1. Supervised Learning:

It is defined as learning by example so, It is a type of machine learning where a model is trained on labelled data. Training data consists of both input data and output.

Example 1:

Predicting Fruit Type

Let us consider we have a basket of fruits, and we want to teach our computer to identify whether a fruit is an apple or an orange. Step by step use of supervised learning to do this:

Collection of Data: We have a basket of fruits and labelled them as

- Apple: Red, Round
- Orange: Orange, Round
- Apple: Green, Round
- Orange: Orange, Rough

And this labelled data is our **training data.**

Training the Model: We send this data into a machine learning algorithm. The algorithm analyses the features (colour and shape) and learns the patterns that differentiate between apples from oranges.

Making Predictions: After training, we can give the model a new fruit with certain features (e.g., Red, Round), and it will predict whether it is an apple or an orange based on what it has learned.

Example 2:

Email spam detection:

- **Data Collection:** We have a dataset of emails labelled as "spam" or "not spam."
- **Training:** The algorithm learns from the features of these emails (e.g., certain words, sender information).
- **Prediction:** For a new email, the model predicts whether it is spam or not based on the learned patterns.

Summary:

We can summarise supervised learning into three bullet points:

- **Training Data:** Labelled data (input-output pairs).
- **Learning:** The algorithm learns the relationship between inputs and outputs.
- **Prediction:** The model can predict the output for new inputs based on what it has learned.

2. Unsupervised Learning:

Unsupervised learning is a type of machine learning where the algorithm is trained on data without labelled input.

In other words, the data given to the algorithm does not have any predefined labels or outcomes. The goal of unsupervised learning is to find hidden patterns.

Example 1:

Let us consider we have a basket of mixed fruits, but we don't know what types of fruits are in there. We only know the attributes of each fruit, such as colour, size, and shape**.**

Steps in Unsupervised Learning:

1. **Data Collection**: Gather the attributes of each fruit in the box.
    - Apple: Red, Round, Medium
    - Banana: Yellow, Long, Medium
    - Grape: Purple, Round, Small
    - Orange: Orange, Round, Medium
    - Lemon: Yellow, Oval, Small
2. **Algorithm Processing**: Send these attributes into an unsupervised learning algorithm, like clustering.
3. **Pattern Discovery**: The algorithm processes the data and groups similar items together based on their features.

Clustering Example:

The algorithm group the fruits like this:

- **Cluster 1**: Apple, Orange (similar in size and shape)
- **Cluster 2**: Banana (unique in shape)
- **Cluster 3:** Grape, Lemon (similar in small size)

In this example:

- **Cluster 1** includes fruits that are medium-sized and round.
- **Cluster 2** includes the unique long fruit.
- **Cluster 3** includes small-sized fruits.

Real-World Applications:

- **Customer Segmentation**: Grouping customers based on purchasing behaviour.
- **Market Basket Analysis**: Identifying items frequently bought together.
- **Anomaly Detection**: Detecting unusual patterns in data, like fraud detection.

Summary:

- **No Labels**: There are no predefined labels or categories in the input data.
- **Pattern Recognition**: The goal is to identify patterns or groupings in the data.
- **Decisions**: Decisions are made on the basis of the data's attributes

Unsupervised learning helps us understand the structure of the data and can be used to make decisions based on that structure.

It’s like sorting things into groups based on their attributes without knowing what each group has in advance.

3. Reinforcement Learning:

Reinforcement Learning is a type of machine learning where an agent learns to make decisions by performing actions in an environment to achieve some goal.

The agent receives rewards or penalties based on its actions, and its objective is to maximise the total reward over time.

Key Concepts

- Agent: The learner or decision-maker (e.g., a robot).
- Environment: The world with which the agent interacts (e.g., a room).
- Action: What the agent can do (e.g., move left or right).
- State: A situation or position in the environment (e.g., the current location of the robot).
- Reward: Feedback from the environment based on the action taken (e.g., +1 for reaching a goal, -1 for hitting a wall).

Example 1: Teaching a Dog to Sit

I have a dog named Kitto, and I want to teach it to sit on command.

Key Concepts

- **Agent:** Kitto.
- **Environment:** The space where me and Kitto are interacting**.**
- **Action:** Kitto sits or does something else**.**
- **State:** The current situation, which includes whether Kitto is sitting or not.
- **Reward:** A treat or praise when the dog sits on command.

Process:

Initial Situation: Kitto is standing.

Command: I commanded "Sit."

Action: Kitto may sit or do something else.

Reward/Penalty:

If Kitto sits, I give her a treat (positive reward).

If Kitto does not sit, no treat is given (neutral response or penalty).

Learning: Over time, the dog learns that sitting on command results in a treat.

Learning Loop

Repeat: I repeat this process multiple times.

Observation: Kitto starts to respond to the command "Sit" with the action of sitting and receiving a treat.

Behaviour Change: Eventually, Kitto learns to sit whenever I give the command to her to gain reward.

Real-World Example: Self-Driving Cars

Scenario

Consider a self-driving car navigating through some city.

Key Concepts

Agent: The self-driving car.

Environment: The city streets, including other vehicles, pedestrians, traffic lights, etc.

Actions: The car can accelerate, brake, turn left, turn right, etc.

State: The current conditions of the car and its surroundings (e.g., speed, position, nearby obstacles).

Reward: Positive rewards for safe driving behaviours (e.g., staying in the lane, stopping at red lights) and penalties for unsafe behaviours (e.g., near collisions, running red lights).

Process

Initial Situation: The car starts at a certain location and needs to reach a destination.

Action Selection: The car chooses an action based on its current state (e.g., accelerate slightly, turn left).

State Change: The car moves to a new state based on the action taken (e.g., it moves forward).

Reward/Penalty:

If the car follows traffic rules and avoids obstacles, it receives a positive reward.

If the car violates traffic rules or comes close to a collision, it receives a penalty.

Learning: The car updates its knowledge to improve future decisions.

Learning Loop

Repeat: The car drives through many scenarios, continuously learning from its experiences.

Observation: The car starts to understand the best actions to take in various situations to maximise its rewards.

Behaviour Change: Over time, the car improves its driving behaviour, becoming safer and more efficient at navigating the streets.

Example: Tesla (Driver less cars)

Summary:

In example 1, Kitto learns to sit on command through positive reinforcement (treats).

In the real-world example, self-driving cars learn to navigate city streets safely by receiving rewards for good driving and penalties for unsafe actions.

Reinforcement learning in both cases involves an agent learning from its environment by taking actions and receiving feedback, Over course of timing improving its behaviour to maximise positive outcomes.

4. Classification vs Regression vs Clustering

The difference between Classification, Regression and Clustering are listed in table below:

Feature	Classification	Regression	Clustering
Definition	Predicting categories	Predicting numbers	Grouping similar items
Output Type	Categories (e.g., red, blue, green)	Numbers (e.g., 3.5, 7.2)	Groups (e.g., group 1, group 2)
Purpose	Sort items into classes	Estimate a value	Find natural groupings in data
Example Algorithms	Decision Trees, KNN	Linear Regression	K-Means, Hierarchical Clustering
Example Use Cases	1.Email spam detection 2. Classify images of animals	1. Predict house prices 2. Forecast sales	1. Group customers by behaviour 2.Segment market data