data*.

Fig.1: Arthur Samuel playing checkers on IBM 701. By 1955, Samuel had done something groundbreaking; he had created a program that could learn — something that no one had done before — and this was demonstrated on television in 1956.[1]

"A computer program is said to learn from experience *E* with respect to some task *T* and some performance measure *P*, if its performance on *T*, as measured by *P*, improves with experience *E*."[2]

- Tom Mitchell, 1997

[1] https://medium.com/hackernoon/machines-that-play-checkers-10f7d4038956
[2] Géron, A. (2019). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* (2nd ed.). O'Reilly Media.

Typical ML Applications

Fig.2: Research interest in artificial intelligence is rapidly increasing, with numerous journals, conferences, and workshops showcasing the latest advancements in the field.

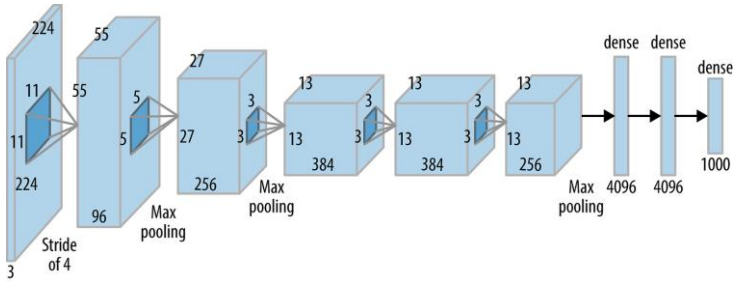
Source: https://ieeexplore.ieee.org

ML has a broad range of applications across various fields, including electronics and communication systems engineering

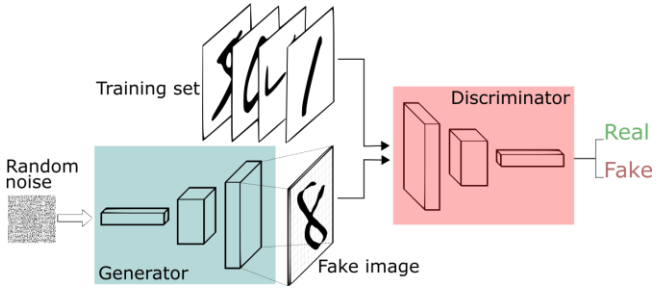
- Computer vision (*facial recognition systems, autonomous vehicles, medical imaging for detection and classification*)
- Natural language processing (*chatbots, sentiment analysis, machine translation, voice assistants*)
- Recommendation systems (*movies, products, videos, webpages, bookings*)
- Finance (*stock market prediction, credit scoring, fraud detection*)
- Signal Processing (*electrophysiological signal processing, communications signal processing, etc.*)
- Control Systems (*data-driven modelling*, *system identification and parameter estimation*, *etc*.)

Significant Advancements in AI

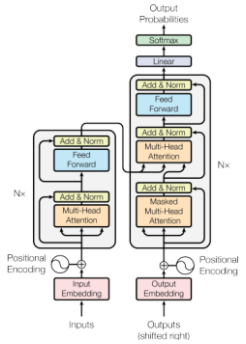
IBM Deep Blue (1997)



AlexNet (2012)

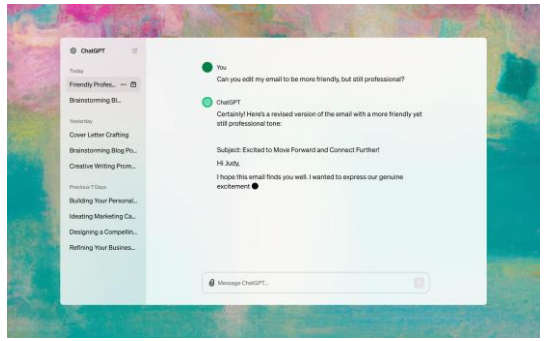


Generative Adversarial Networks (2014)



Transformers (2017)

OpenAI Five (2018)

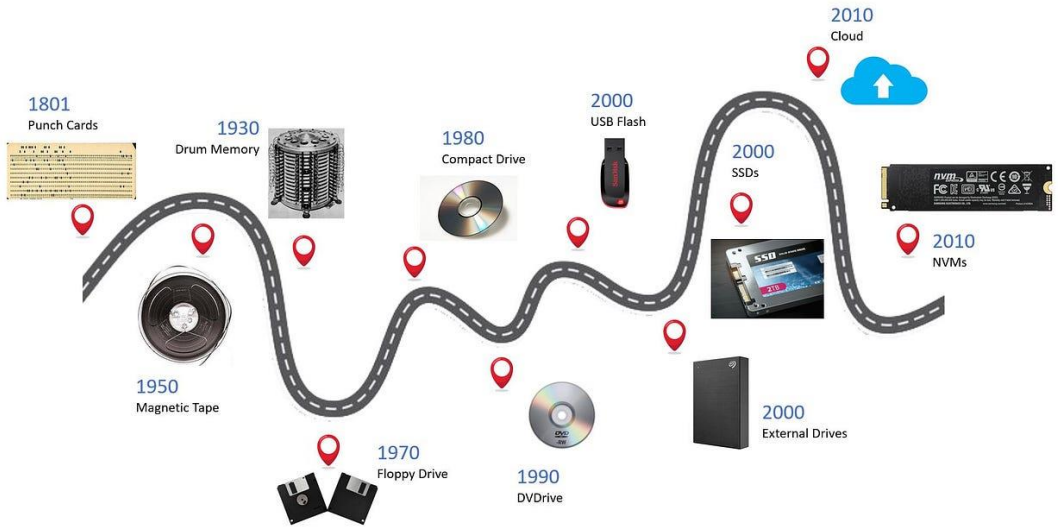


ChatGPT (2022)

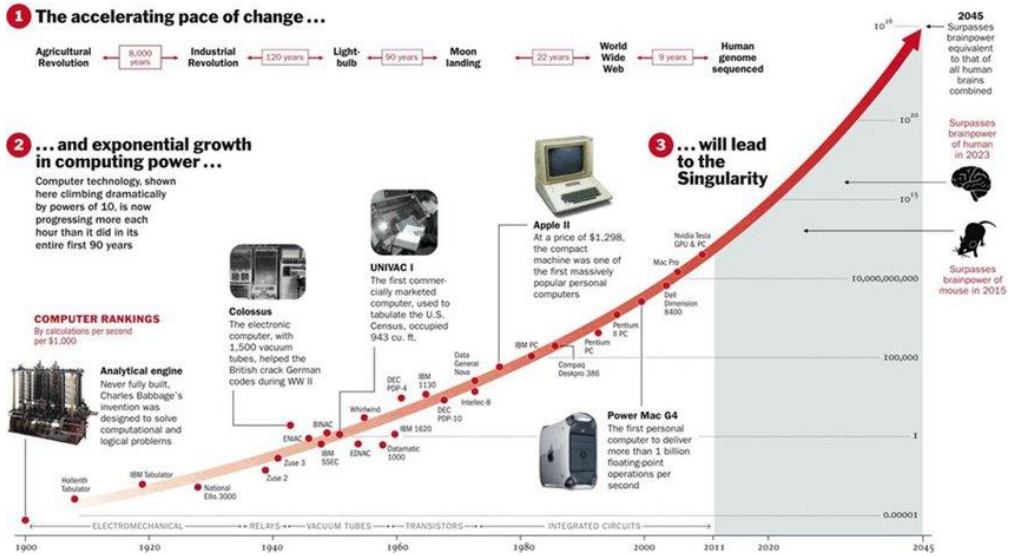
Fig.3: Significant advancements in AI through notable projects across different years; IBM's Deep Blue (1997), the first AI to defeat a world chess champion; AlexNet (2012) a deep learning model that revolutionized image classification; generative Adversarial Networks (2014) introduced a method for creating realistic synthetic data; transformers (2017) reshaped natural language processing with a new sequence processing architecture; OpenAI Five (2018) demonstrated AI's capability to play the complex strategy game Dota 2 and ChatGPT (2022) represents a major leap in conversational AI with advanced language generation capabilities.

Why Machine Learning?

Machine learning has been around for quite some time. However, it is much more in demand right now because:



Growth in data storage[3]

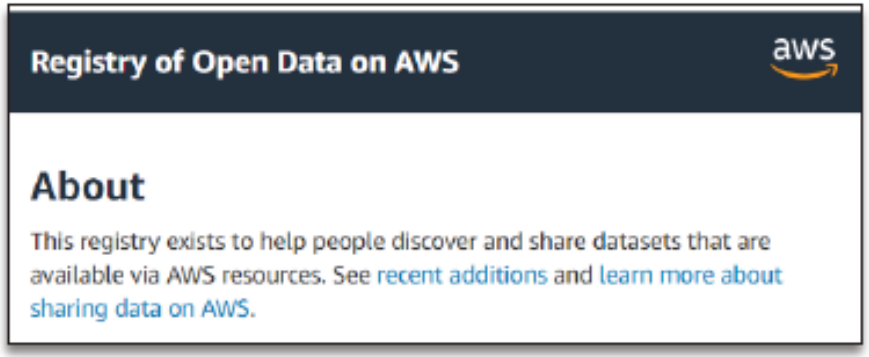


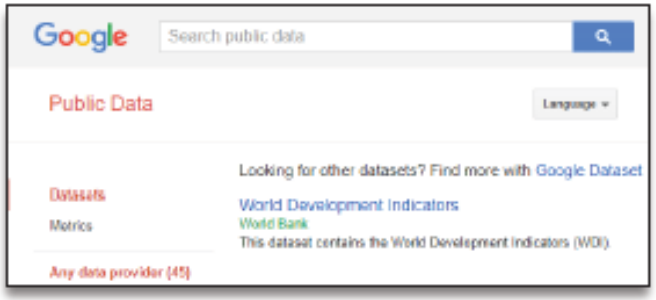
Growth in computing power[4]

[3] *https://medium.com/@veejeah/evolution-of-storage-technologies-from-punched-cards-to-cloud-storage-and-beyond-b6149109dc32*
[4] https://www.researchgate.net/figure/Exponential-growth-of-the-computing-power-Source-Time-Magazine_fig4_318502923

Why Machine Learning?

Popular websites where we can get publicly available data:





Why Machine Learning?

There are three approaches to solve an engineering problem:

- Physics-driven methods
- Knowledge-driven methods
- Data-driven methods

Machine learning is a **data-driven method**.

Why Machine Learning?

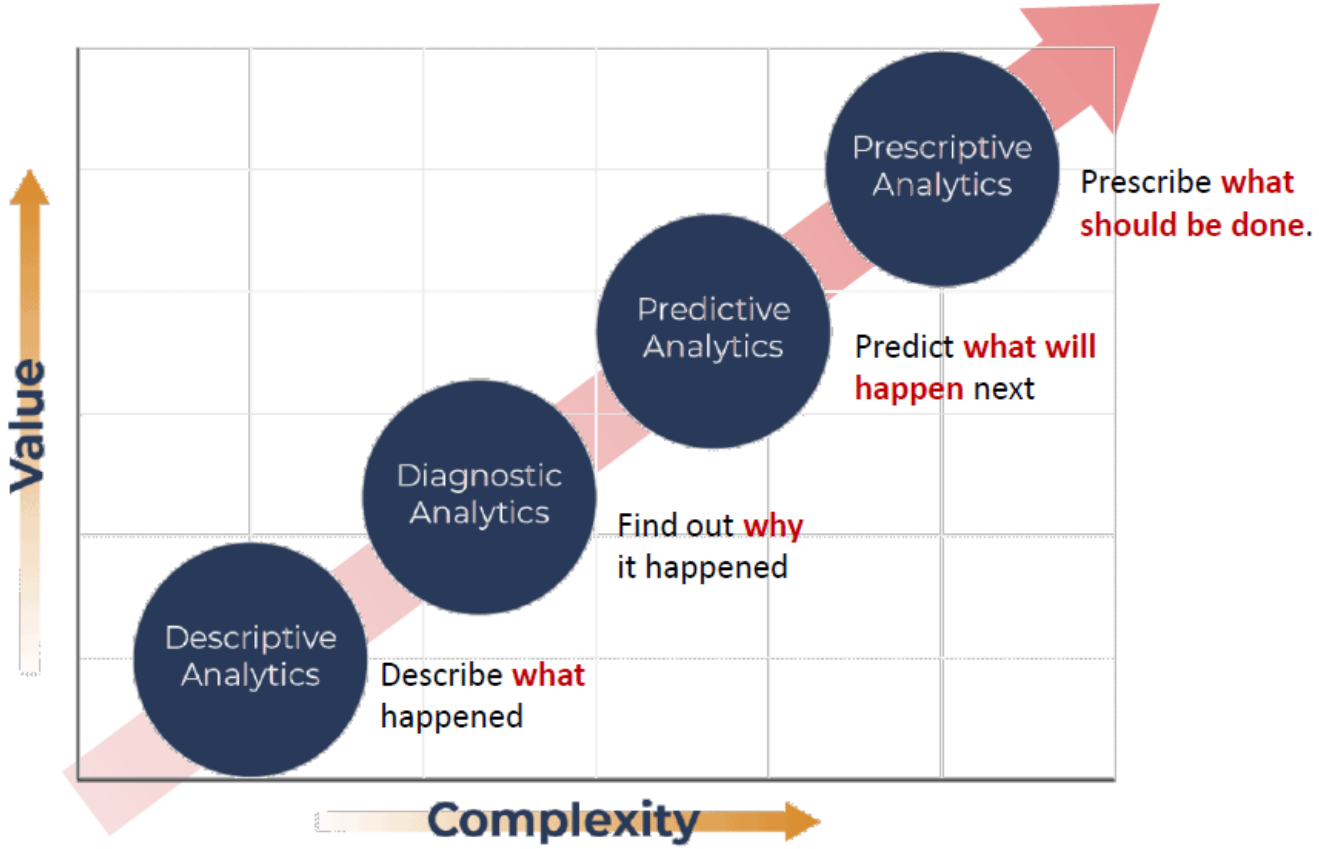


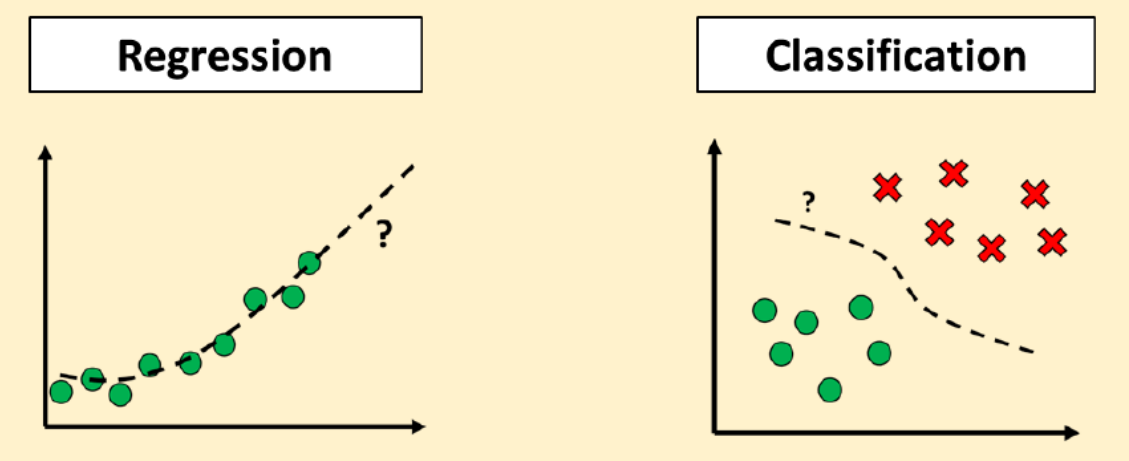
Fig.4: In general, there are four types of analytics, descriptive analytics analyzes historical data to understand past events, patterns, and performance; diagnostic analytics investigates the reasons behind patterns; predictive analytics uses statistical models and machine learning to forecast future outcomes and identify risks and opportunities; and prescriptive analytics recommends optimal actions based on insights from previous stages, guiding decision-making and resource allocation.

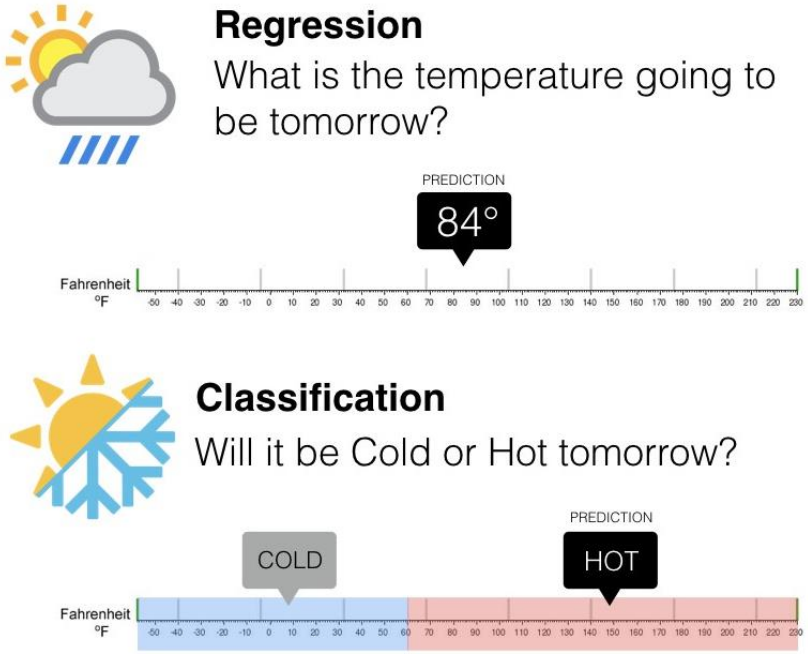
Source: *https://iterationinsights.com/article/understanding-the-different-types-of-analytics/*

Types of Learning Problems

Supervised Learning

Learn a mapping function y = f(x) from inputs (x) to outputs (y), given a *labelled set of input-output examples*.

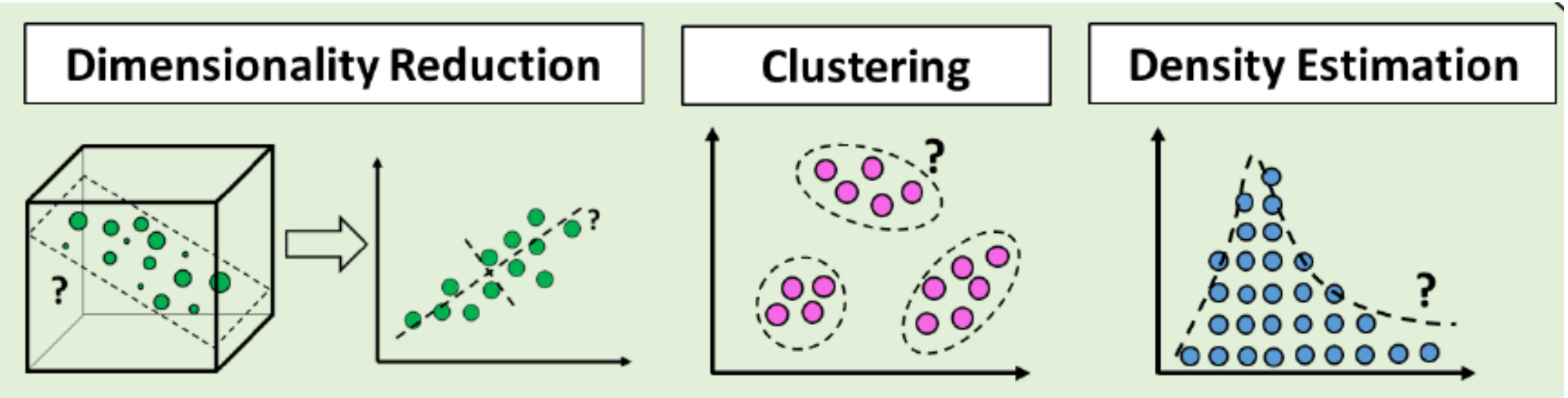




Types of Learning Problems

Unsupervised Learning

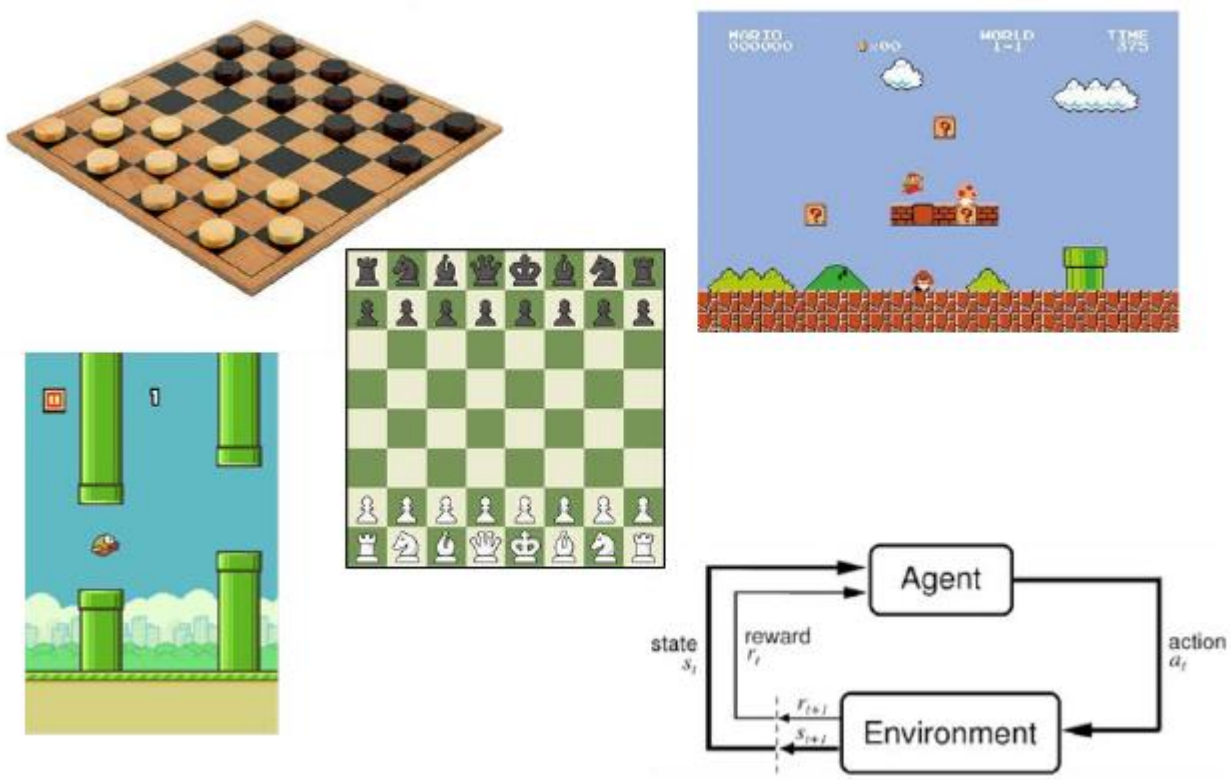
Discover patterns or structure from a dataset without any label or information.



Types of Learning Problems

Reinforcement Learning

Learn by interacting with an environment.



Types of Learning Problems

Example 1

Given the weight of the car, its model year, and horsepower, predict its mileage in miles per gallon (mpg).

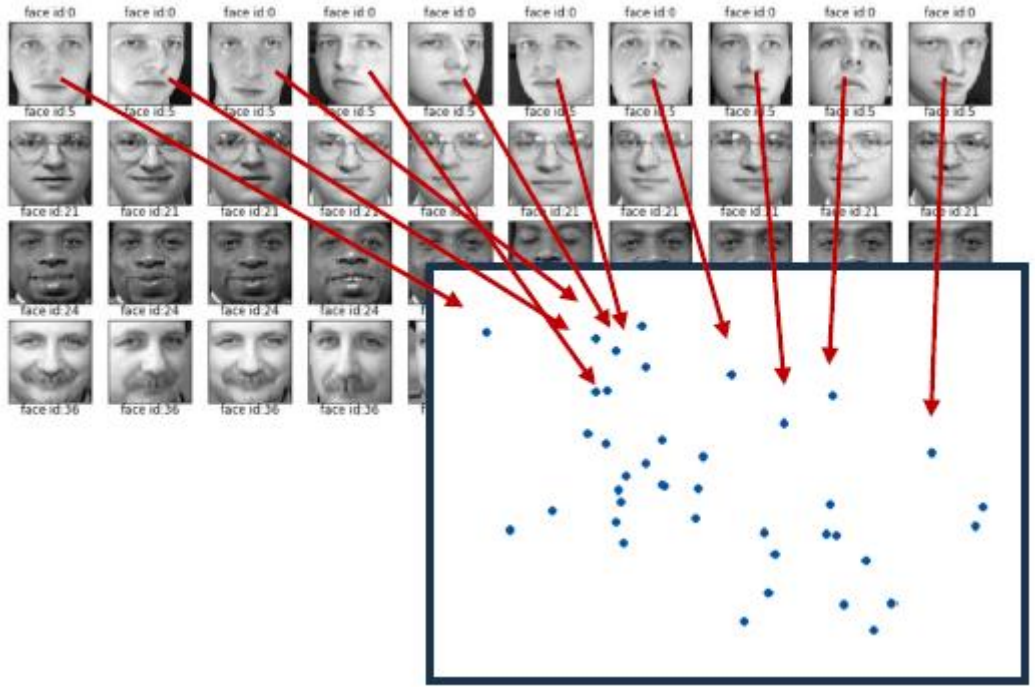
car_weight	model_year	horsepower	mileage
1522 kg	2020	150	18 mpg
1930 kg	2017	185	16 mpg
1321 kg	2018	200	21 mpg
2128 kg	2019	168	?
2498 kg	2018	170	15 mpg
1882 kg	2021	155	17 mpg
1956 kg	2019	190	?
1672 kg	2017	182	18 mpg

Answer: Regression

Types of Learning Problems

Example 2

Given images of faces with varying poses and expressions, map each image onto a 2D point so that similar-looking images are closer together on the map.



Answer: Dimensionality reduction

Types of Learning Problems

Example 3

Given a tweet, predict whether the sentiment is positive, negative, or neutral.

Tweet	Sentiment
I'm in pain...	Negative
Manifesting a promotion this year!	Positive
It's 2AM. Who's awake?	Neutral
Heavy traffic at EDSA	Negative
Family dinner... So full!	Positive
Spoiler alert: RIP Tony Stark	?
Tesla sucks!	?
It's a boy!	Positive

Answer: Classification

Types of Learning Problems

Example 4

Given student grades in 5 subjects: Math, Chemistry, Physics, English, and Reading, group the students with similar competencies.

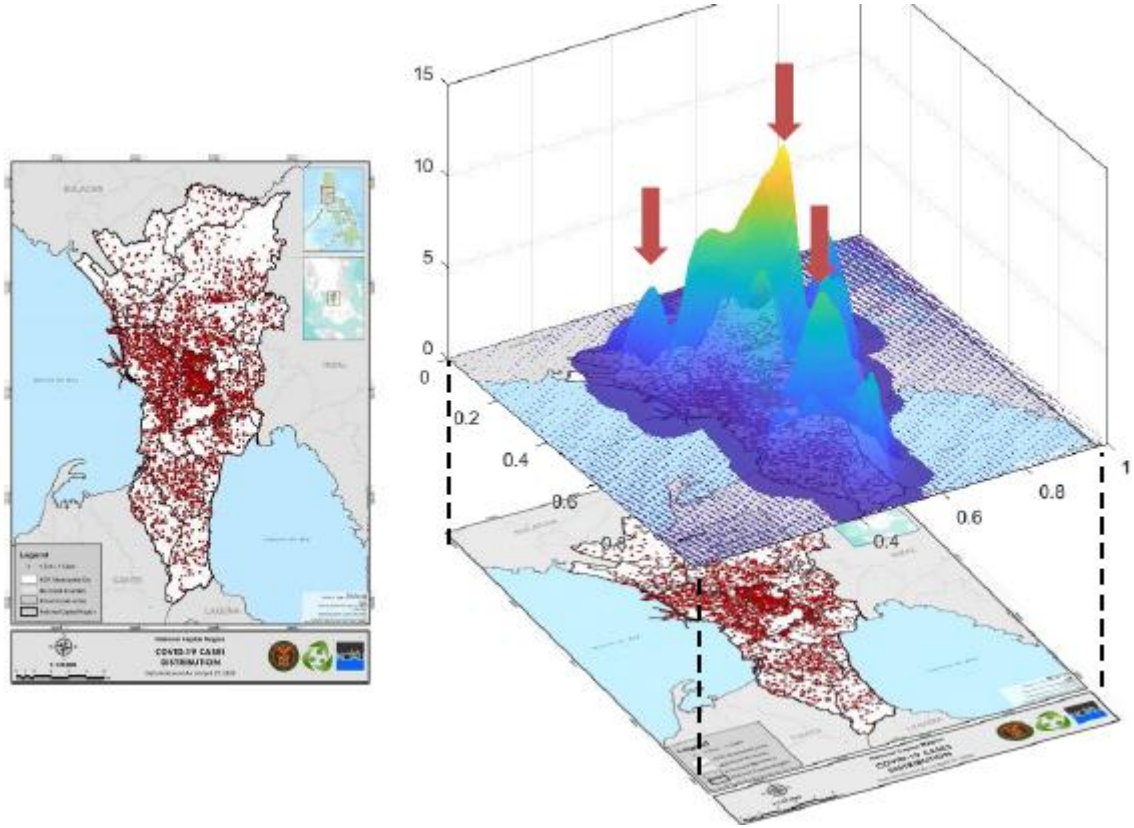
Student	Math	Chemistry	Physics	English	Reading
1	81	85	88	94	92
2	95	80	94	93	85
3	92	94	89	81	80
4	94	83	90	91	84
5	88	84	90	97	95
6	90	93	88	85	82
7	92	94	91	87	81
8	87	82	85	93	94

Answer: Clustering

Types of Learning Problems

Example 5

Given the spatial occurrence of Covid cases in Metro Manila, find the area with the most cases.

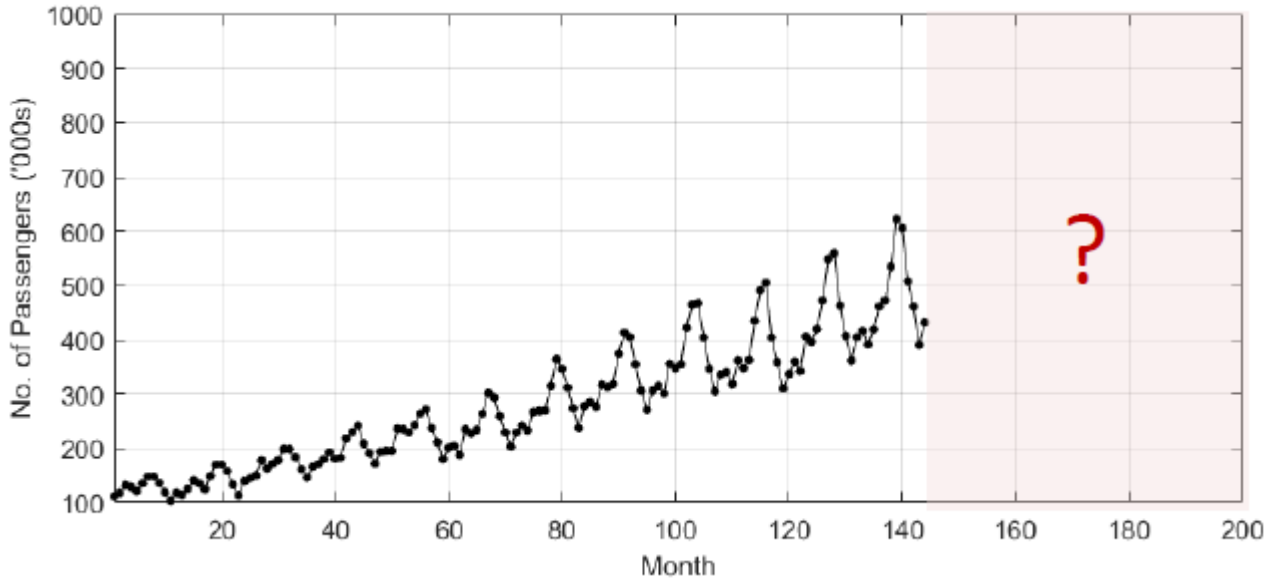


Answer: density estimati

Types of Learning Problems

Example 6

Given the number of airline passengers in the previous months, predict the number of passengers for the next few months.

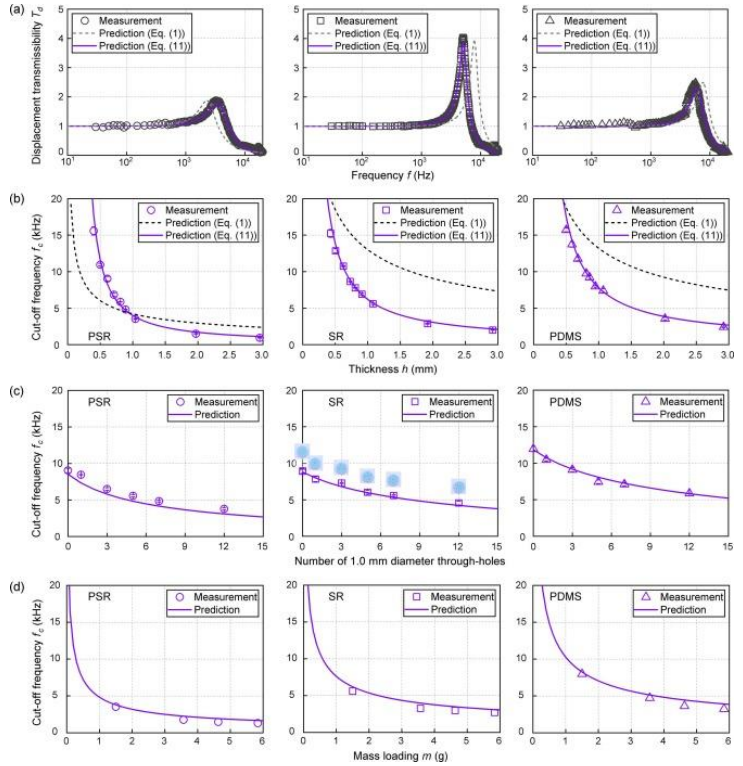


Answer: regression

Types of Learning Problems

Example 7

Given the frequency response and physical characteristics (e.g., material type, dimensions) of various RF filters, map them onto a 3D space based on their similarities, then predict their cutoff frequencies.



Answer: dimensionality reduction and regression

Thank You!