Applied AI & Machine Learning
CS-333

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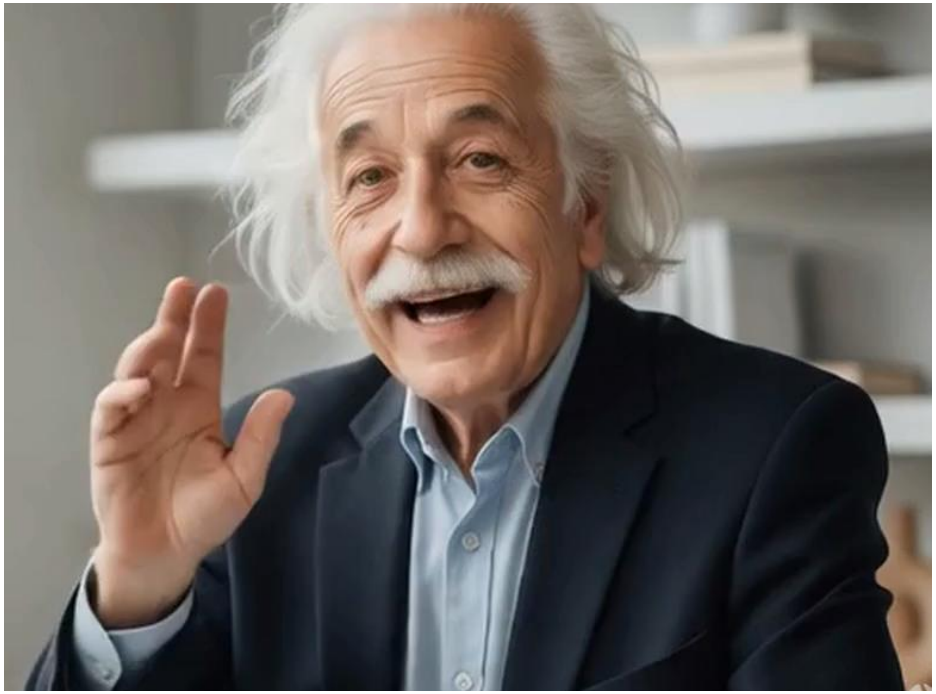
PNEC, NUST

Lecture 1

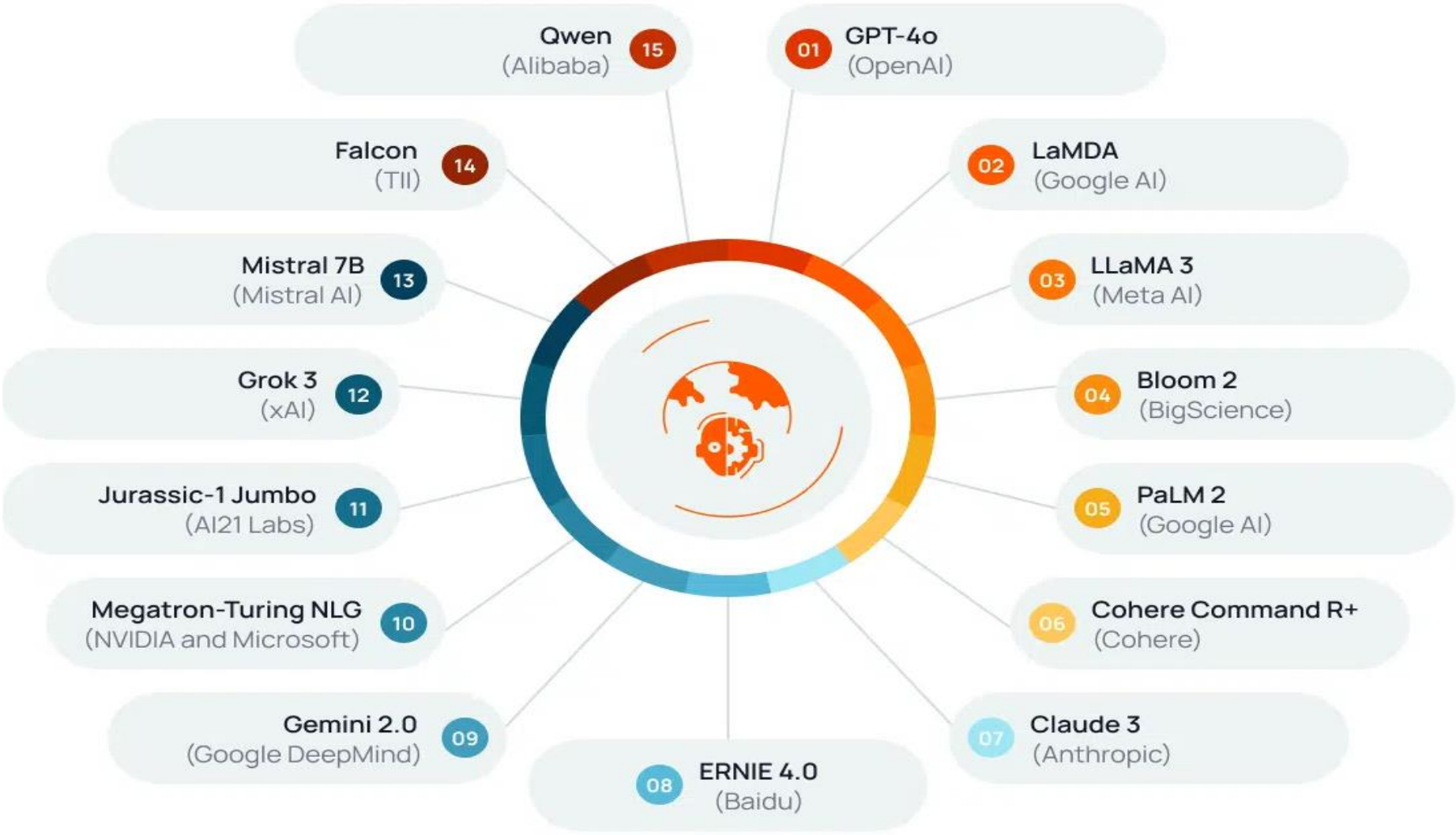
Spring 2026

“Observing” the progress of AI over the years

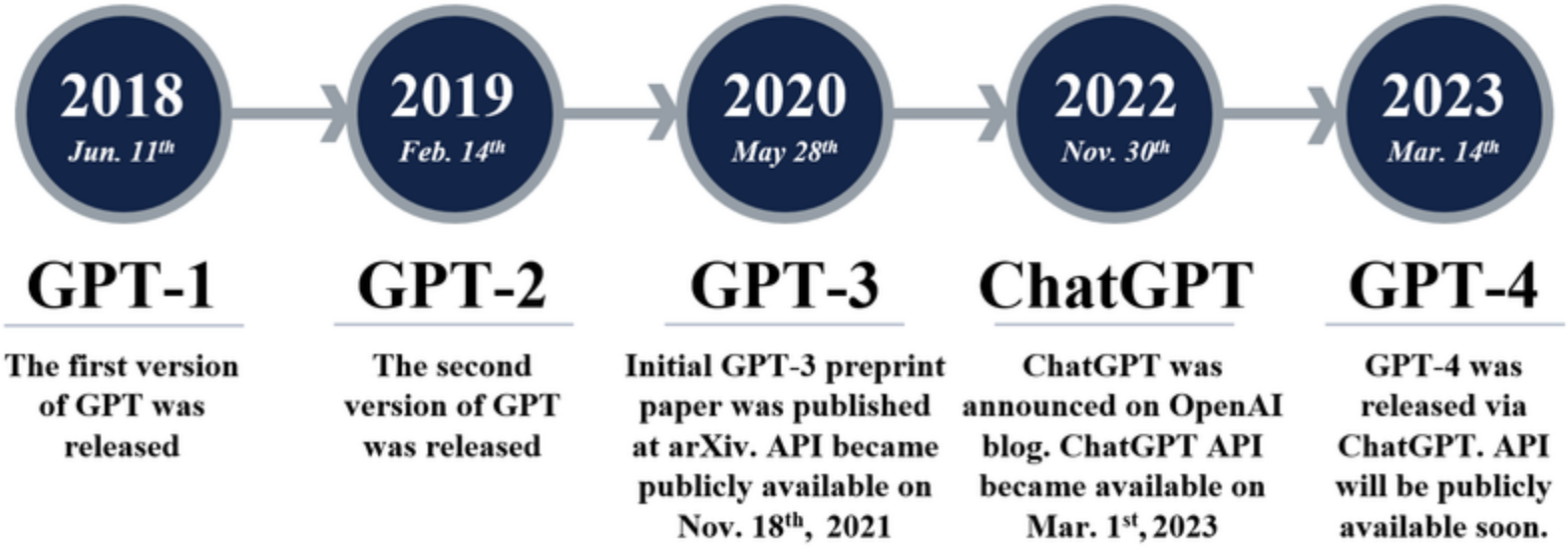


AI avatar video

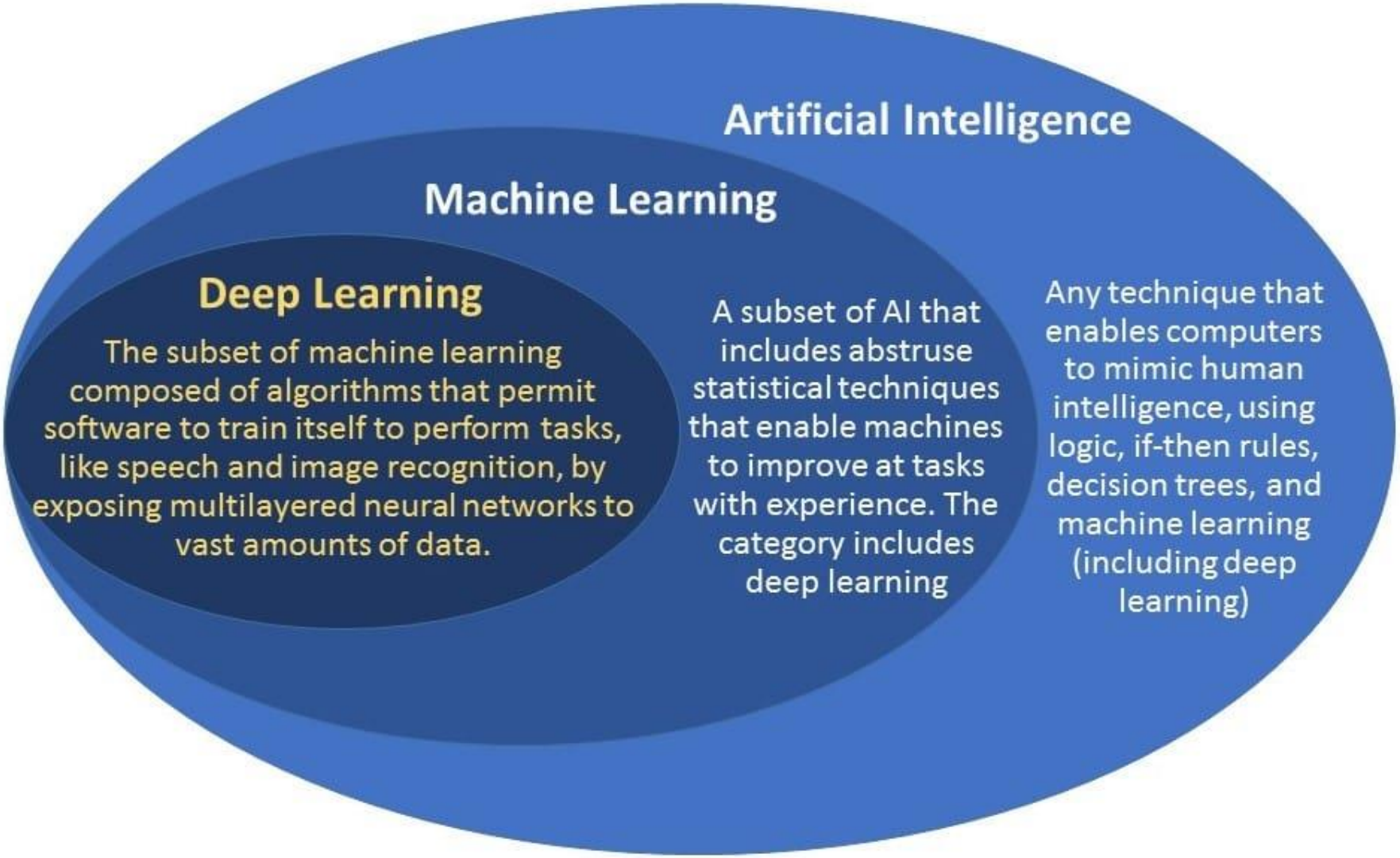
Language has transformed the way that we interact with AI



Language has transformed the way that we interact with AI



What is ?



Teaching computers how to **learn a task** directly from **raw data**

Lecture Content

- Introduction to Machine Learning
- SVM and Softmax loss
- Stochastic Gradient Descent
- Computer Vision Basics
- Image analysis
- Feature extraction and processing
- Shallow neural network
- Introduction to Deep learning
- Backpropagation in neural networks
- Dropout, Batch normalization and optimization
- ML Explainability

Course Evaluation

Quiz, OHT, Final

Labs: Google Colab

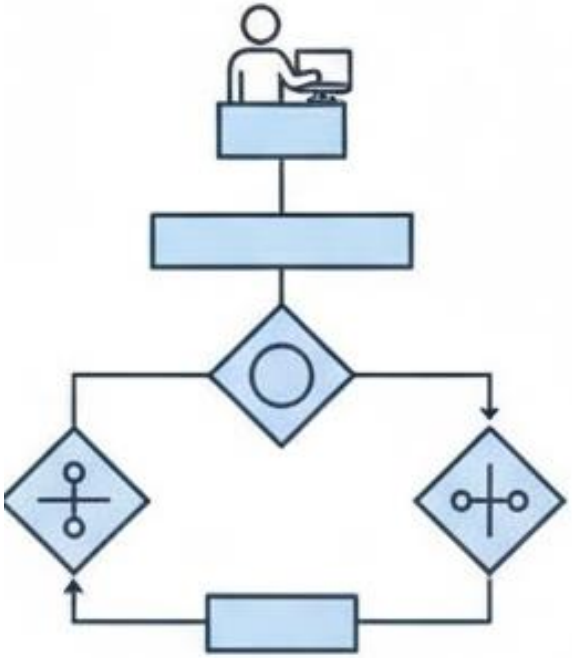
Final Capstone Project (Competitions)

Why AI and ML and Why Now?

Why AI and ML ?

It help us learn from **data** to make **accurate predictions** and smarter decisions **automatically**.

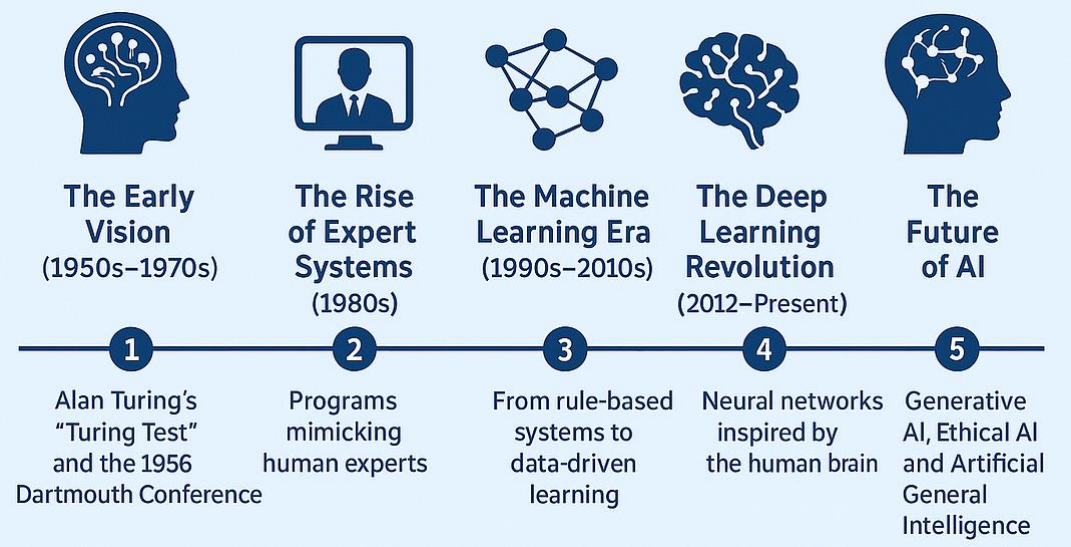
Data is everywhere



In short AI / ML learns patterns from data and helps solve real problems

Traditional Programming has limits

Why Now?



AI dates back decades, so why the dominance?

1. Big Data

- Larger Datasets
- Easier Collection & Storage

IMAGENET

WIKIPEDIA

2. Hardware

- Graphics Processing Units (GPUs)
- Massively Parallelizable

3. Software

- Improved Techniques
- New Models
- Toolboxes

Introduction to ML

Learning objectives:

1) Understand the different types of machine learning.

2) Understand the key concepts of supervised machine learning.

3) Learn how solving problems with ML is different from traditional approaches.

What is ML?

ML is the process of training a piece of software, called a model, to make useful predictions or generate content (like text, images, audio, or video) from data.

For example, **create an app to predict rainfall**. We could use either a traditional approach or an ML approach.

Using a traditional approach

- create a physics-based representation of the Earth's atmosphere and surface, computing massive amounts of fluid dynamics equations. This is incredibly difficult.

Using an ML approach

- ML model enormous amounts of weather data until the ML model eventually *learned* the mathematical relationship between weather patterns that produce differing amounts of rain. We would then give the model the current weather data, and it would predict the amount of rain.

Some examples of tasks that are best solved by using a learning algorithm

- Recognizing patterns:
  - Facial identities or facial expressions
  - Handwritten or spoken words
  - Medical images
- Generating patterns:
  - Generating images or motion sequences
- Recognizing anomalies:
  - Unusual credit card transactions
  - Unusual patterns of sensor readings in a nuclear power plant
- Prediction:
  - Future stock prices or currency exchange rates

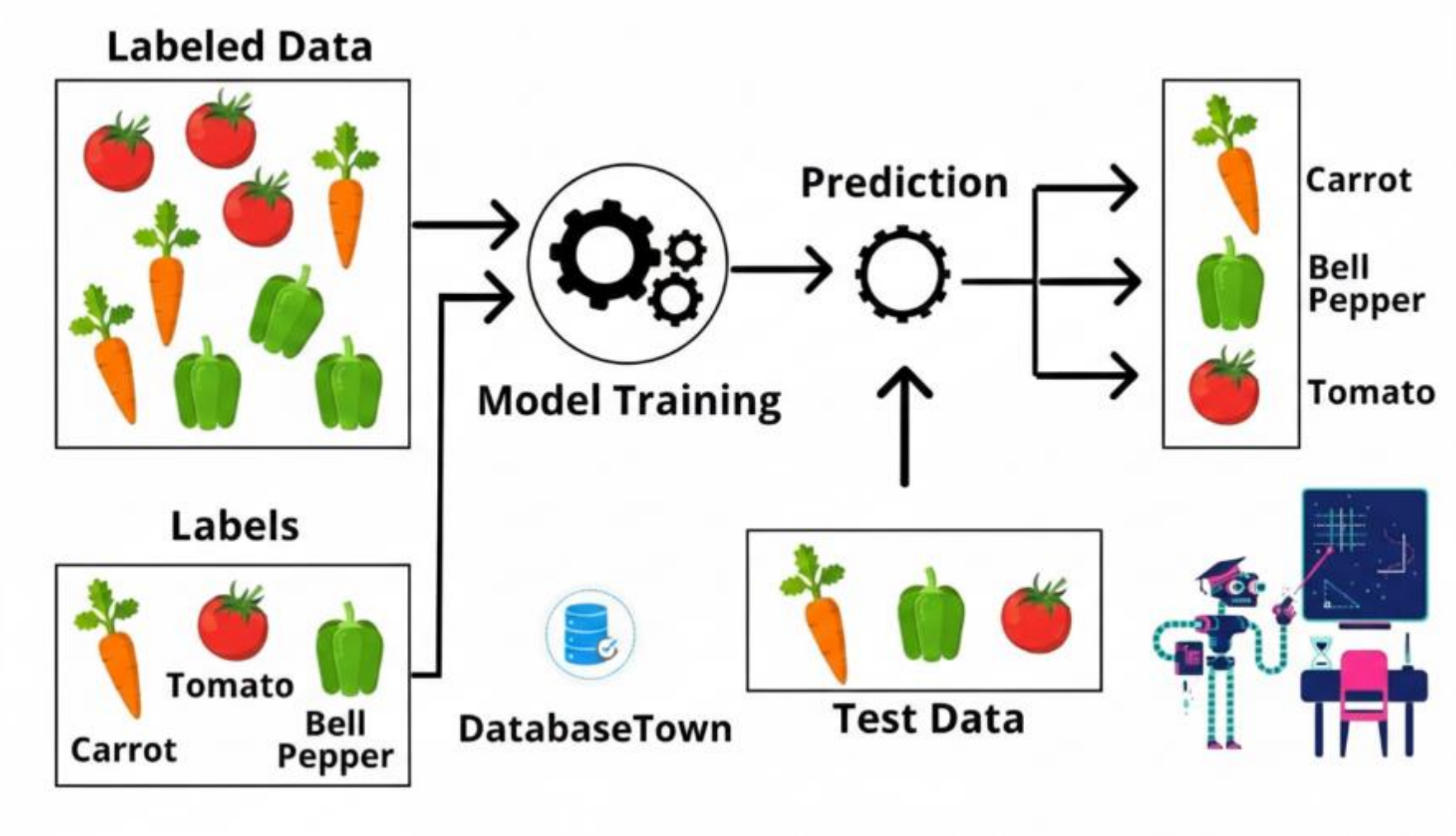
Type of ML Systems

ML systems fall into one or more of the following categories based on how they learn to make predictions or generate content:

- Supervised learning
- Unsupervised learning
- Reinforcement learning
- Generative AI

Supervised learning

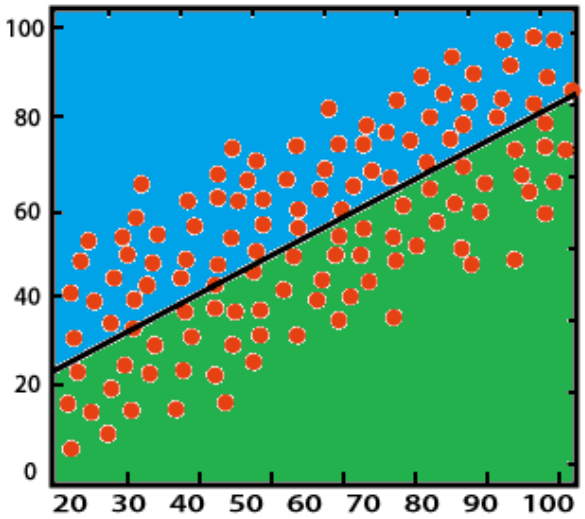
Supervised learning trains a model on labeled data (correct answers) to learn patterns and predict outcomes for new, unseen data.

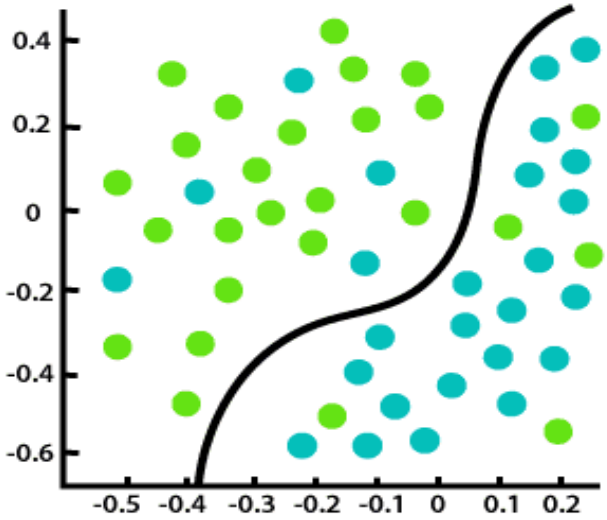


Supervised learning

Two of the most common use cases for supervised learning are **regression** and **classification**.

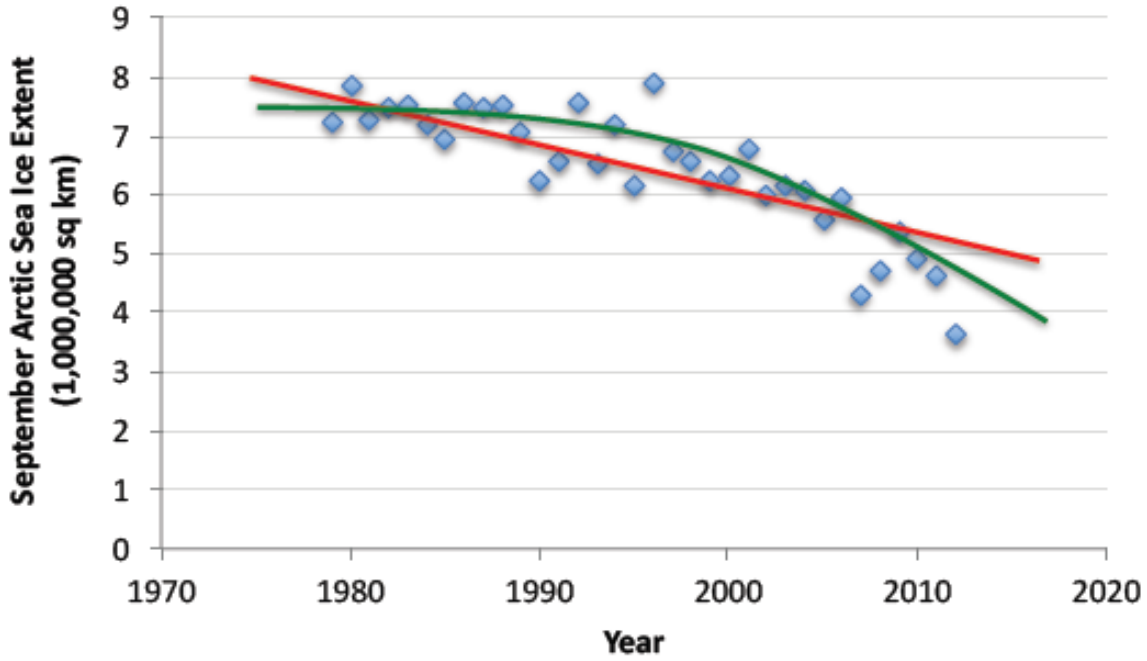
- A **regression model** predicts a numeric value. For example, a weather model that predicts the amount of rain, in inches or millimeters, is a regression model.
- **Classification models** predict the likelihood that something belongs to a category.





Supervised Learning: Regression

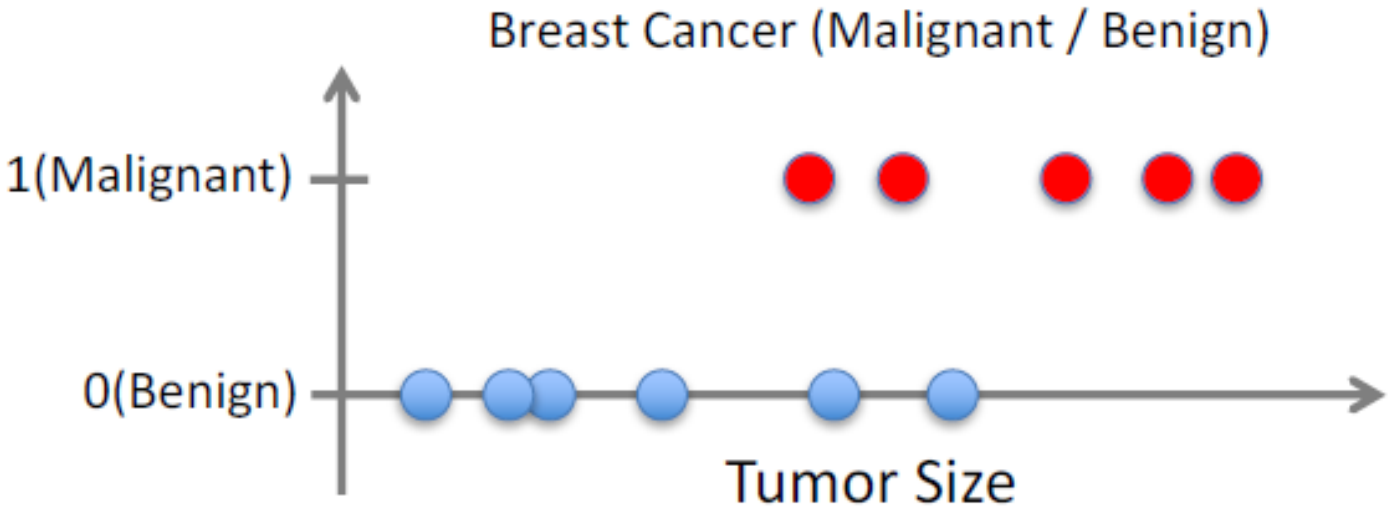
- Given $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$
- Learn a function $f(x)$ to predict y given x
  - y is real-valued == regression



Data from G. Witt. Journal of Statistics Education, Volume 21, Number 1 (2013)

Supervised Learning: Classification

- Given $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$
- Learn a function $f(x)$ to predict y given x
  - y is categorical == classification

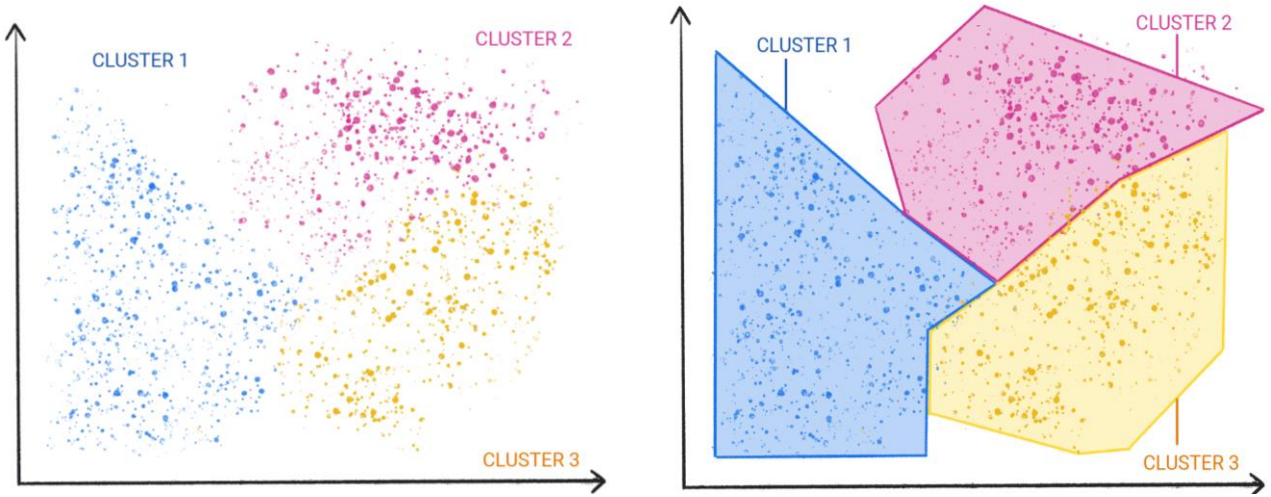


Unsupervised learning

Unsupervised learning models make predictions by being given data that does not contain any correct answers

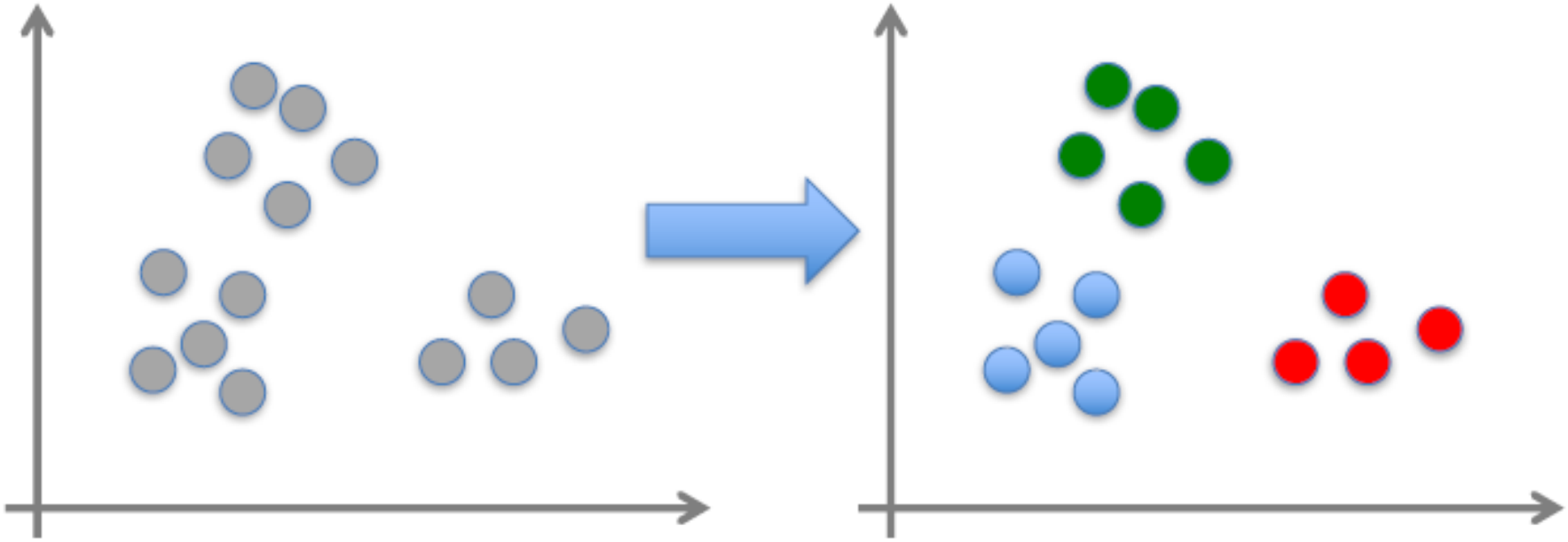
- An unsupervised learning model's goal is to identify meaningful patterns among the data. In other words, the model has no hints on how to categorize each piece of data, but instead it must infer its own rules.

- A commonly used unsupervised learning model employs a technique called clustering. The model finds data points that demarcate natural groupings.



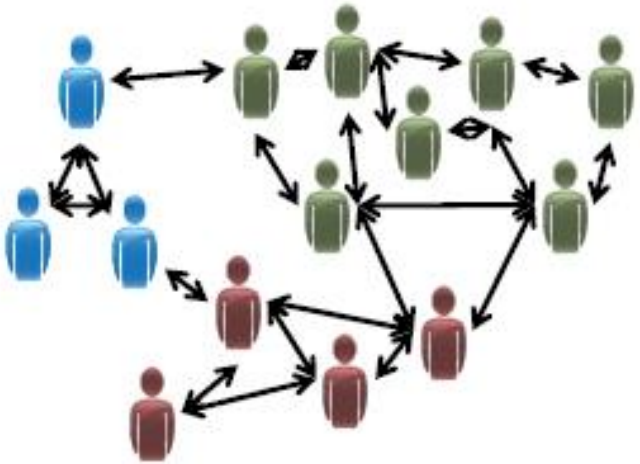
Unsupervised Learning

- Given $x_1, x_2, \ldots, x_n$ (without labels)
- Output hidden structure behind the x's
  - E.g., clustering



Unsupervised Learning

Organize computing clusters



Social network analysis

Market segmentation

Astronomical data analysis

Reinforcement learning

Reinforcement learning models make predictions by getting rewards or penalties based on actions performed within an environment.

- A reinforcement learning system generates a policy that defines the best strategy for getting the most rewards.
- Reinforcement learning is used to train robots to perform tasks, like walking around a room, and software programs like AlphaGo to play the game of Go.

https://www.geeksforgeeks.org/machine-learning/what-is-reinforcement-learning/

Reinforcement Learning

- Given a sequence of states and actions with (delayed) rewards, output a policy
  - Policy is a mapping from states → actions that tells you what to do in a given state
- Examples:
  - Credit assignment problem
  - Game playing
  - Robot in a maze
  - Balance a pole on your hand

Generative AI

Generative AI is a class of models that creates content from user input. For example, generative AI can create unique images, music compositions, and jokes; it can summarize articles, explain how to perform a task, or edit a photo.

For example, the following is a partial list of some inputs and outputs for generative models:

- Text-to-text
- Text-to-image
- Text-to-video
- Text-to-code
- Text-to-speech
- Image and text-to-image

Foundational supervised learning concepts

Supervised machine learning is based on the following core concepts:

- Data
- Model
- Training
- Evaluating
- Inference

Foundational supervised learning concepts

Data

Data is the driving force of ML. Data comes in the form of words and numbers stored in tables, or as the values of pixels and waveforms captured in images and audio files.
We store related data in datasets. For example, we might have a dataset of the following:

- Images of cats
- Housing prices
- Weather information

- Datasets are made up of individual examples that contain features and a label.
- Examples that contain both features and a label are called labeled examples.

Foundational supervised learning concepts

Data

Features

Label

date	lat	long	temp	humidity	cloud_coverage	wind_direction	atmp_pressure	rainfall
2021-09-09	49.71N	82.16W	74	20	3	N	18.6	.01
2021-09-09	32.71N	117.16W	82	42	6	SW	29.94	.23

Example

Features

date	lat	long	temp	humidity	cloud_coverage	wind_direction	atmp_pressure
2021-09-09	49.71N	82.16W	74	20	3	N	18.6
2021-09-09	32.71N	117.16W	82	42	6	SW	29.94

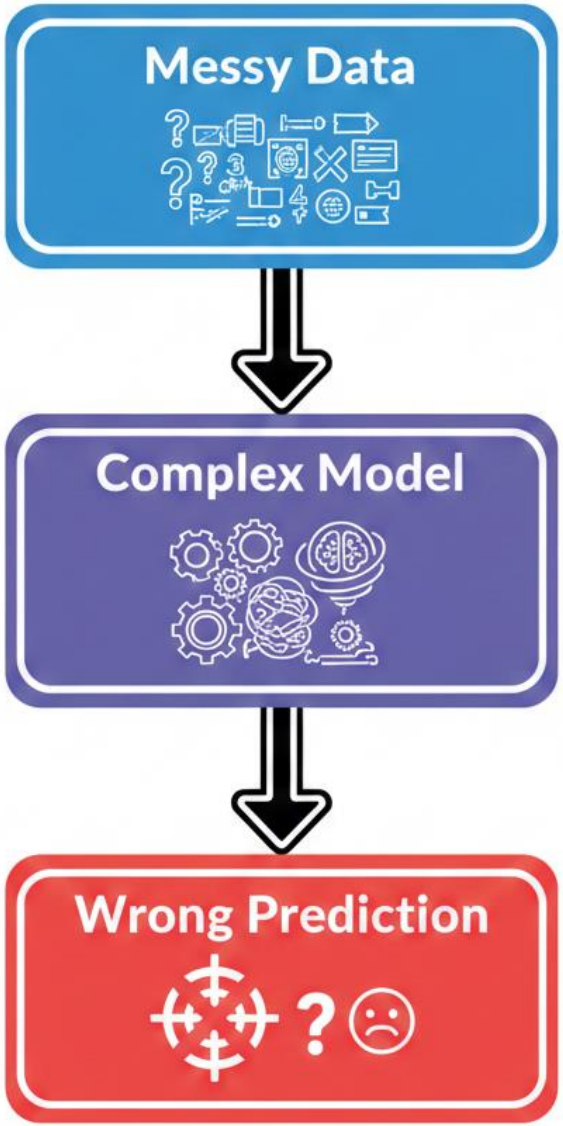
Example

Foundational supervised learning concepts

Why Data Matters

"Garbage In ⟶ Garbage Out"

- 80% of an ML Engineer's time is spent cleaning and preparing data.



Types of Data

- **Structured:** Highly organized (Excel, SQL tables).
- **Semi-Structured:** Tags and markers (JSON, XML).
- **Unstructured:** The 'Wild West' (Images, Audio, Video, PDFs).

Foundational supervised learning concepts

Let Consider this data

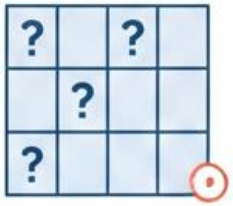
Spot the Flaws

ID	Age	Salary	City	Purchased?
1	25	$50k	NY	Yes
2	?	$1M	LA	No
3	25	$50k	NY	Yes
4	30	-$5k	SF	Yes

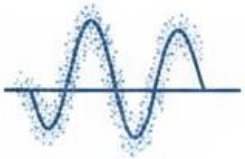
Missing values (?), Outliers ($1M), Duplicates (Row 1 & 3), Errors (-$5k), and Noise

Foundational supervised learning concepts

Missing Values: Gaps in knowledge

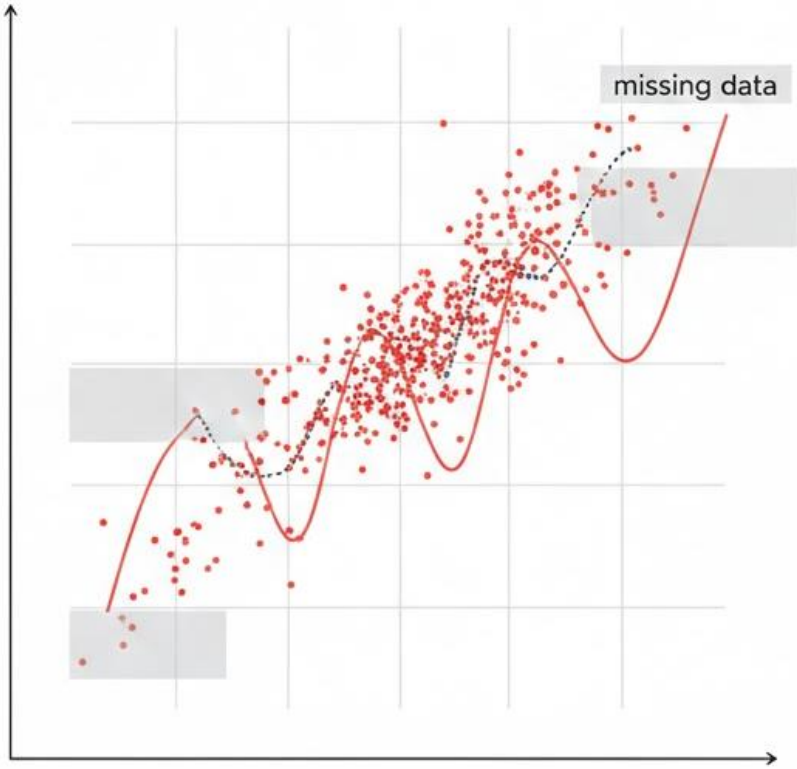


Noise: Random "static" in the data.



Outliers: Data points that livat live of another planet.

Visual:



Foundational supervised learning concepts

Exploratory Data Analysis (EDA)

- **What is it?** "Interviewing" your data before you use it
- **Key Tools:**
  - **Summary Stats:** Mean, Median, Std Dev.
  - **Distributions:** Is the data balanced?
  - **Correlations:** Do two things move together?