MPSSDEGB
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FITT
Foundation For Innovation And Technology Transfer

SANKALP
Ministry of Skill Development & Entrepreneurship

# Day 3 - Machine Learning Continuation

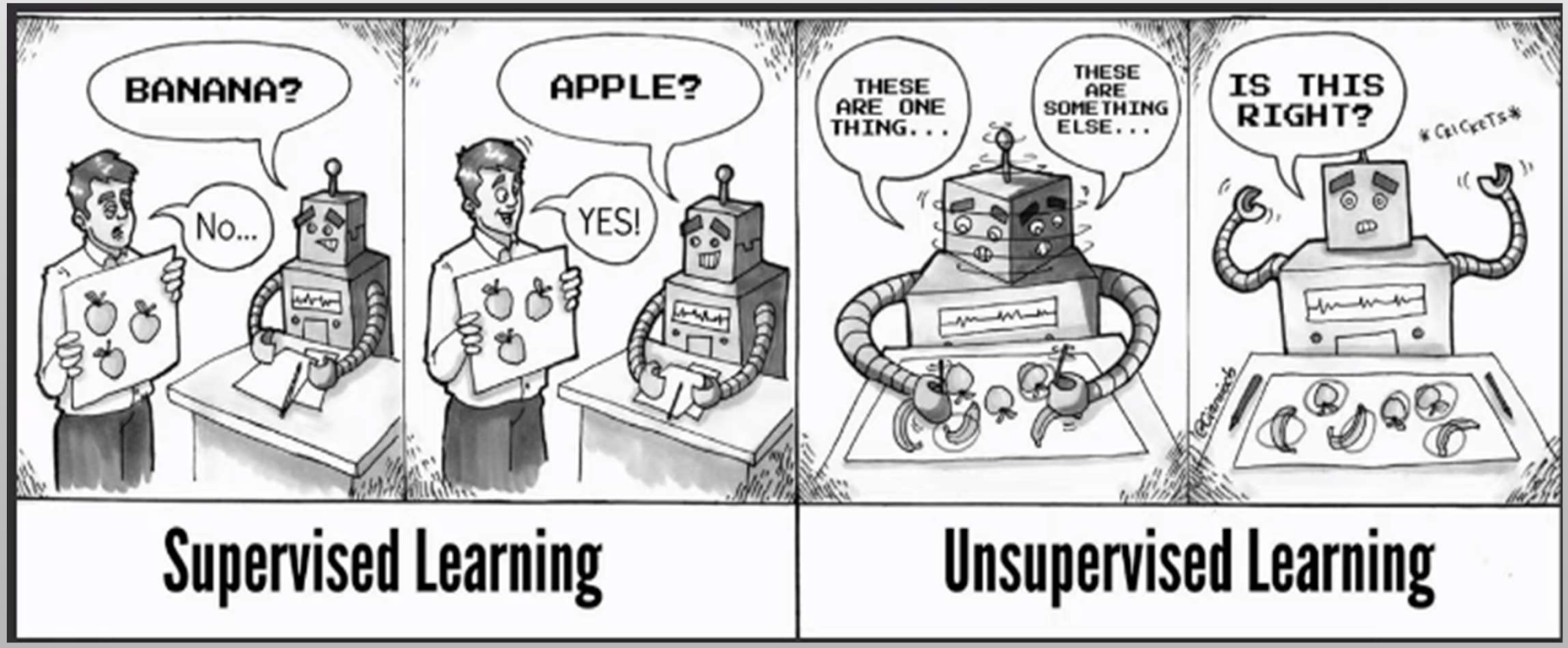
# Contents

1. Unsupervised Learning and Algorithms
2. Reinforcement Learning Introduction
3. Interactive simulation demonstration.
4. Q&A and reflection on learning applications.

# Unsupervised Learning

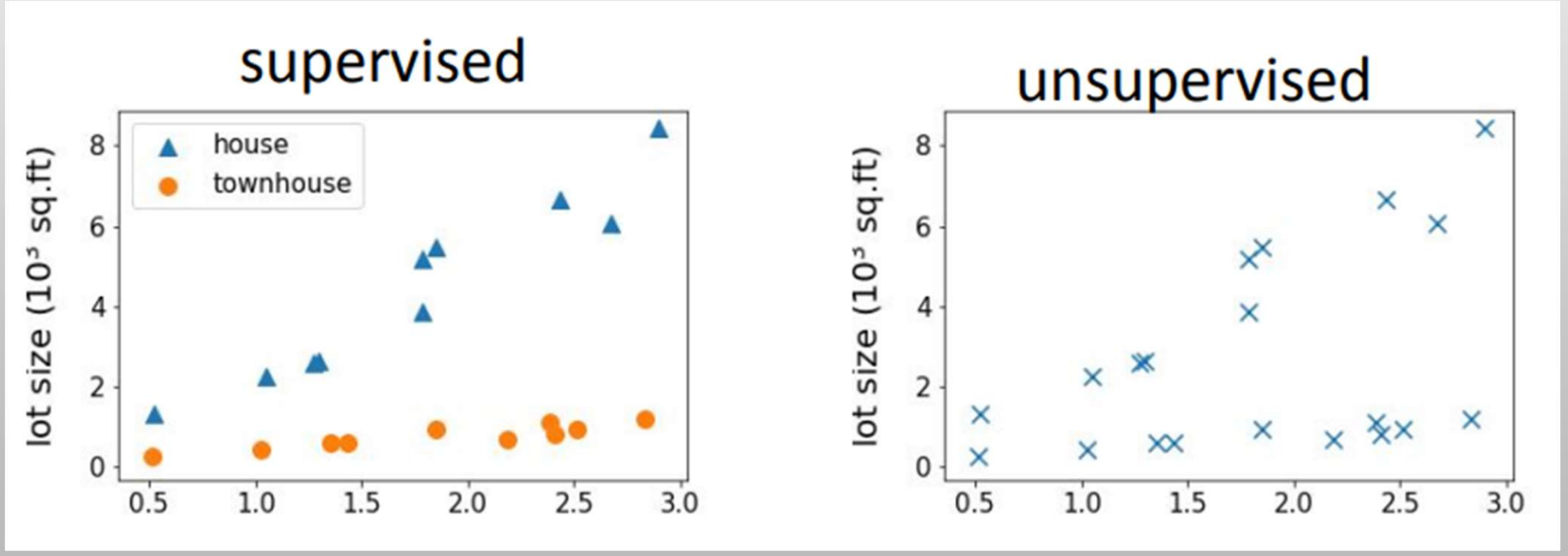
## What is Unsupervised Learning?

Unsupervised learning is a machine learning technique, where we do not need to supervise the model,Instead of that we need to encourage the model to work on its own to discover knowledge. It mainly deals with the unlabelled data.



# Unsupervised Learning

- Dataset contains no labels:
  $x^1,...x^n$
- Goal: to find interesting structures in the data



# Unsupervised Learning Algorithms

- Unsupervised Learning Algorithms allow users to perform more complex processing tasks compared to supervised learning.
- Although, unsupervised learning can be more unpredictable compared with other natural learning methods.
- Unsupervised learning algorithms include clustering, anomaly detection, neural networks, etc.

# Example of Unsupervised Learning

- Let's, take an example of Unsupervised Learning for a baby and her family dog.

- She knows and identifies this dog. Few weeks later a family friend brings along a dog and tries to play with the baby.
- Baby has not seen this dog earlier. But it recognizes many features (2 ears, eyes, walking on 4 legs) are like her pet dog. She identifies the new animal as a dog. This is unsupervised learning, where you are not taught but you learn from the data (in this case data about a dog.)

# Why is it important?

- They find patterns which are previously unknown.
- Patterns help you to find features which can be useful for categorization.
- They can detect anomalies and defects in the data.
- They work on unlabeled data which makes our work easier.

# Need for Unsupervised Learning

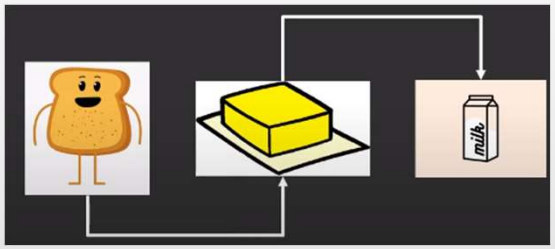
- Annotating large datasets is very costly and time consuming. Example: Speech Recognition, Medical Image Analysis, etc.
- There may be cases where we don’t know how many/what classes is the data divided into. Example: Data Mining, Sentimental Analysis.
- We may want to use clustering to gain some insight into the structure of the data before designing a classifier

# Types of Unsupervised Learning:

## Clustering

- Clustering is the task of dividing the population or data points into a number of groups such that data points in the same groups are more similar to other data points and dissimilar to the data points in the other groups.

## Association



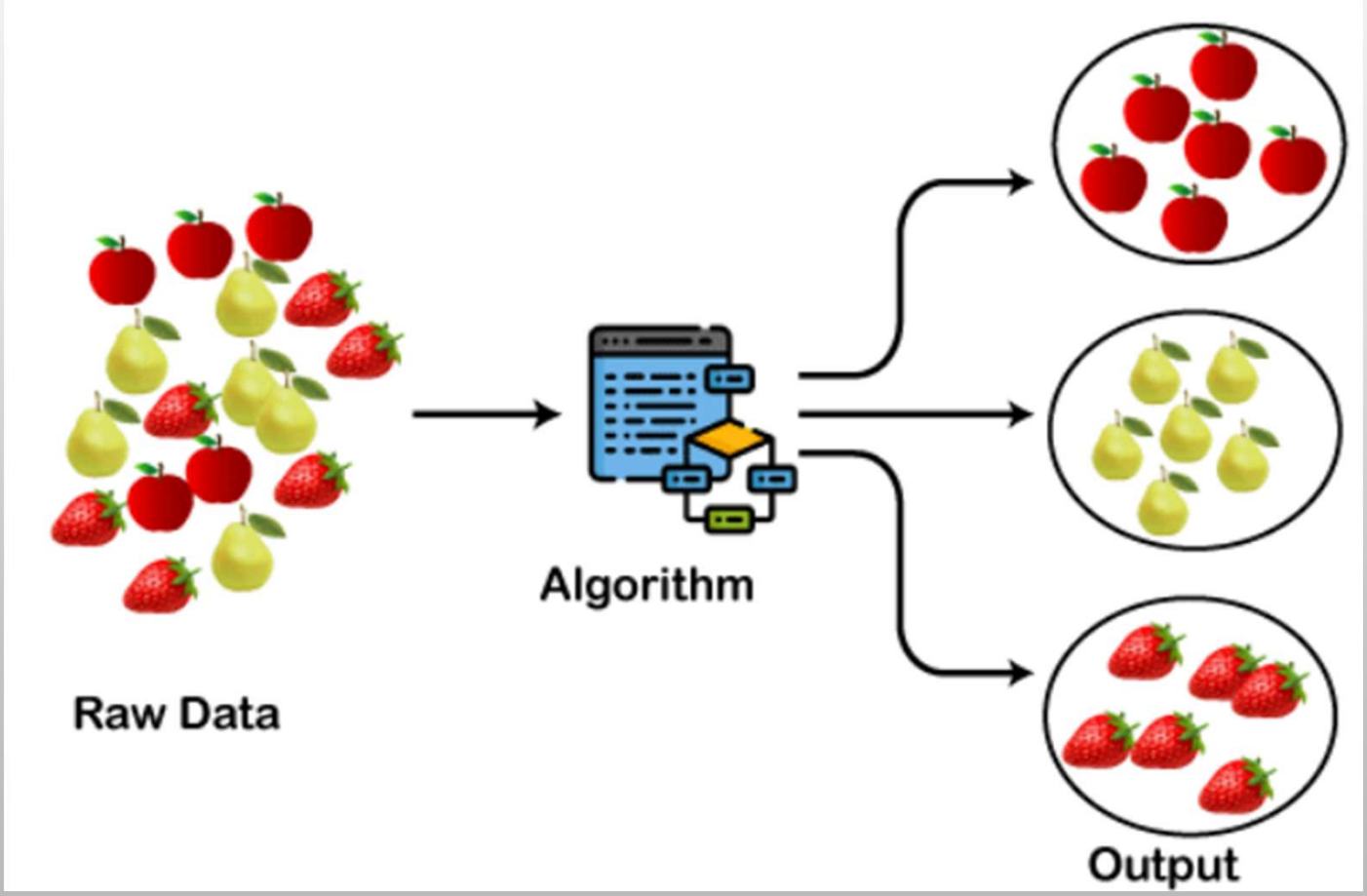

- Association rules allow us to establish associations amongst data objects inside large databases. This unsupervised technique includes discovering important relationships between variables in large databases.

# Clustering in Machine Learning

- Clustering or cluster analysis is a machine learning technique, which groups the unlabelled dataset.
- It does it by finding some similar patterns in the unlabelled dataset such as shape, size, color, behavior, etc., and divides them as per the presence and absence of those similar patterns.
- It is an unsupervised learning method, hence no supervision is provided to the algorithm, and it deals with the unlabeled dataset.
- After applying this clustering technique, each cluster or group is provided with a cluster-ID. ML system can use this id to simplify the processing of large and complex datasets.
- The clustering technique is commonly used for statistical data analysis.

# Clustering in Machine Learning

- working of the clustering algorithm



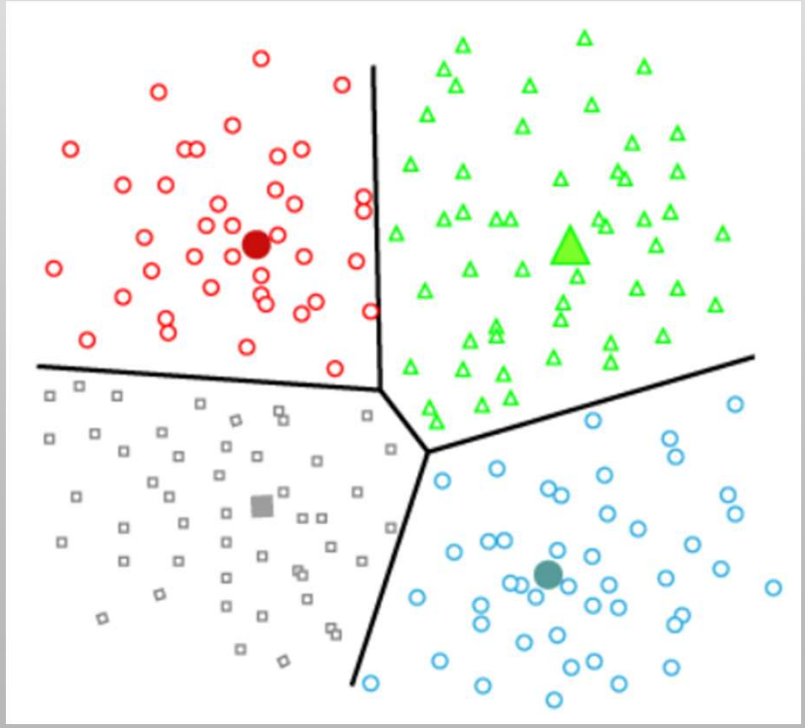
# Types of Clustering Methods

- **Main clustering methods used in Machine learning:**
  - Partitioning Clustering
  - Density-Based Clustering
  - Distribution Model-Based Clustering
  - Hierarchical Clustering
  - Fuzzy Clustering

# Types of Clustering Methods

## Partitioning Clustering

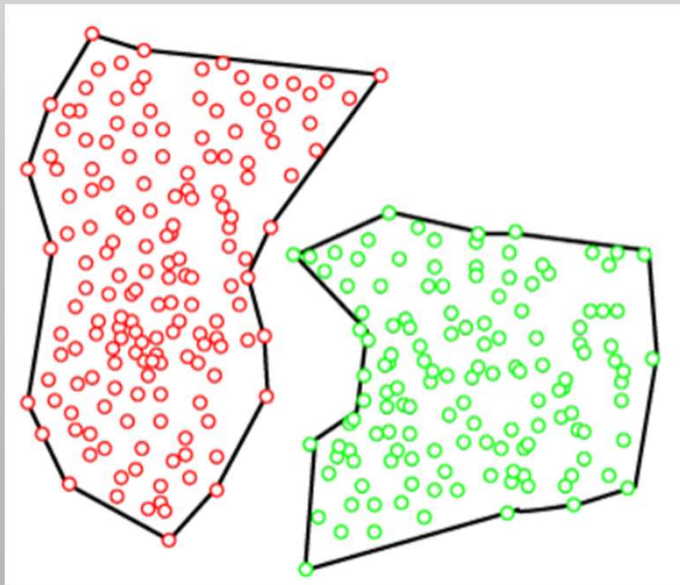
It is a type of clustering that divides the data into non-hierarchical groups. It is also known as the centroid-based method. The most common example of partitioning clustering is the K-Means Clustering algorithm.



# Types of Clustering Methods

## Density-Based Clustering

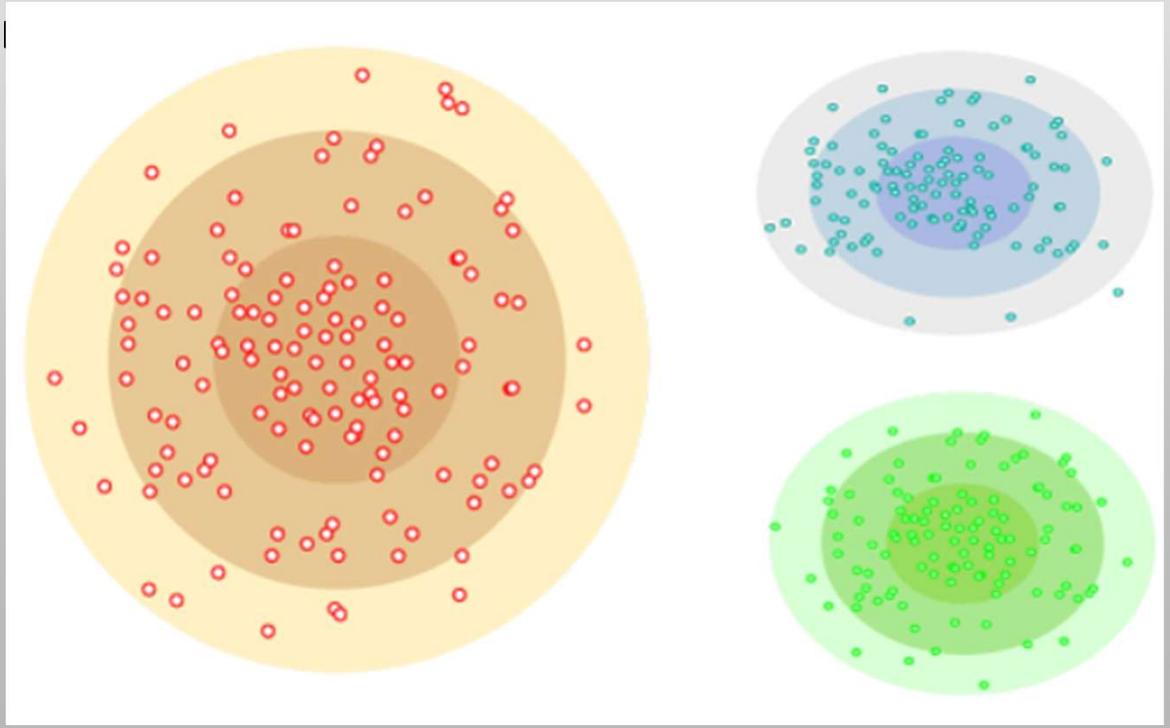
The density-based clustering method connects the highly-dense areas into clusters, and the arbitrarily shaped distributions are formed as long as the dense region can be connected. This algorithm does it by identifying different clusters in the dataset and connects the areas of high densities into clusters. The dense areas in data space are divided from each other by sparser areas.



# Types of Clustering Methods

## Distribution Model-Based Clustering

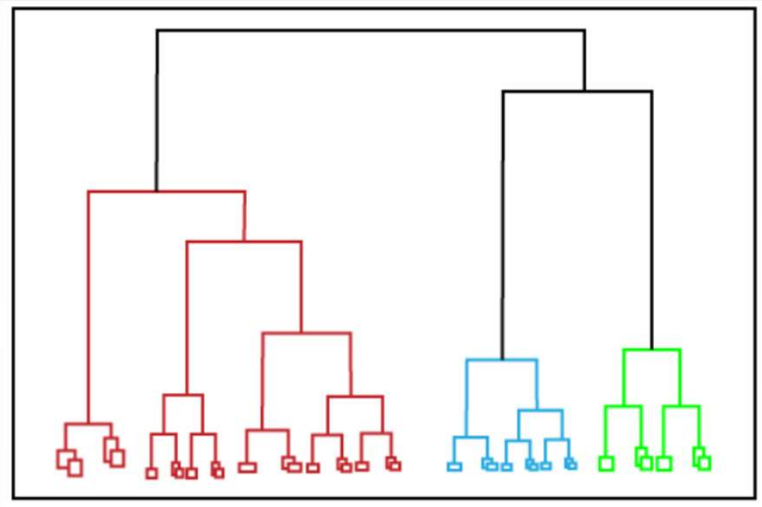
In the distribution model-based clustering method, the data is divided based on the probability of how a dataset belongs to a particular distribution. The grouping is done by assuming some distributions commonly Gaussian Distr



# Types of Clustering Methods

## Hierarchical Clustering

Hierarchical clustering can be used as an alternative for the partitioned clustering as there is no requirement of pre-specifying the number of clusters to be created. In this technique, the dataset is divided into clusters to create a tree-like structure, which is also called a dendrogram. The observations or any number of clusters can be selected by cutting the tree at the correct level. The most common example of this method is the Agglomerative Hierarchical algorithm.



# Types of Clustering Methods

## Fuzzy Clustering

Fuzzy clustering is a type of soft method in which a data object may belong to more than one group or cluster. Each dataset has a set of membership coefficients, which depend on the degree of membership to be in a cluster. Fuzzy C-means algorithm is the example of this type of clustering; it is sometimes also known as the Fuzzy k-means algorithm.

# Clustering Algorithms

**K-Means algorithm:** The k-means algorithm is one of the most popular clustering algorithms. It classifies the dataset by dividing the samples into different clusters of equal variances. The number of clusters must be specified in this algorithm. It is fast with fewer computations required, with the linear complexity of O(n).

**Mean-shift algorithm:** Mean-shift algorithm tries to find the dense areas in the smooth density of data points. It is an example of a centroid-based model, that works on updating the candidates for centroid to be the center of the points within a given region.

**DBSCAN Algorithm:** It stands for Density-Based Spatial Clustering of Applications with Noise. It is an example of a density-based model similar to the mean-shift, but with some remarkable advantages. In this algorithm, the areas of high density are separated by the areas of low density. Because of this, the clusters can be found in any arbitrary shape.

# Clustering Algorithms

**Expectation-Maximization Clustering using GMM:** This algorithm can be used as an alternative for the k-means algorithm or for those cases where K-means can be failed. In GMM, it is assumed that the data points are Gaussian distributed.

**Agglomerative Hierarchical algorithm:** The Agglomerative hierarchical algorithm performs the bottom-up hierarchical clustering. In this, each data point is treated as a single cluster at the outset and then successively merged. The cluster hierarchy can be represented as a tree-structure.

**Affinity Propagation:** It is different from other clustering algorithms as it does not require to specify the number of clusters. In this, each data point sends a message between the pair of data points until convergence. It has O(N2T) time complexity, which is the main drawback of this algorithm.

# Clustering Algorithms

## K-Means Algorithm

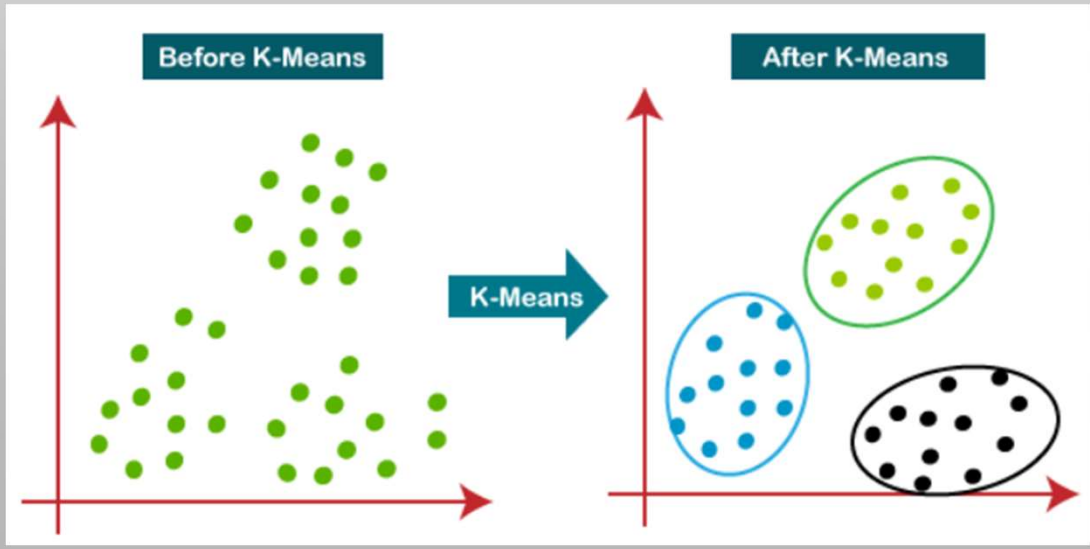
- It will groups the unlabeled dataset into different clusters.
- Here K defines the number of predefined clusters that need to be created in the process, as if K=2, there will be two clusters, and for K=3, there will be three clusters, and so on.
- It allows us to cluster the data into different groups and a convenient way to discover the categories of groups in the unlabeled dataset on its own without the need for any training.
- It is a centroid-based algorithm, where each cluster is associated with a centroid. The main aim of this algorithm is to minimize the sum of distances between the data point and their corresponding clusters.
- The algorithm takes the unlabeled dataset as input, divides the dataset into k-number of clusters, and repeats the process until it does not find the best clusters. The value of k should be predetermined in this algorithm.

# Clustering Algorithms

## K-Means Algorithm

- The k-means clustering algorithm mainly performs two tasks:
  - Determines the best value for K center points or centroids by an iterative process.
  - Assigns each data point to its closest k-center. Those data points which are near to the particular k-center, create a cluster.

working of the K-means Clustering Algorithm:



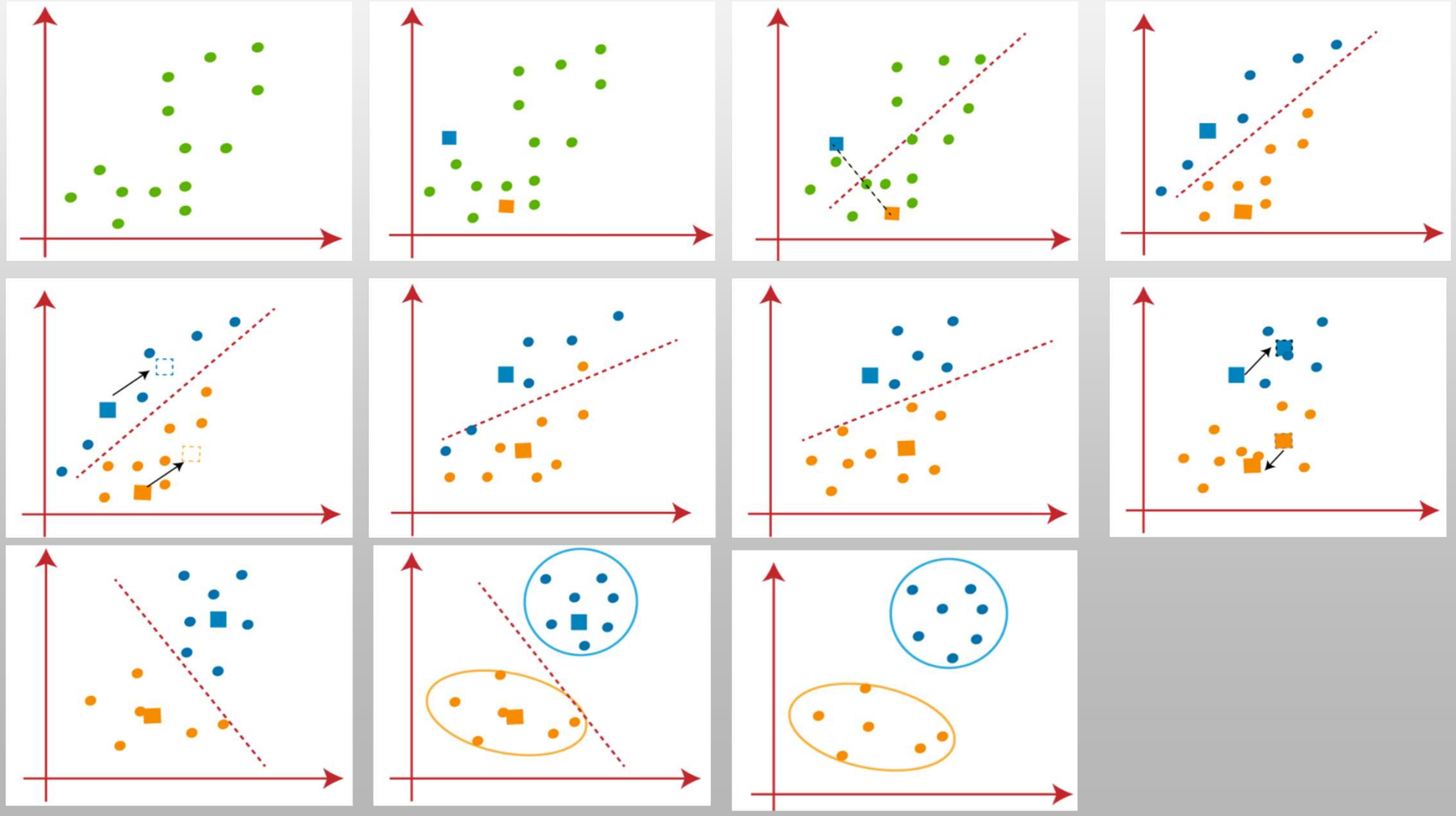
# Clustering Algorithms

**The working of the K-Means algorithm is explained in the below steps:**

- Step-1: Select the number K to decide the number of clusters.
- Step-2: Select random K points or centroids. (It can be other from the input dataset).
- Step-3: Assign each data point to their closest centroid, which will form the predefined K clusters.
- Step-4: Calculate the variance and place a new centroid of each cluster.
- Step-5: Repeat the third steps, which means reassign each datapoint to the new closest centroid of each cluster.
- Step-6: If any reassignment occurs, then go to step-4 else go to FINISH.
- Step-7: The model is ready.

# Clustering Algorithms

## K-Means Algorithm



# Clustering Algorithms

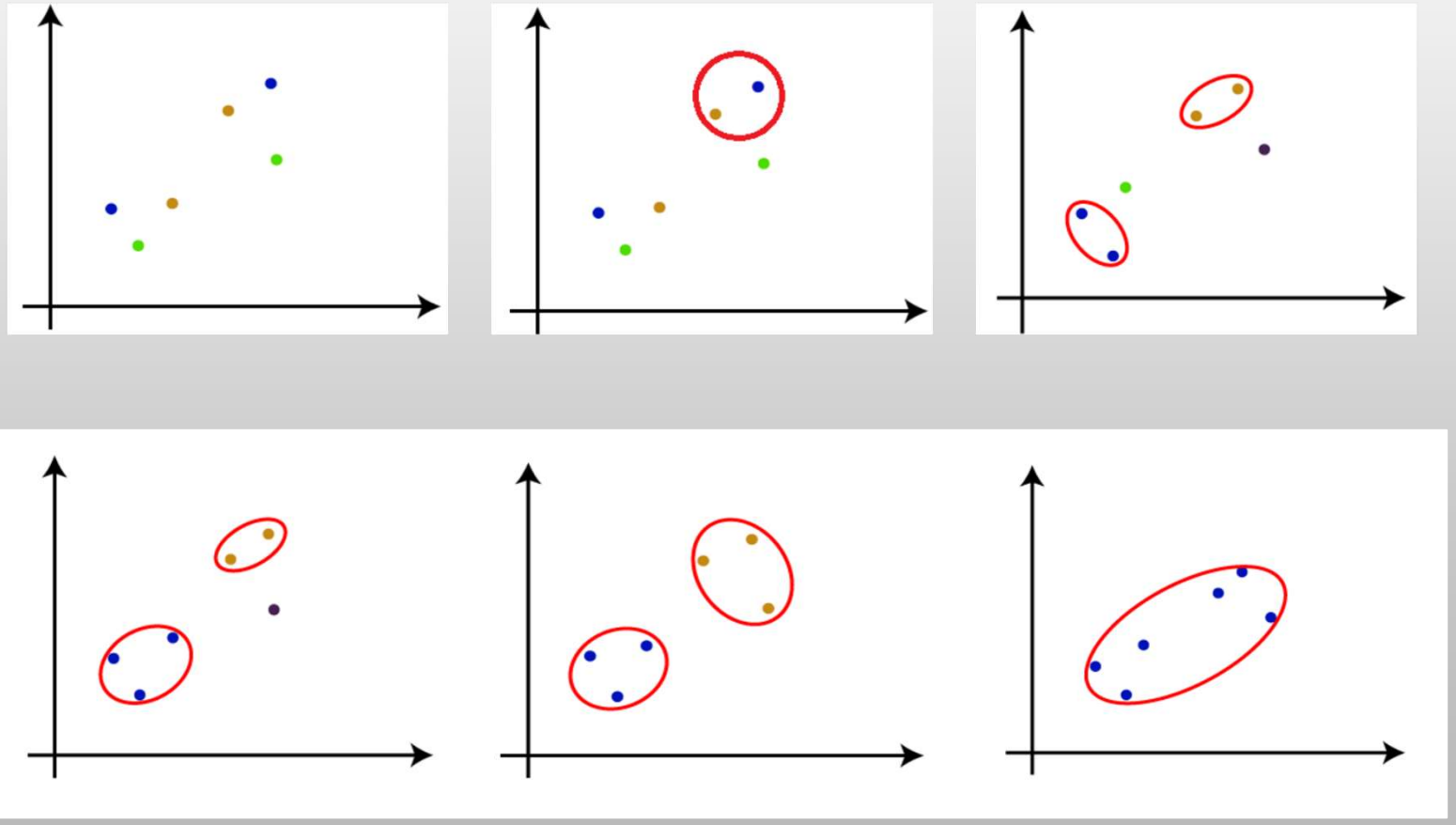
## Agglomerative Hierarchical clustering

- To group the datasets into clusters, it follows the bottom-up approach.
- This algorithm considers each dataset as a single cluster at the beginning, and then start combining the closest pair of clusters together. It does this until all the clusters are merged into a single cluster that contains all the datasets.

This hierarchy of clusters is represented in the form of the dendrogram.

# Clustering Algorithms

## How the Agglomerative Hierarchical clustering Work?



# Applications of Clustering Algorithms

- In Identification of Cancer Cells
- In Search Engines
- Customer Segmentation
- In Biology
- In Land Use

# Association Rule Learning

- Association rule learning is a type of unsupervised learning technique that checks for the dependency of one data item on another data item and maps accordingly so that it can be more profitable.
- It tries to find some interesting relations or associations among the variables of dataset.
- It is based on different rules to discover the interesting relations between variables in the database.
- it is employed in Market Basket analysis, Web usage mining, continuous production, etc.

# Association Rule Learning Algorithms

- **Apriori Algorithm**
  - This algorithm uses frequent datasets to generate association rules. It is designed to work on the databases that contain transactions. This algorithm uses a breadth-first search and Hash Tree to calculate the itemset efficiently.
  - It is mainly used for market basket analysis and helps to understand the products that can be bought together. It can also be used in the healthcare field to find drug reactions for patients.
- **Eclat Algorithm**
  - Eclat algorithm stands for Equivalence Class Transformation. This algorithm uses a depth-first search technique to find frequent itemsets in a transaction database. It performs faster execution than Apriori Algorithm.
- **F-P Growth Algorithm**
  - The F-P growth algorithm stands for Frequent Pattern, and it is the improved version of the Apriori Algorithm. It represents the database in the form of a tree structure that is known as a frequent pattern or tree. The purpose of this frequent tree is to extract the most frequent patterns.

# Association Rule Learning Algorithms

## Apriori Algorithm

The Apriori algorithm uses frequent itemsets to generate association rules, and it is designed to work on the databases that contain transactions. With the help of these association rule, it determines how strongly or how weakly two objects are connected. This algorithm uses a **breadth-first search** and **Hash Tree** to calculate the itemset associations efficiently. It is the iterative process for finding the frequent itemsets from the large dataset.

## Steps for Apriori Algorithm

- Step-1: Determine the support of itemsets in the transactional database, and select the minimum support and confidence.
- Step-2: Take all supports in the transaction with higher support value than the minimum or selected support value.
- Step-3: Find all the rules of these subsets that have higher confidence value than the threshold or minimum confidence.
- Step-4: Sort the rules as the decreasing order of lift.

# Association Rule Learning Algorithms

## FP-Growth Algorithm

It is an alternative way to find frequent item sets without using candidate generations, thus improving performance. For so much, it uses a divide-and-conquer strategy. The core of this method is the usage of a special data structure named frequent-pattern tree (FP-tree), which retains the item set association information.

## Steps of FP-Growth Algorithm

- First, it compresses the input database creating an FP-tree instance to represent frequent items.
- After this first step, it divides the compressed database into a set of conditional databases, each associated with one frequent pattern.
- Finally, each such database is mined separately.

# Applications of Association Rule Learning

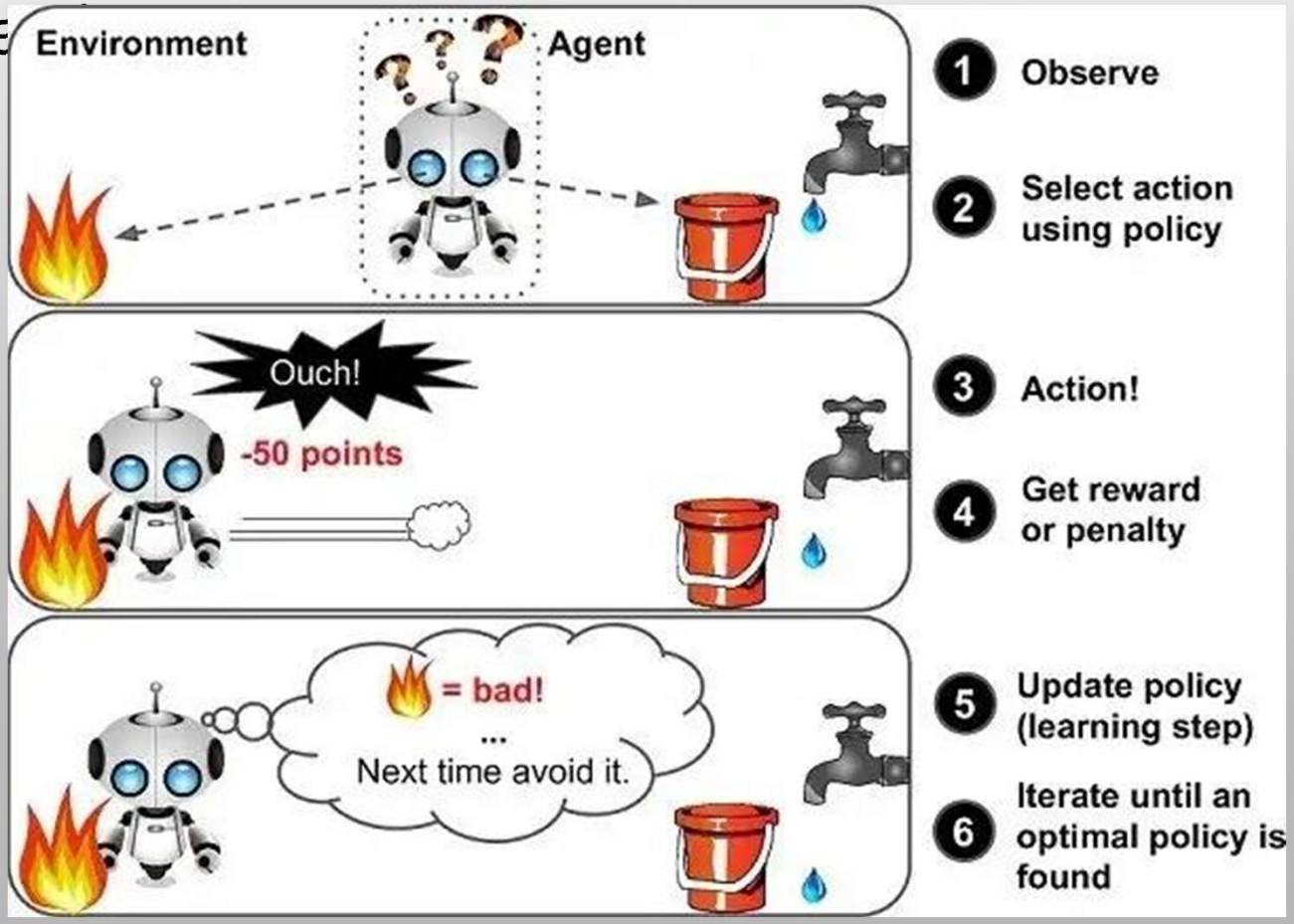
- **Market Basket Analysis**
- **Medical Diagnosis**
- **Protein Sequence**
- It is also used for the Catalog Design and Loss-leader Analysis and many more other applications.

# Disadvantages of Unsupervised Learning

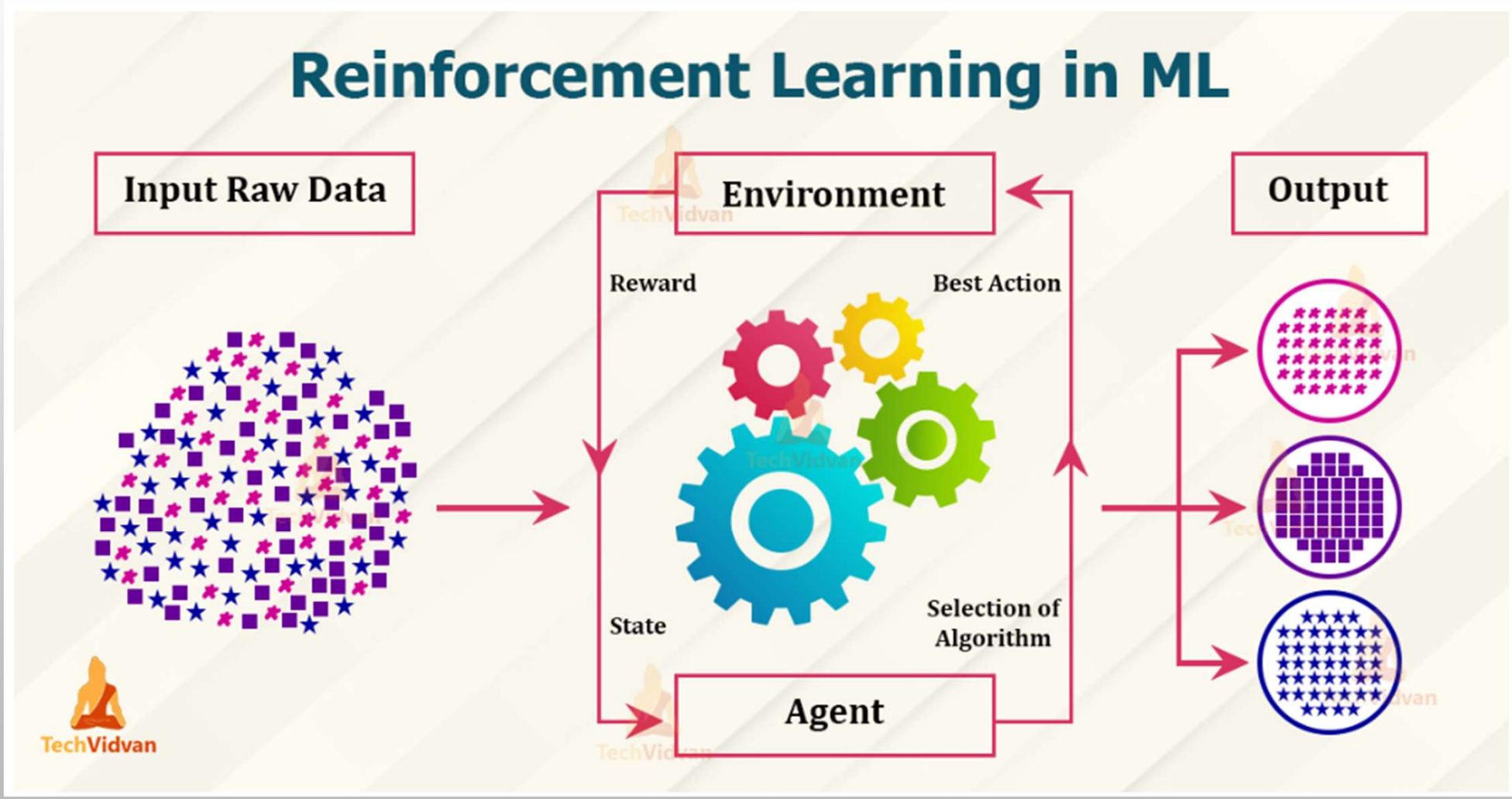
- Unsupervised Learning is harder as compared to Supervised Learning. Since, quantifying the inference made is difficult, since the ground-truth is missing.
- How do we know if results are meaningful since it has unlabelled data?
  - External evaluation- Expert analysis.
  - Internal evaluation- Objective function.

# Reinforcement Algorithms

- A reinforcement learning algorithm, or agent, learns by interacting with its environment. The agent receives rewards by performing correctly and penalties for performing incorre



# Terminologies used in Reinforcement Learning



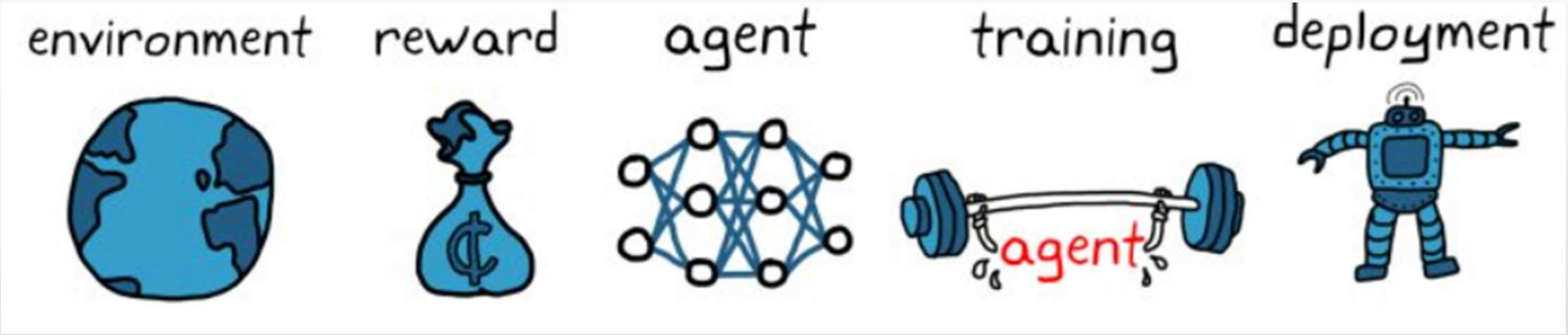
# Terminologies used in Reinforcement Learning

- **Agent —** the learner and the decision maker.
- **Environment —** where the agent learns and decides what actions to perform.
- **Action —** a set of actions which the agent can perform.
- **State —** the state of the agent in the environment.
- **Reward —** for each action selected by the agent the environment provides a reward. Usually a scalar value.
- **Policy —** the decision-making function (control strategy) of the agent, which represents a mapping from situations to actions.
- **Value function —** mapping from states to real numbers, where the value of a state represents the long-term reward achieved starting from that state, and executing a particular policy.
- **Function approximator —** refers to the problem of inducing a function from training examples. Standard approximators include decision trees, neural networks, and nearest-neighbor methods

# Terminologies used in Reinforcement Learning

- **Markov decision process (MDP) —** A probabilistic model of a sequential decision problem, where states can be perceived exactly, and the current state and action selected determine a probability distribution on future states. Essentially, the outcome of applying an action to a state depends only on the current action and state (and not on preceding actions or states).
- **Dynamic programming (DP) —** is a class of solution methods for solving sequential decision problems with a compositional cost structure. Richard Bellman was one of the principal founders of this approach.
- **Monte Carlo methods —** A class of methods for learning of value functions, which estimates the value of a state by running many trials starting at that state, then averages the total rewards received on those trials.
- **Temporal Difference (TD) algorithms —** A class of learning methods, based on the idea of comparing temporally successive predictions. Possibly the single most fundamental idea in all of reinforcement learning.
- **Model —** The agent's view of the environment, which maps state-action pairs to probability distributions over states. Note that not every reinforcement learning agent uses a model of its environment.

# Reinforcement Learning Workflow




- Create the Environment
- Define the reward
- Create the agent
- Train and validate the agent
- Deploy the policy

# Need for Reinforcement Learning

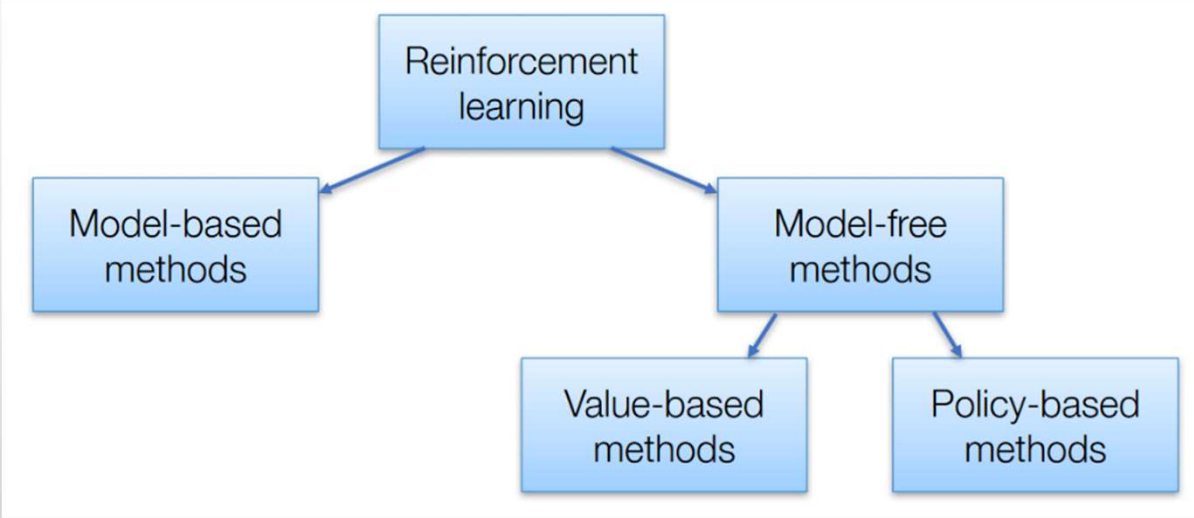
- Reinforcement learning can be used to solve very complex problems that cannot be solved by conventional techniques.
- In the absence of a training dataset, it is bound to learn from its experience.

  • Reinforcement learning models can outperform humans in many tasks and learning process is similar to human learning.
- DeepMind's AlphaGo program, a reinforcement learning model, beat the world champion Lee Sedol at the game of Go in March 2016.

# Characteristics of Reinforcement Learning

- No supervision, only a real value or reward signal
- Decision making is sequential
- Time plays a major role in reinforcement problems
- Feedback isn’t prompt but delayed
- The following data it receives is determined by the agent’s actions

# Reinforcement Learning Algorithms

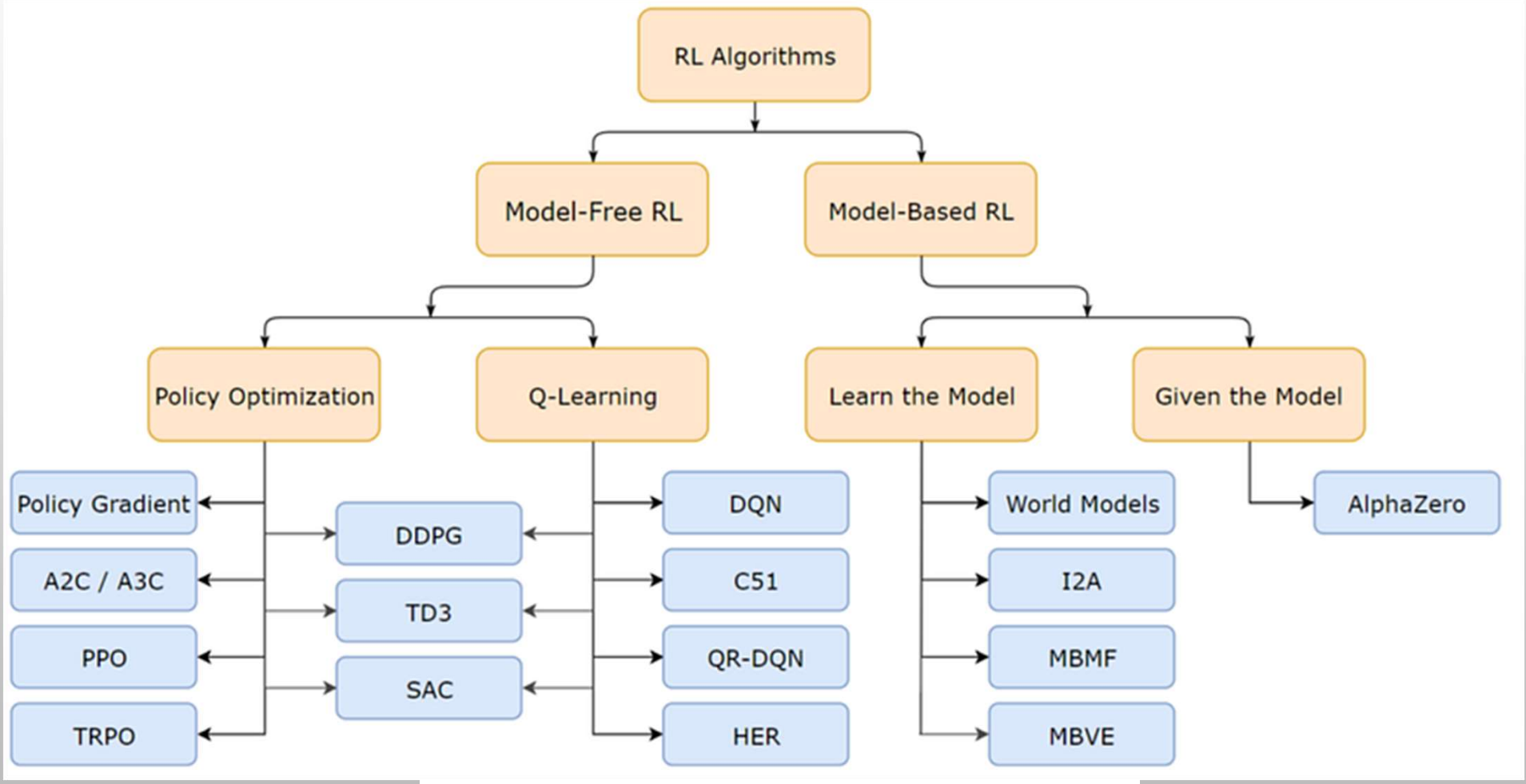



**Value-Based** – The main goal of this method is to maximize a value function. Here, an agent through a policy expects a long-term return of the current states.

**Policy-Based** – In policy-based, you enable to come up with a strategy that helps to gain maximum rewards in the future through possible actions performed in each state. Two types of policy-based methods are deterministic and stochastic.

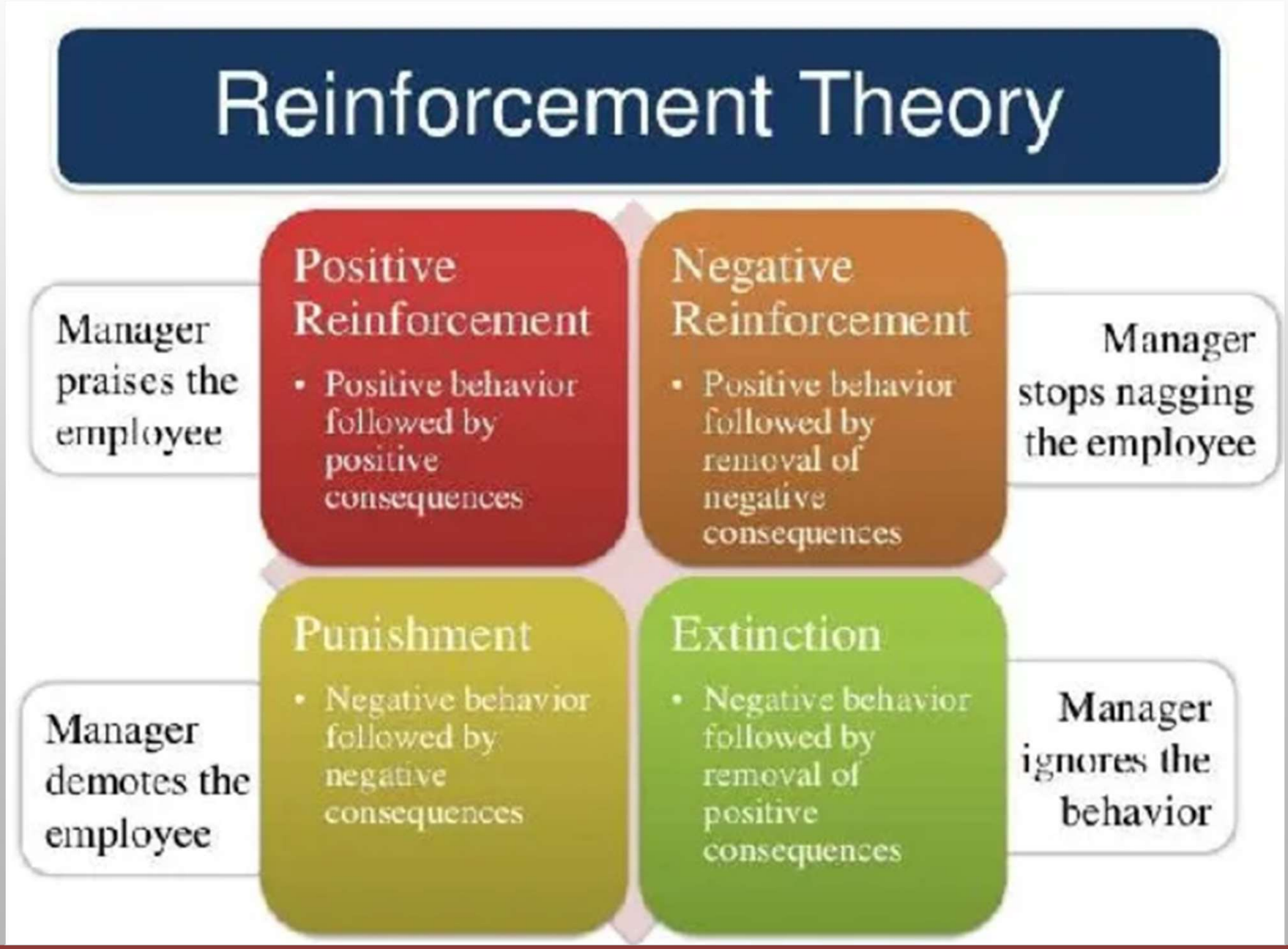
**Model-Based** – In this method, we need to create a virtual model for the agent to help in learning to perform in each specific environment

# Reinforcement Learning Algorithm




Reinforcement Learning taxonomy as defined by OpenAI [Source]

# Types of Reinforcement Learning



# Types of Reinforcement Learning

## Positive Reinforcement

Positive reinforcement is defined as when an event, occurs due to specific behavior, increases the strength and frequency of the behavior. It has a positive impact on behavior.

**Advantages**

– Maximizes the performance of an action

– Sustain change for a longer period

**Disadvantage**

– Excess reinforcement can lead to an overload of states which would minimize the results.

## Negative Reinforcement

Negative Reinforcement is represented as the strengthening of a behavior. In other ways, when a negative condition is barred or avoided, it tries to stop this action in the future.

**Advantages**

– Maximized behavior

– Provide a decent to minimum standard of performance

**Disadvantage**

– It just limits itself enough to meet up a minimum behavior

# Applications of Reinforcement Learning

- **Gaming**

  Reinforcement learning has been applied to various games, from classic board games like chess and Go to modern video games like Dota 2 and StarCraft II. In these games, an agent learns to make decisions and compete against human players or other agents.

- **Robotics**

  Reinforcement learning has been used in robotics to enable robots to learn to navigate environments, manipulate objects, and perform complex tasks. In these applications, an agent learns from feedback received through sensors and actuators.

# Applications of Reinforcement Learning

- **Finance**

  Reinforcement learning has found applications in finance, including algorithmic trading, portfolio optimization, and fraud detection. In these applications, an agent learns to make decisions based on market data and financial indicators.

- **Healthcare**

  Reinforcement learning has been used in healthcare to optimize treatment plans and drug dosages. In these applications, an agent learns from patient data and medical records to make decisions that maximize patient outcomes.

# Practical Applications of reinforcement learning

- Robotics for Industrial Automation
- Text summarization engines, dialogue agents (text, speech), gameplays
- Autonomous Self Driving Cars
- Machine Learning and Data Processing
- Training system which would issue custom instructions and materials with respect to the requirements of students
- AI Toolkits, Manufacturing, Automotive, Healthcare, and Bots
- Aircraft Control and Robot Motion Control
- Building artificial intelligence for computer games

# QUIZ Time:

https://forms.gle/mX8DJMBzMmcB9d4L8

# Demonstration.

https://colab.research.google.com/drive/17l6NxZN-lz-oc2A598iqYU1mn7aUbws6?usp=sharing

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# THANKS