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Machine Learning unit 1

History of Machine Learning

- 1950s
  - Samuel's checker player
  - Selfridge's Pandemonium
- 1960s:
  - Neural networks: Perceptron
  - Pattern recognition
  - Learning in the limit theory
  - Minsky and Papert prove limitations of Perceptron
- 1970s:
  - Symbolic concept induction
  - Winston's arch learner
  - Expert systems and the knowledge acquisition bottleneck
  - Quinlan's ID3
  - Michalski's AQ and soybean diagnosis
  - Scientific discovery with BACON
  - Mathematical discovery with AM

History of Machine Learning (cont.)

- 1980s:
  - Advanced decision tree and rule learning
  - Explanation-based Learning (EBL)
  - Learning and planning and problem solving
  - Utility problem
  - Analogy
  - Cognitive architectures
  - Resurgence of neural networks (connectionism, backpropagation)
  - Valiant's PAC Learning Theory
  - Focus on experimental methodology
- 1990s
  - Data mining
  - Adaptive software agents and web applications
  - Text learning
  - Reinforcement learning (RL)
  - Inductive Logic Programming (ILP)
  - Ensembles: Bagging, Boosting, and Stacking
  - Bayes Net learning

History of Machine Learning (cont.)

- 2000s
  - Support vector machines
  - Kernel methods
  - Graphical models
  - Statistical relational learning
  - Transfer learning
  - Sequence labeling
  - Collective classification and structured outputs
  - Computer Systems Applications
    - Compilers
    - Debugging
    - Graphics
    - Security (intrusion, virus, and worm detection)
  - E mail management
  - Personalized assistants that learn
  - Learning in robotics and vision

Machine Learning at 21st century

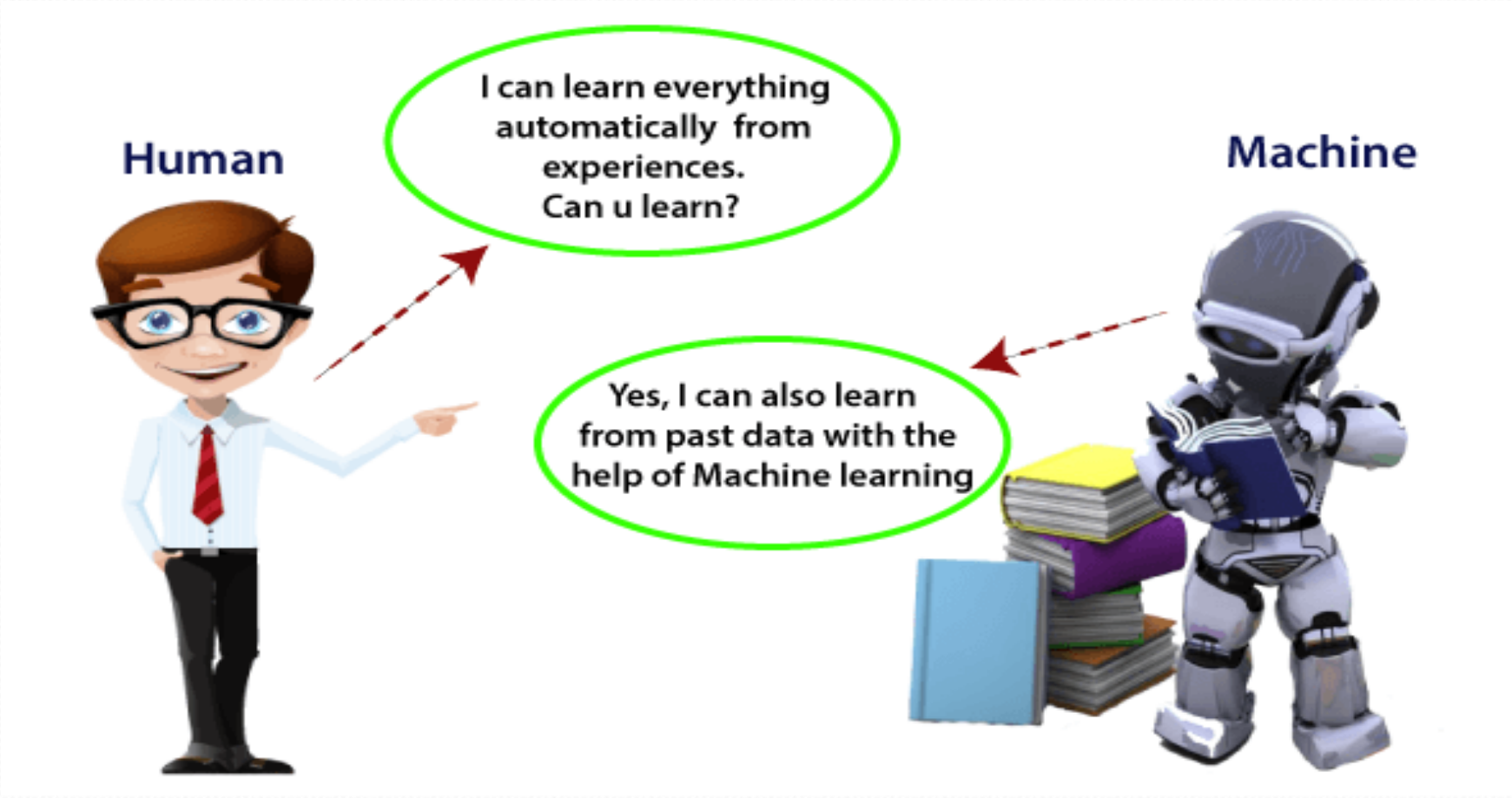
- **2006:** In the year 2006, computer scientist Geoffrey Hinton has given a new name to neural net research as "**deep learning**," and nowadays, it has become one of the most trending technologies.
- **2012:** In 2012, Google created a deep neural network which learned to recognize the image of humans and cats in YouTube videos.
- **2014:** In 2014, the Chabot "**Eugen Goostman**" cleared the Turing Test. It was the first Chabot who convinced the 33% of human judges that it was not a machine.

- **2014: DeepFace** was a deep neural network created by Facebook, and they claimed that it could recognize a person with the same precision as a human can do.
- **2016: AlphaGo** beat the world's number second player **Lee sedol** at **Go game**. In 2017 it beat the number one player of this game **Ke Jie**.
- **2017:** In 2017, the Alphabet's Jigsaw team built an intelligent system that was able to learn the **online trolling**. It used to read millions of comments of different websites to learn to stop online trolling.

Machine Learning

- Machine learning is a growing technology which enables computers to learn automatically from past data or experience without being explicitly programmed.
- example: Machine learning is used in internet search engines, email filters to sort out spam, websites to make personalised recommendations, banking software to detect unusual transactions, and lots of apps on our phones such as voice recognition filters, intrusion detection

- In the real world, we are surrounded by humans who can learn everything from their experiences with their learning capability, and we have computers or machines which work on our instructions. But can a machine also learn from experiences or past data like a human does? So here comes the role of **Machine Learning**


Human
I can learn everything automatically from experiences. Can u learn?
Machine
Yes, I can also learn from past data with the help of Machine learning

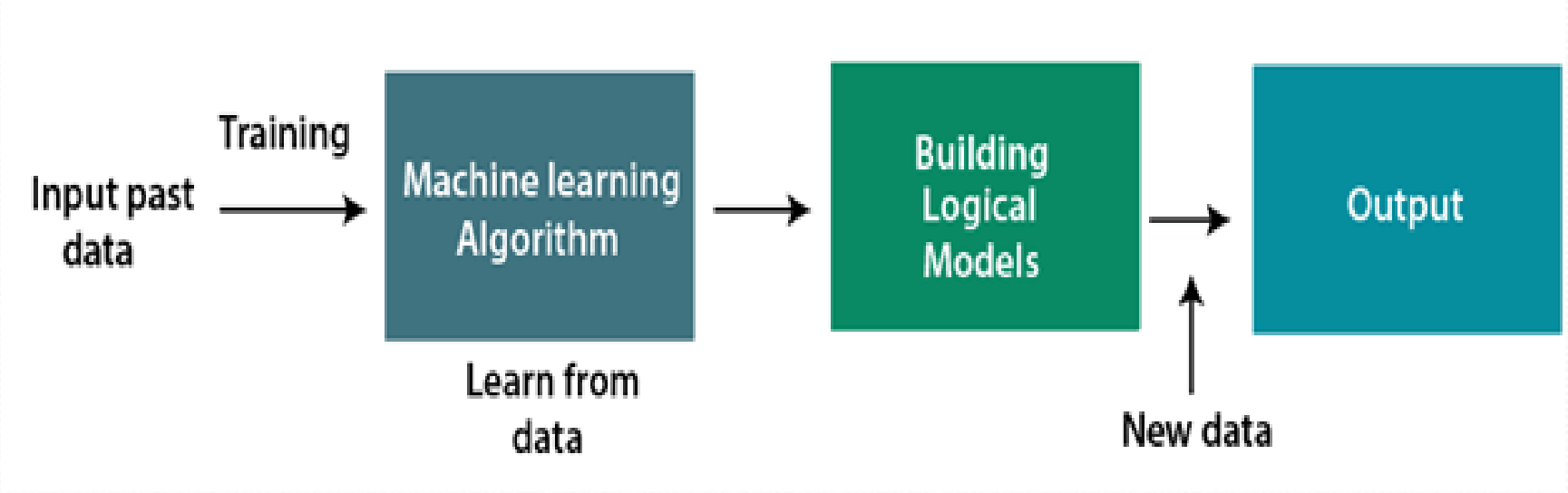
- Machine Learning is said as a subset of **artificial intelligence** that is mainly concerned with the development of algorithms which allow a computer to learn from the data and past experiences on their own.
- The term machine learning was first introduced by **Arthur Samuel** in **1959**. We can define it in a summarized way as:

  Machine learning enables a machine to automatically learn from data, improve performance from experiences, and predict things without being explicitly programmed.
- With the help of sample historical data, which is known as **training data**, machine learning algorithms build a **mathematical model** that helps in making predictions or decisions without being explicitly programmed.

- Machine learning brings computer science and statistics together for creating predictive models.
- Machine learning constructs or uses the algorithms that learn from historical data.
- The more we will provide the information, the higher will be the performance.
- **A machine has the ability to learn if it can improve its performance by gaining more data.**

How ML work ?

- A Machine Learning system **learns from historical data, builds the prediction models, and whenever it receives new data, predicts the output for it**.
- The accuracy of predicted output depends upon the amount of data, as the huge amount of data helps to build a better model which .predicts the output more accurately



Features of Machine Learning:

- Machine learning uses data to detect various patterns in a given dataset.
- It can learn from past data and improve automatically.
- It is a data-driven technology.
- Machine learning is much similar to data mining as it also deals with the huge amount of the data.

Cont..

- Generally, all machine learning algorithms take input data to generate the output. The input data remains in a tabular form consisting of rows (instances or observations) and columns (variable or attributes), and these attributes are often known as **features**.
- For example, an image is an instance in computer vision, but a line in the image could be the feature. Similarly, in NLP, a document can be an observation, and the word count could be the feature. So, we can say **a feature is an attribute that impacts a problem or is useful for the problem**.

Need of ML

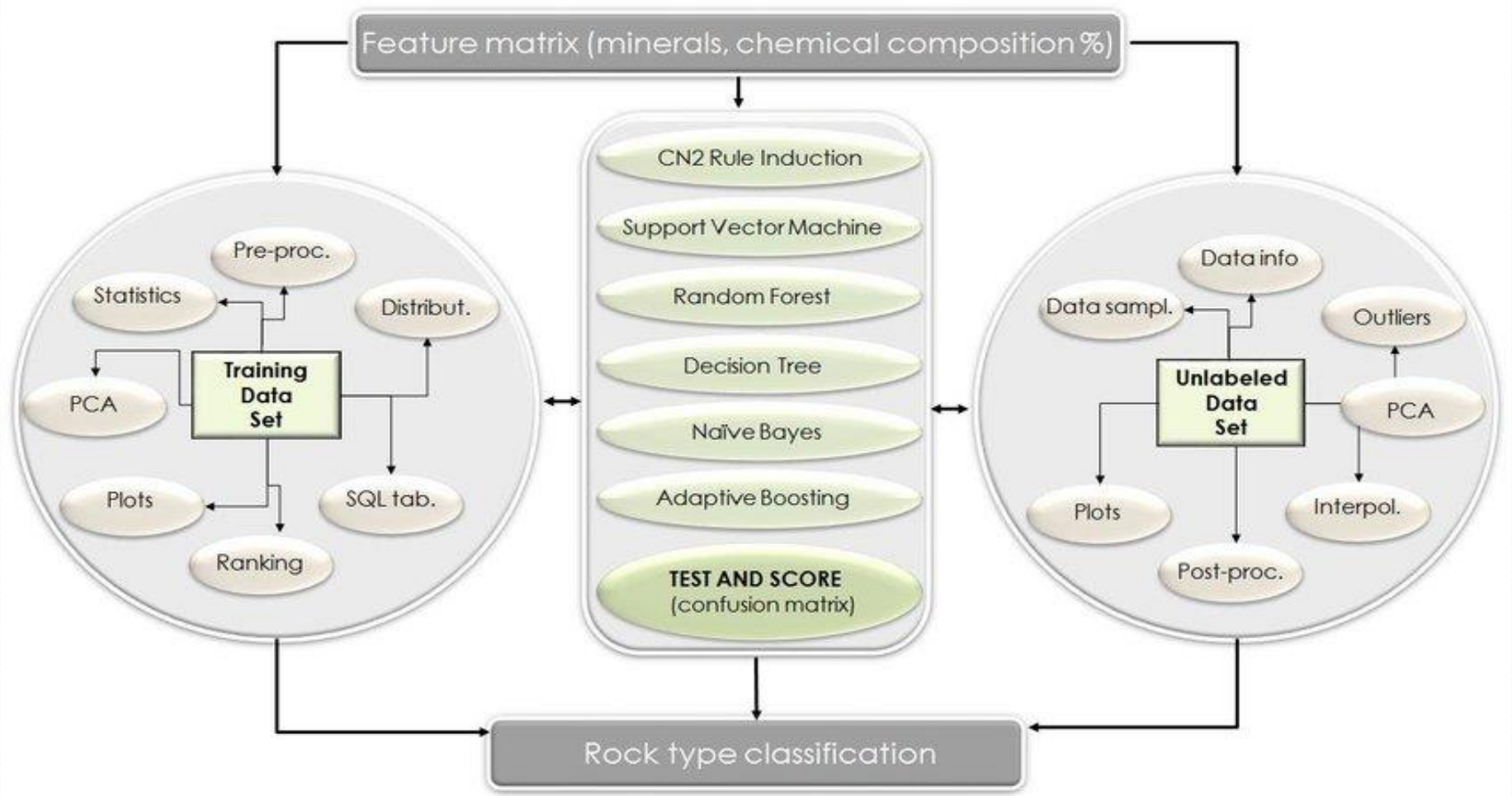
- As a human, we have some limitations as we cannot access the huge amount of data manually, so for this, we need some computer systems and here comes the machine learning to make things easy for us.
- We can train machine learning algorithms by providing them the huge amount of data and let them explore the data, construct the models, and predict the required output automatically.
- The importance of machine learning can be easily understood by its uses cases, Currently, machine learning is used in **self-driving cars**, **cyber fraud detection**, **face recognition**, and **friend suggestion by Facebook**, etc.

- Various top companies such as Netflix and Amazon have build machine learning models that are using a vast amount of data to analyze the user interest and recommend product accordingly.

Following are some key points which show the importance of Machine Learning:

- Rapid increment in the production of data
- Solving complex problems, which are difficult for a human
- Decision making in various sector including finance
- Finding hidden patterns and extracting useful information from data.

Block Diagram Representation of ML



Classification of ML

At a broad level, machine learning can be classified into three types:

- **Supervised learning**
- **Unsupervised learning**
- **Reinforcement learning**

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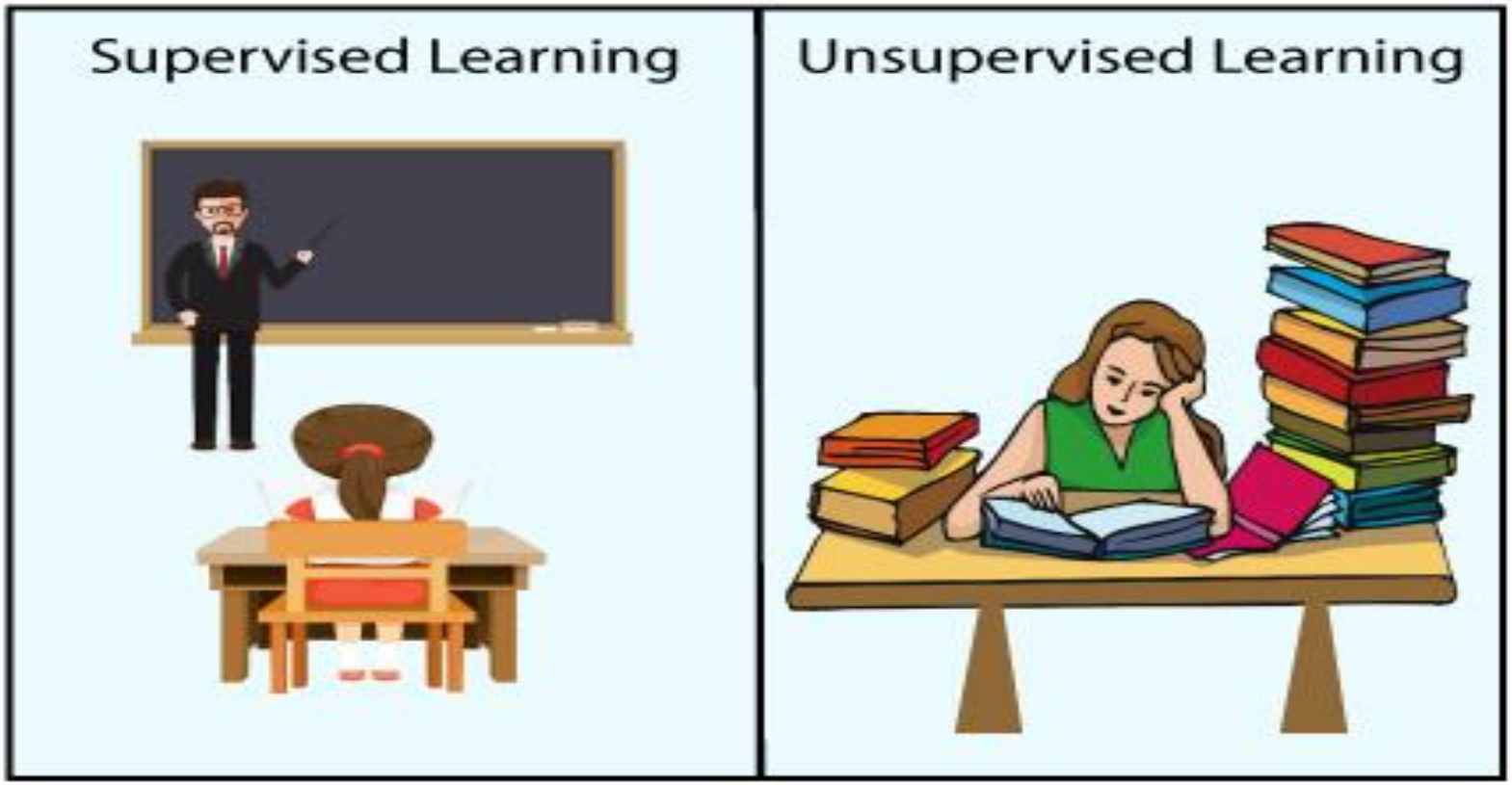


Supervised Learning

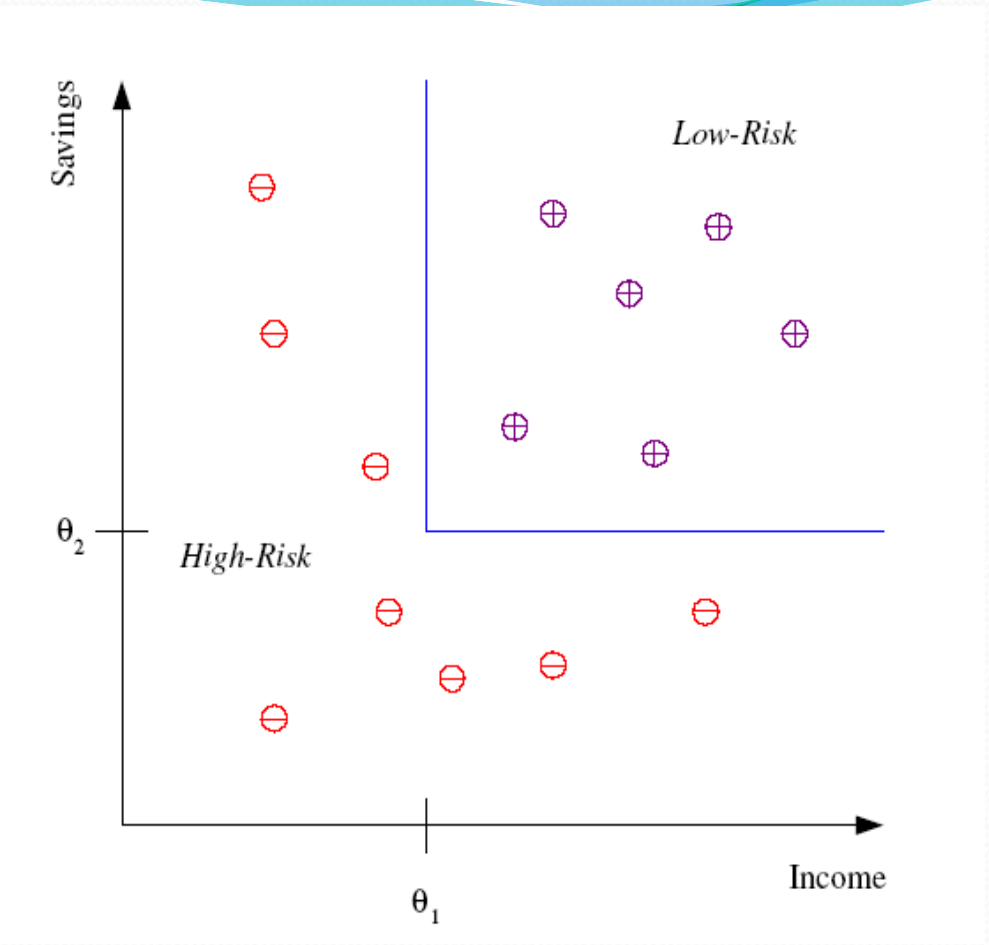
- Supervised learning is a type of machine learning method in which we provide sample labeled data to the machine learning system in order to train it, and on that basis, it predicts the output.
- The system creates a model using labeled data to understand the datasets and learn about each data, once the training and processing are done then we test the model by providing a sample data to check whether it is predicting the exact output or not.
- The goal of supervised learning is to map input data with the output data. The supervised learning is based on supervision, and it is the same as when a student learns things in the supervision of the teacher. The example of supervised learning is **spam filtering**.

Supervised learning can be grouped further in two categories of algorithms:

- **Classification**
- **Regression**

Classification

- Example: Credit scoring
- Differentiating between low-risk and high-risk customers from their *income* and *savings*



Discriminant: IF *income* > θ_1 AND *savings* > θ_2
THEN low-risk ELSE high-risk

Classification: Applications

- Aka Pattern recognition
- Face recognition: Pose, lighting, occlusion (glasses, beard), make-up, hair style
- Character recognition: Different handwriting styles.
- Speech recognition: Temporal dependency.
- Medical diagnosis: From symptoms to illnesses
- Biometrics: Recognition/authentication using physical and/or behavioral characteristics: Face, iris, signature, etc
- ...

Regression

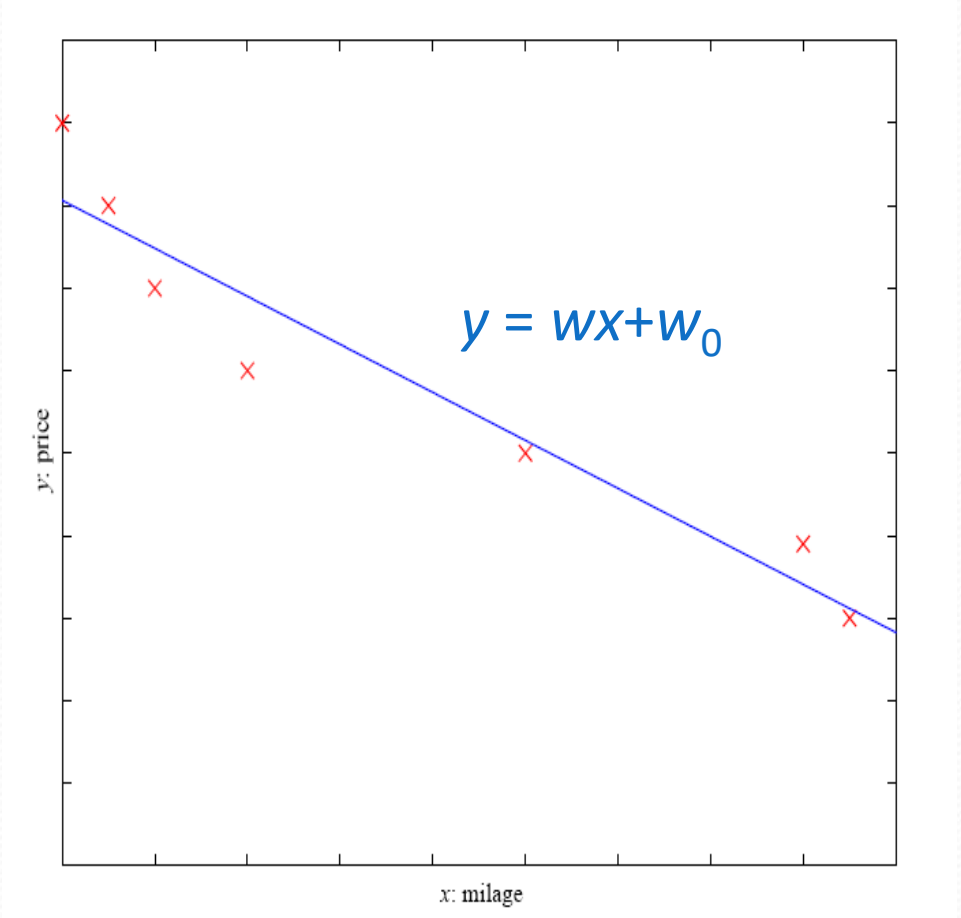
- Example: Price of a used car
- x : car attributes

  y : price

  $$y = g(x \mid \theta)$$

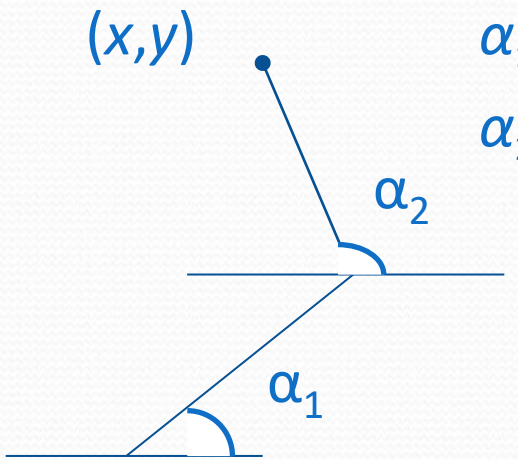
  $g(\ )$ model,

  θ parameters



Regression Applications

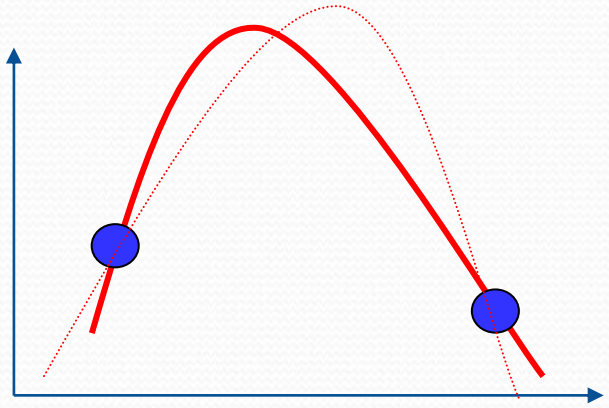
- Navigating a car: Angle of the steering
- Kinematics of a robot arm



$\alpha_1 = g_1(x,y)$

$\alpha_2 = g_2(x,y)$

- Response surface design



Supervised Learning: Uses

- Prediction of future cases: Use the rule to predict the output for future inputs
- Knowledge extraction: The rule is easy to understand
- Compression: The rule is simpler than the data it explains
- Outlier detection: Exceptions that are not covered by the rule, e.g., fraud

Unsupervised Learning

- Unsupervised learning is a learning method in which a machine learns without any supervision.
- The training is provided to the machine with the set of data that has not been labeled, classified, or categorized, and the algorithm needs to act on that data without any supervision.
- The goal of unsupervised learning is to restructure the input data into new features or a group of objects with similar patterns.
- In unsupervised learning, we don't have a predetermined result. The machine tries to find useful insights from the huge amount of data.

- It can be further classifieds into two categories of algorithms:
- **Clustering**
- **Association**

Main Clustering Algorithms

- **Hierarchical-based:**
- In this types of algorithms data must be in a hierarchical model for applying the dendrogram process.
- A dendrogram is used to represents the datasets in form of tree structure, in this structure individual data is presented by leaf nodes.
- Examples : Agglomerative,divisive are some of the well-known algorithms of this category.
- **Density-based:**In this types of algorithms data objects are separated based on their regions of density, connectivity and boundary.
- Density-based algorithms are capable of finding clusters of different shapes.
- Examples : DBSCAN , OPTICS, are algorithms that use such a method to filter out noise (outliers) and discover clusters of arbitrary shape.

Cont.

- **Grid-based:** Here data sets are divided into grids. The main advantage of these algorithms are fast in their processing time The performance of a grid-based method depends on the size of the grid, which is usually much less than the size of the database.Wave-Cluster and STING are typical examples of this category.

Cont.

- **Partitioning Based**: According to this algorithms we divide data objects into a number of partitions, where each partition represents a cluster. Each clusters should fulfil the following requirements:
- Each group must contain at least one object
- Each object must belong to exactly one group

There are many partitioning algorithms: K-means,Kmodes,PAM. One of the top ten most influential data mining algorithms, k-means, is known for being simple and scalable. Nowadays, k-means is possibly the most widely used partitional clustering algorithm in practice.

Learning Associations

- Basket analysis:

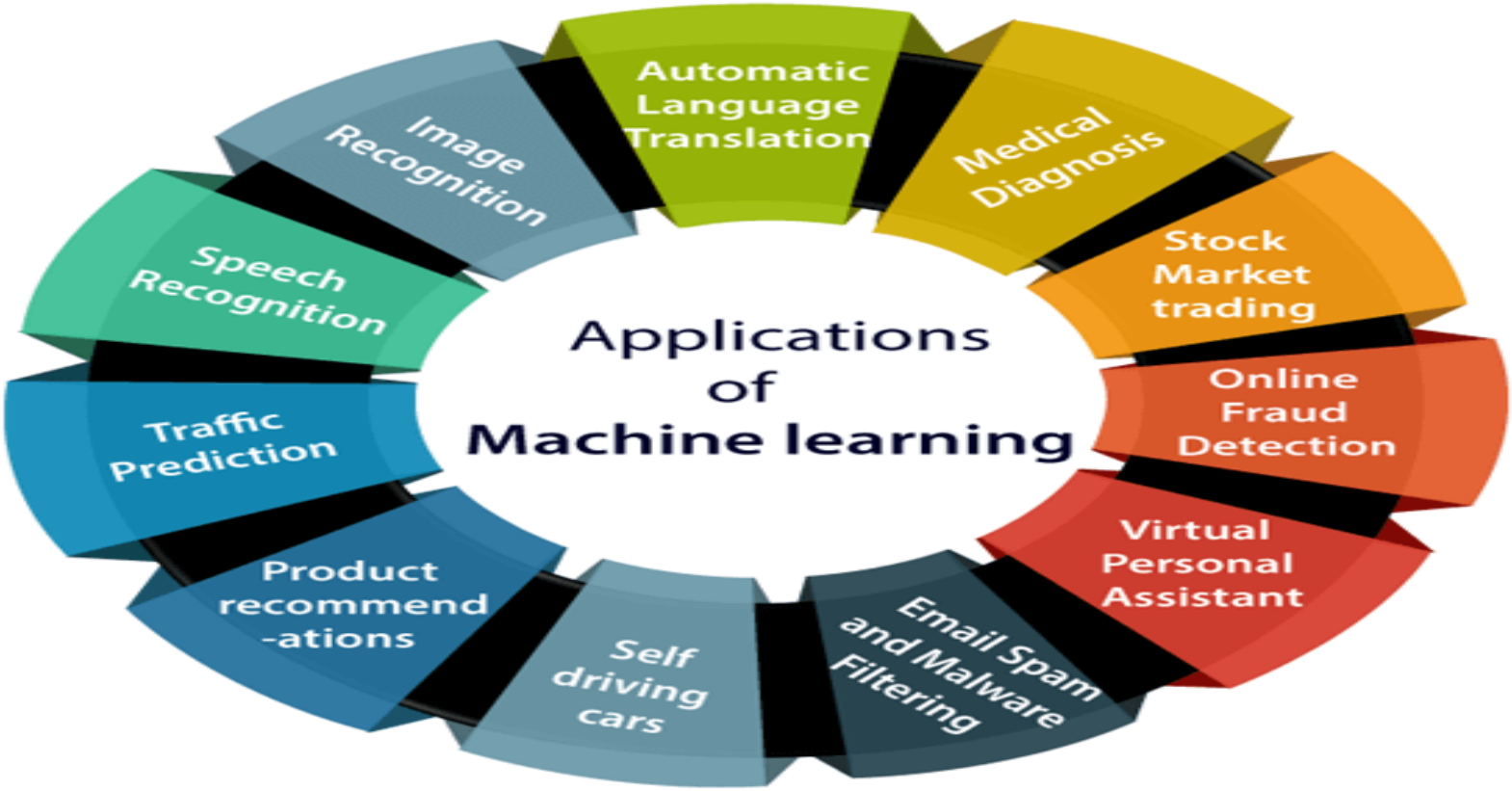
  $P(Y \mid X)$ probability that somebody who buys X also buys Y where X and Y are products/services.

Reinforcement Learning

- Reinforcement learning is a feedback-based learning method, in which a learning agent gets a reward for each right action and gets a penalty for each wrong action.
- The agent learns automatically with these feedbacks and improves its performance.
- In reinforcement learning, the agent interacts with the environment and explores it.
- The goal of an agent is to get the most reward points, and hence, it improves its performance.
- The robotic dog, which automatically learns the movement of his arms, is an example of Reinforcement learning.

Application of ML

- Machine learning is a buzzword for today's technology, and it is growing very rapidly day by day. We are using machine learning in our daily life even without knowing it such as Google Maps, Google assistant, Alexa, etc. :



- 1. Image Recognition:
- Image recognition is one of the most common applications of machine learning. It is used to identify objects, persons, places, digital images, etc. The popular use case of image recognition and face detection is, **Automatic friend tagging suggestion**:
- Facebook provides us a feature of auto friend tagging suggestion. Whenever we upload a photo with our Facebook friends, then we automatically get a tagging suggestion with name, and the technology behind this is machine learning's **face detection** and **recognition algorithm**.
- It is based on the Facebook project named "**Deep Face**," which is responsible for face recognition and person identification in the picture.

- 2. Speech Recognition
- While using Google, we get an option of "**Search by voice**," it comes under speech recognition, and it's a popular application of machine learning.
- Speech recognition is a process of converting voice instructions into text, and it is also known as "**Speech to text**", or "**Computer speech recognition**." At present, machine learning algorithms are widely used by various applications of speech recognition.
- **Google assistant**, **Siri**, **Cortana**, and **Alexa** are using speech recognition technology to follow the voice instructions.

- 3. Traffic prediction:
- If we want to visit a new place, we take help of Google Maps, which shows us the correct path with the shortest route and predicts the traffic conditions.
- It predicts the traffic conditions such as whether traffic is cleared, slow-moving, or heavily congested with the help of two ways:
- **Real Time location** of the vehicle form Google Map app and sensors
- **Average time has taken** on past days at the same time.
- Everyone who is using Google Map is helping this app to make it better. It takes information from the user and sends back to its database to improve the performance.

- 4. Product recommendations:
- Machine learning is widely used by various e-commerce and entertainment companies such as **Amazon**, **Netflix**, etc., for product recommendation to the user. Whenever we search for some product on Amazon, then we started getting an advertisement for the same product while internet surfing on the same browser and this is because of machine learning.
- Google understands the user interest using various machine learning algorithms and suggests the product as per customer interest.
- As similar, when we use Netflix, we find some recommendations for entertainment series, movies, etc., and this is also done with the help of machine learning.

5. Self-driving cars:

- One of the most exciting applications of machine learning is self-driving cars. Machine learning plays a significant role in self-driving cars. Tesla, the most popular car manufacturing company is working on self-driving car. It is using unsupervised learning method to train the car models to detect people and objects while driving.

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- 6. Email Spam and Malware Filtering:
- Whenever we receive a new email, it is filtered automatically as important, normal, and spam. We always receive an important mail in our inbox with the important symbol and spam emails in our spam box, and the technology behind this is Machine learning. Below are some spam filters used by Gmail:
- Content Filter
- Header filter
- General blacklists filter
- Rules-based filters
- Permission filters
- Some machine learning algorithms such as **Multi-Layer Perceptron**, **Decision tree**, and **Naïve Bayes classifier** are used for email spam filtering and malware detection.

Cont..

- 7. Virtual Personal Assistant:
- We have various virtual personal assistants such as **Google assistant**, **Alexa**, **Cortana**, **Siri**. As the name suggests, they help us in finding the information using our voice instruction. These assistants can help us in various ways just by our voice instructions such as Play music, call someone, Open an email, Scheduling an appointment, etc.
- These virtual assistants use machine learning algorithms as an important part.
- These assistant record our voice instructions, send it over the server on a cloud, and decode it using ML algorithms and act accordingly.

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8. Online Fraud Detection:

- Machine learning is making our online transaction safe and secure by detecting fraud transaction. Whenever we perform some online transaction, there may be various ways that a fraudulent transaction can take place such as **fake accounts**, **fake ids**, and **steal money** in the middle of a transaction.
- So to detect this, **Feed Forward Neural network** helps us by checking whether it is a genuine transaction or a fraud transaction.
- For each genuine transaction, the output is converted into some hash values, and these values become the input for the next round. For each genuine transaction, there is a specific pattern which gets change for the fraud transaction hence, it detects it and makes our online transactions more secure.

9. Stock Market Trading:

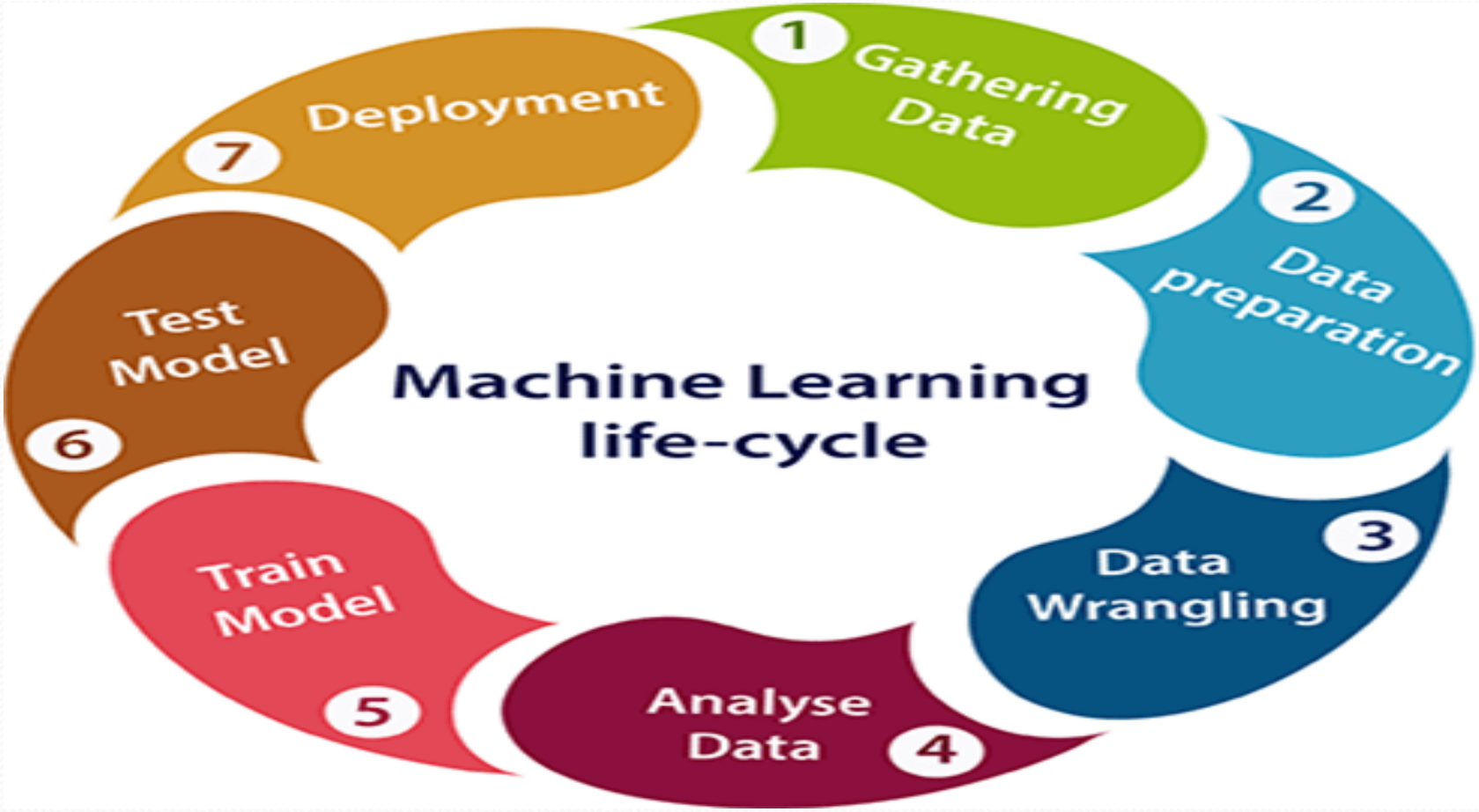
- Machine learning is widely used in stock market trading. In the stock market, there is always a risk of up and downs in shares, so for this machine learning's **long short term memory neural network** is used for the prediction of stock market trends.

- 10. Medical Diagnosis:
- In medical science, machine learning is used for diseases diagnoses. With this, medical technology is growing very fast and able to build 3D models that can predict the exact position of lesions in the brain.
- It helps in finding brain tumors and other brain-related diseases easily.

- 11. Automatic Language Translation:
- Nowadays, if we visit a new place and we are not aware of the language then it is not a problem at all, as for this also machine learning helps us by converting the text into our known languages.
- Google's GNMT (Google Neural Machine Translation) provide this feature, which is a Neural Machine Learning that translates the text into our familiar language, and it called as automatic translation.
- The technology behind the automatic translation is a sequence to sequence learning algorithm, which is used with image recognition and translates the text from one language to another language

- Machine learning Life cycle
- Machine learning has given the computer systems the abilities to automatically learn without being explicitly programmed. But how does a machine learning system work? So, it can be described using the life cycle of machine learning.
- Machine learning life cycle is a cyclic process to build an efficient machine learning project. The main purpose of the life cycle is to find a solution to the problem or project.

LC for ML


Machine Learning life-cycle
1 Gathering Data
2 Data preparation
3 Data Wrangling
4 Analyse Data
5 Train Model
6 Test Model
7 Deployment

Cont..

Machine learning life cycle involves seven major steps, which are given below:

- **Gathering Data**
- **Data preparation**
- **Data Wrangling**
- **Analyse Data**
- **Train the model**
- **Test the model**
- **Deployment**

Cont..

- The most important thing in the complete process is to understand the problem and to know the purpose of the problem. Therefore, before starting the life cycle, we need to understand the problem because the good result depends on the better understanding of the problem.
- In the complete life cycle process, to solve a problem, we create a machine learning system called "model", and this model is created by providing "training". But to train a model, we need data, hence, life cycle starts by collecting data.

1. Gathering Data:

- In this step, we need to identify the different data sources, as data can be collected from various sources such as **files**, **database**, **internet**, or **mobile devices**. It is one of the most important steps of the life cycle.
- The quantity and quality of the collected data will determine the efficiency of the output.
- The more will be the data, the more accurate will be the prediction.

This step includes the below tasks:

- **Identify various data sources**
- **Collect data**
- **Integrate the data obtained from different sources**
- .

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- By performing the above task, we get a coherent set of data, also called as a **dataset**. It will be used in further steps

2. Data preparation

- Data preparation is a step where we put our data into a suitable place and prepare it to use in our machine learning training.
- In this step, first, we put all data together, and then randomize the ordering of data.

This step can be further divided into two processes:

- **Data exploration:**
  It is used to understand the nature of data that we have to work with. We need to understand the characteristics, format, and quality of data.
  A better understanding of data leads to an effective outcome. In this, we find Correlations, general trends, and outliers.
- **Data pre-processing:**
  Now the next step is preprocessing of data for its analysis.

3. Data Wrangling

- Data wrangling is the process of cleaning and converting raw data into a useable format.
- It is the process of cleaning the data, selecting the variable to use, and transforming the data in a proper format to make it more suitable for analysis in the next step.
- It is one of the most important steps of the complete process. Cleaning of data is required to address the quality issues.
- It is not necessary that data we have collected is always of our use as some of the data may not be useful.
- In real-world applications, collected data may have various issues, including:
- **Missing Values**
- **Duplicate data**

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- **Invalid data**
- **Noise**
- So, we use various filtering techniques to clean the data.
- It is mandatory to detect and remove the above issues because it can negatively affect the quality of the outcome.

4. Data Analysis

This step involves:

- **Selection of analytical techniques**
- **Building models**
- **Review the result**
- The aim of this step is to build a machine learning model to analyze the data using various analytical techniques and review the outcome.
- It starts with the determination of the type of the problems, where we select the machine learning techniques such as **Classification**, **Regression**, **Cluster analysis**, **Association**, etc. then build the model using prepared data, and evaluate the model.
- Hence, in this step, we take the data and use machine learning algorithms to build the model.

5. Train Model

- Now the next step is to train the model, in this step we train our model to improve its performance for better outcome of the problem.
- We use datasets to train the model using various machine learning algorithms. Training a model is required so that it can understand the various patterns, rules, and, features.

6. Test Model

- Once our machine learning model has been trained on a given dataset, then we test the model.
- In this step, we check for the accuracy of our model by providing a test dataset to it.
- Testing the model determines the percentage accuracy of the model as per the requirement of project or problem.

7. Deployment

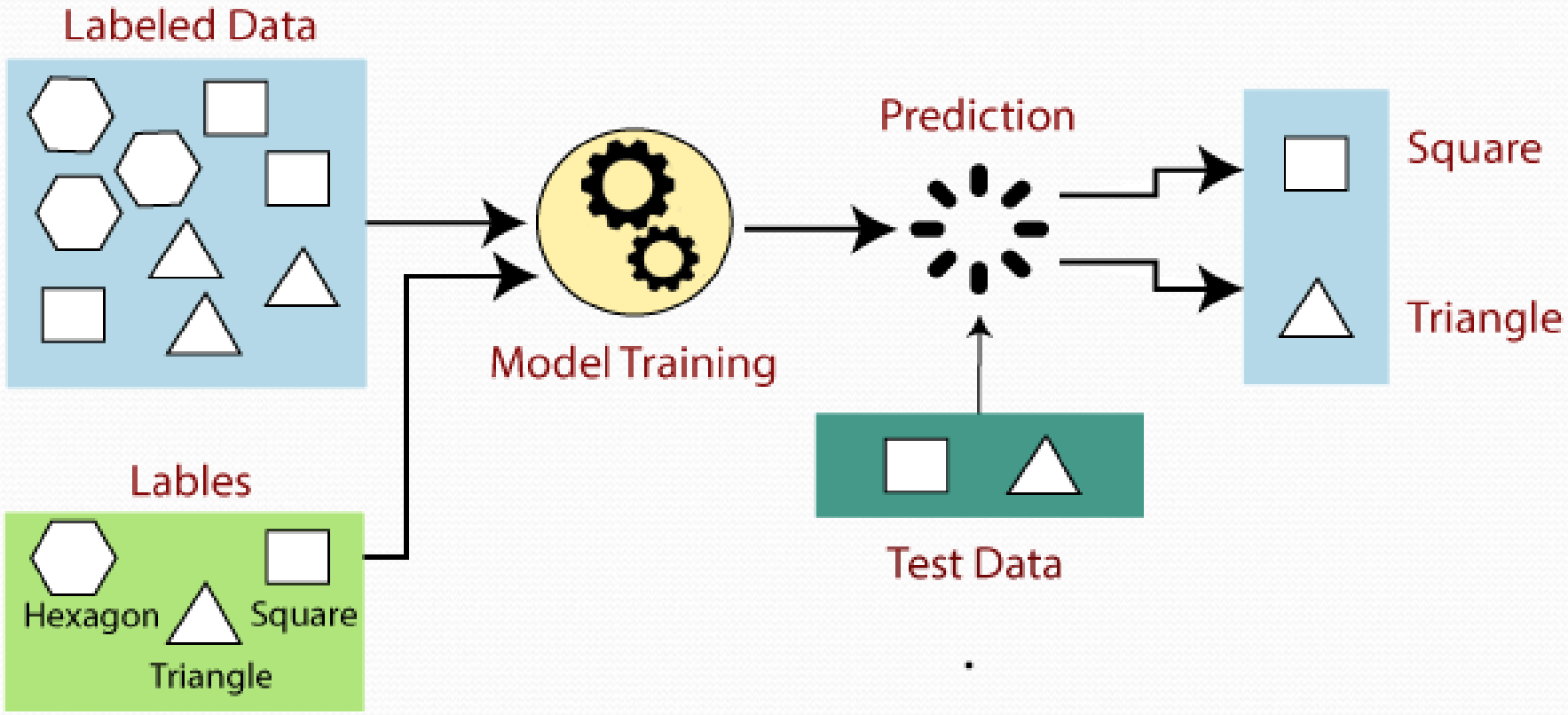
- The last step of machine learning life cycle is deployment, where we deploy the model in the real-world system.
- If the above-prepared model is producing an accurate result as per our requirement with acceptable speed, then we deploy the model in the real system.
- But before deploying the project, we will check whether it is improving its performance using available data or not.
- The deployment phase is similar to making the final report for a project.

Supervised Machine Learning

- Supervised learning is the types of machine learning in which machines are trained using well "labelled" training data, and on basis of that data, machines predict the output.
- The labelled data means some input data is already tagged with the correct output.
- The aim of a supervised learning algorithm is to **find a mapping function to map the input variable(x) with the output variable(y)**.
- In the real-world, supervised learning can be used for **Risk Assessment, Image classification, Fraud Detection, spam filtering**, etc.

How Supervised Learning Works?

- In supervised learning, models are trained using labelled dataset, where the model learns about each type of data. Once the training process is completed, the model is tested on the basis of test data (a subset of the training set), and then it predicts the output.



- Suppose we have a dataset of different types of shapes which includes square, rectangle, triangle, and Polygon.
- Now the first step is that we need to train the model for each shape.
- If the given shape has four sides, and all the sides are equal, then it will be labelled as a **Square**.
- If the given shape has three sides, then it will be labelled as a **triangle**.
- If the given shape has six equal sides then it will be labelled as **hexagon**.
- Now, after training, we test our model using the test set, and the task of the model is to identify the shape.
- it classifies the shape on the bases of a number of sides, and predicts the output.

Steps Involved in Supervised Learning:

- First Determine the type of training dataset
- Collect/Gather the labelled training data.
- Split the training dataset into training **dataset, test dataset, and validation dataset**.
- Determine the input features of the training dataset, which should have enough knowledge so that the model can accurately predict the output.
- Determine the suitable algorithm for the model, such as support vector machine, decision tree, etc.

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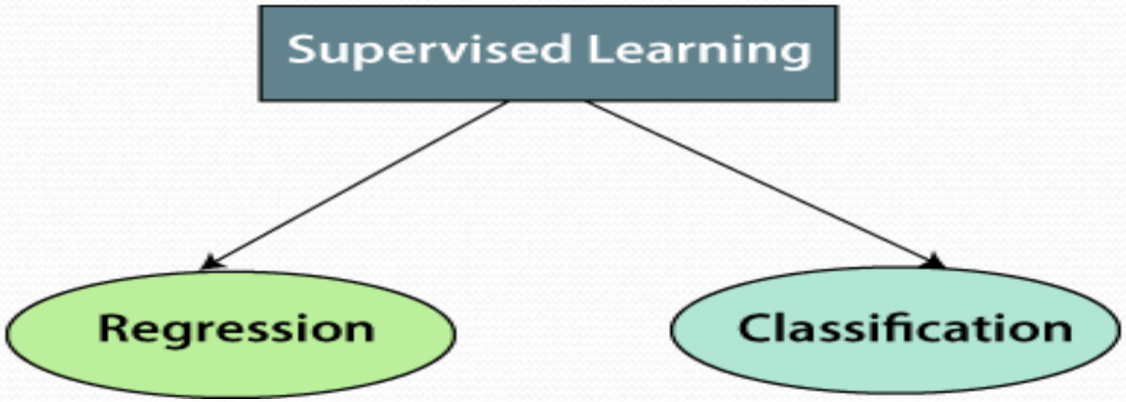
- Execute the algorithm on the training dataset. Sometimes we need validation sets as the control parameters, which are the subset of training datasets.
- Evaluate the accuracy of the model by providing the test set. If the model predicts the correct output, which means our model is accurate

Types of supervised Machine learning Algorithms:

- Supervised learning can be further divided into two types of problems:



- **1. Regression**
- Regression algorithms are used if there is a relationship between the input variable and the output variable.
- It is used for the prediction of continuous variables, such as Weather forecasting, Market Trends, etc.

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- Below are some popular Regression algorithms which come under supervised learning:
- Linear Regression
- Regression Trees
- Non-Linear Regression
- Bayesian Linear Regression
- Polynomial Regression

2. Classification

- Classification algorithms are used when the output variable is categorical, which means there are two classes such as Yes-No, Male-Female, True-false, etc.
- Spam Filtering,
- Random Forest
- Decision Trees
- Logistic Regression
- Support vector Machines

Advantages of Supervised learning:

- With the help of supervised learning, the model can predict the output on the basis of prior experiences.
- In supervised learning, we can have an exact idea about the classes of objects.
- Supervised learning model helps us to solve various real-world problems such as **fraud detection, spam filtering**, etc.

Disadvantages of supervised learning:

- Supervised learning models are not suitable for handling the complex tasks.
- Supervised learning cannot predict the correct output if the test data is different from the training dataset.
- Training required lots of computation times.
- In supervised learning, we need enough knowledge about the classes of object.

Unsupervised Machine Learning

- In the previous topic, we learned supervised machine learning in which models are trained using labeled data under the supervision of training data.
- But there may be many cases in which we do not have labeled data and need to find the hidden patterns from the given dataset. So, to solve such types of cases in machine learning, we need unsupervised learning techniques.

What is Unsupervised Learning?

- As the name suggests, unsupervised learning is a machine learning technique in which models are not supervised using training dataset.
- Instead, models itself find the hidden patterns and insights from the given data.
- It can be compared to learning which takes place in the human brain while learning new things. It can be defined as:
- *Unsupervised learning is a type of machine learning in which models are trained using unlabeled dataset and are allowed to act on that data without any supervision.*
- Unsupervised learning cannot be directly applied to a regression or classification problem because unlike supervised learning, we have the input data but no corresponding output data

- The goal of unsupervised learning is to **find the underlying structure of dataset, group that data according to similarities, and represent that dataset in a compressed format**.
- **Example:** Suppose the unsupervised learning algorithm is given an input dataset containing images of different types of cats and dogs. The algorithm is never trained upon the given dataset, which means it does not have any idea about the features of the dataset. The task of the unsupervised learning algorithm is to identify the image features on their own..

- Unsupervised learning algorithm will perform this task by clustering the image dataset into the groups according to similarities between images

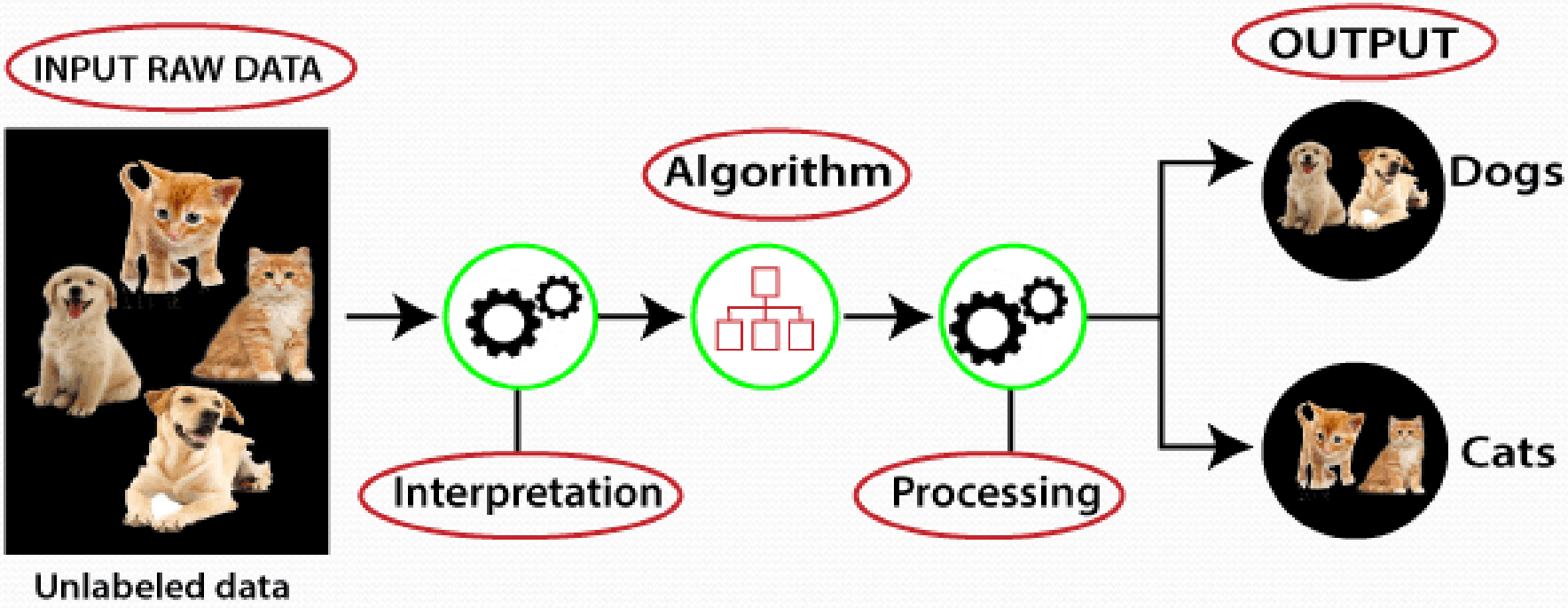
Why use Unsupervised Learning?

importance of Unsupervised Learning:

- Unsupervised learning is helpful for finding useful insights from the data.
- Unsupervised learning is much similar as a human learns to think by their own experiences, which makes it closer to the real AI.
- Unsupervised learning works on unlabeled and uncategorized data which make unsupervised learning more important.
- In real-world, we do not always have input data with the corresponding output so to solve such cases, we need unsupervised learning.

Working of Unsupervised Learning

- Working of unsupervised learning can be understood by the below diagram:

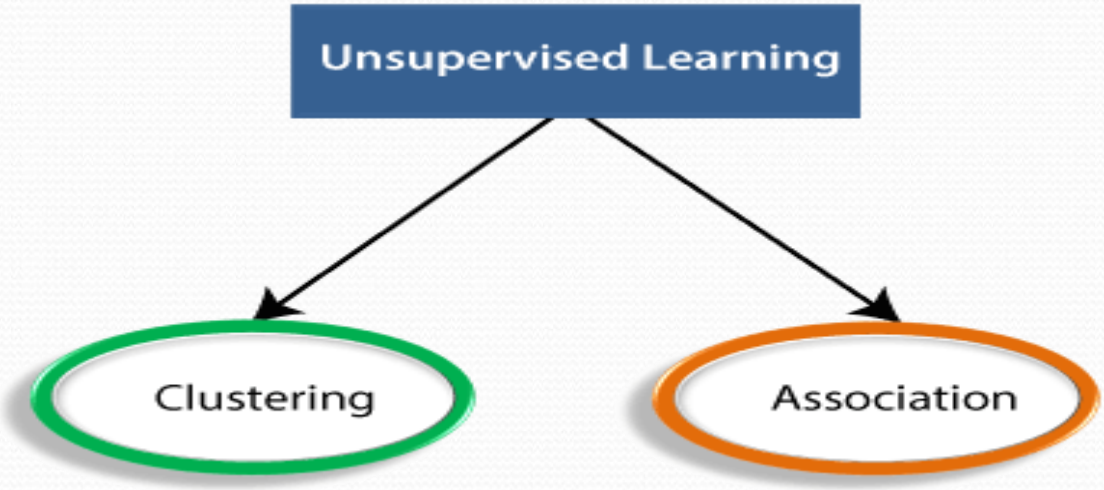


Cont..

- Here, we have taken an unlabeled input data, which means it is not categorized and corresponding outputs are also not given.
- Now, this unlabeled input data is fed to the machine learning model in order to train it.
- Firstly, it will interpret the raw data to find the hidden patterns from the data and then will apply suitable algorithms such as k-means clustering,Association etc.
- Once it applies the suitable algorithm, the algorithm divides the data objects into groups according to the similarities and difference between the objects.

Types of Unsupervised Learning Algorithm:

- The unsupervised learning algorithm can be further categorized into two types of problems:



- **Clustering**: Clustering is a method of grouping the objects into clusters such that objects with most similarities remains into a group and has less or no similarities with the objects of another group.
- Cluster analysis finds the commonalities between the data objects and categorizes them as per the presence and absence of those commonalities.

Association:

- An association rule is an unsupervised learning method which is used for finding the relationships between variables in the large database.
- It determines the set of items that occurs together in the dataset.
- Association rule makes marketing strategy more effective.
- Such as people who buy X item (suppose a bread) are also tend to purchase Y (Butter/Jam) item.
- A typical example of Association rule is Market Basket Analysis.

Unsupervised Learning algorithms:

- K-means clustering
- KNN (k-nearest neighbors)
- Hierarchal clustering
- Anomaly detection
- Neural Networks
- Principle Component Analysis
- Independent Component Analysis
- Apriori algorithm
- Singular value decomposition

Advantages of Unsupervised Learning

- Unsupervised learning is used for more complex tasks as compared to supervised learning because, in unsupervised learning, we don't have labeled input data.
- Unsupervised learning is preferable as it is easy to get unlabeled data in comparison to labeled data.

Disadvantages of Unsupervised Learning

- Unsupervised learning is intrinsically more difficult than supervised learning as it does not have corresponding output.
- The result of the unsupervised learning algorithm might be less accurate as input data is not labeled, and algorithms do not know the exact output in advance.

Difference between Sup Vs Unsup Learning

Supervised Learning	Unsupervised Learning
Supervised learning algorithms are trained using labeled data.	Unsupervised learning algorithms are trained using unlabeled data.
Supervised learning model predicts the output.	Unsupervised learning model finds the hidden patterns in data.
In supervised learning, input data is provided to the model along with the output.	In unsupervised learning, only input data is provided to the model.
The goal of supervised learning is to train the model so that it can predict the output when it is given new data.	The goal of unsupervised learning is to find the hidden patterns and useful insights from the unknown dataset.

Supervised Learning	Unsupervised Learning
Supervised learning needs supervision to train the model.	Unsupervised learning does not need any supervision to train the model.
Supervised learning can be categorized in **Classification** and **Regression** problems.	Unsupervised Learning can be classified in **Clustering** and **Associations** problems.
Supervised learning can be used for those cases where we know the input as well as corresponding outputs.	Unsupervised learning can be used for those cases where we have only input data and no corresponding output data.
Supervised learning model produces an accurate result.	Unsupervised learning model may give less accurate result as compared to supervised learning.
Supervised learning is not close to true Artificial intelligence as in this, we first train the model for each data, and then only it can predict the correct output.	Unsupervised learning is more close to the true Artificial Intelligence as it learns similarly as a child learns daily routine things by his experiences.
It includes various algorithms such as Linear Regression, Logistic Regression, Support Vector Machine, Multi-class Classification, Decision tree, Bayesian Logic, etc.	It includes various algorithms such as Clustering, KNN, and Apriori algorithm.

Reinforcement Learning

- Learning a policy: A sequence of outputs
- No supervised output but delayed reward
- Credit assignment problem
- Game playing
- Robot in a maze
- Multiple agents, partial observability, ...

What is Reinforcement Learning(RL)?

- Reinforcement Learning is a feedback-based Machine learning technique in which an agent learns to behave in an environment by performing the actions and seeing the results of actions. For each good action, the agent gets positive feedback, and for each bad action, the agent gets negative feedback or penalty.
- In RL agents learns automatically using feedbacks without any labeled data, unlike supervised learning.
- Since there is no labeled data, so the agent is bound to learn by its experience only.
- RL solves a specific type of problem where decision making is sequential, and the goal is long-term, such as **game-playing, robotics**, etc.

Cont..

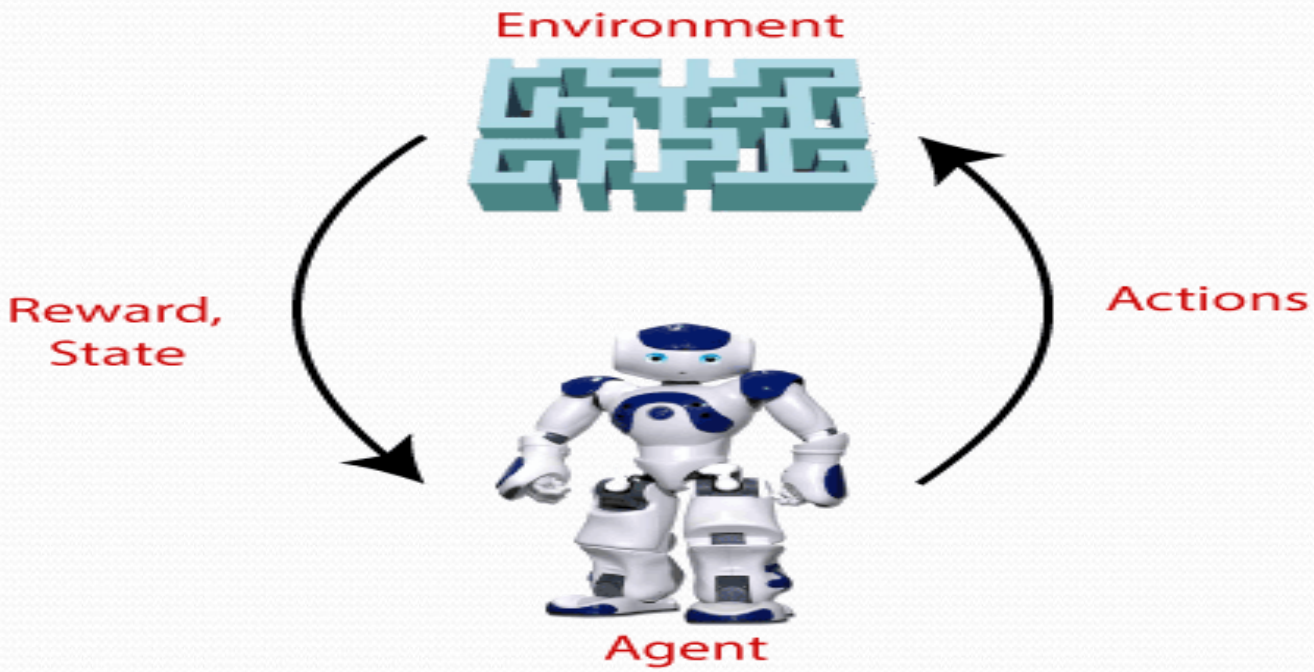
- The agent interacts with the environment and explores it by itself.
- The primary goal of an agent in RL is to improve the performance by getting the maximum positive rewards.
- The agent learns with the process of hit and trial, and based on the experience, it learns to perform the task in a better way.
- Hence, we can say that ***"Reinforcement learning is a type of machine learning method where an intelligent agent (computer program) interacts with the environment and learns to act within that."*** How a Robotic dog learns the movement of his arms is an example of Reinforcement learning.

Cont..

- It is a core part of Artificial intelligence, and all AI agent works on the concept of reinforcement learning.
- Here we do not need to pre-program the agent, as it learns from its own experience without any human intervention.
- **Example:** Suppose there is an AI agent present within a maze environment, and his goal is to find the diamond. The agent interacts with the environment by performing some actions, and based on those actions, the state of the agent gets changed, and it also receives a reward or penalty as feedback.
- The agent continues doing these three things (**take action, change state/remain in the same state, and get feedback**), and by doing these actions, he learns and explores the environment.

Cont..

- The agent learns that what actions lead to positive feedback or rewards and what actions lead to negative feedback penalty. As a positive reward, the agent gets a positive point, and as a penalty, it gets a negative point.



Terms used in Reinforcement Learning

- **Agent():** An entity that can perceive/explore the environment and act upon it.
- **Environment():** A situation in which an agent is present or surrounded by. In RL, we assume the stochastic environment, which means it is random in nature.
- **Action():** Actions are the moves taken by an agent within the environment.
- **State():** State is a situation returned by the environment after each action taken by the agent.
- **Reward():** A feedback returned to the agent from the environment to evaluate the action of the agent.
- **Policy():** Policy is a strategy applied by the agent for the next action based on the current state.

Cont..

- **Value():** It is expected long-term retuned with the discount factor and opposite to the short-term reward.
- **Q-value():** It is mostly similar to the value, but it takes one additional parameter as a current action (a).

Key Features of Reinforcement Learning

- In RL, the agent is not instructed about the environment and what actions need to be taken.
- It is based on the hit and trial process.
- The agent takes the next action and changes states according to the feedback of the previous action.
- The agent may get a delayed reward.
- The environment is stochastic, and the agent needs to explore it to reach to get the maximum positive rewards.

Approaches to implement Reinforcement Learning

- There are mainly three ways to implement reinforcement-learning in ML, which are:
- **Value-based:**
  The value-based approach is about to find the optimal value function, which is the maximum value at a state under any policy. Therefore, the agent expects the long-term return at any state(s) under policy π.
- **Policy-based:**
  Policy-based approach is to find the optimal policy for the maximum future rewards without using the value function. In this approach, the agent tries to apply such a policy that the action performed in each step helps to

- maximize the future reward.
  The policy-based approach has mainly two types of policy:
  - **Deterministic:** The same action is produced by the policy (π) at any state.
  - **Stochastic:** In this policy, probability determines the produced action.
- **Model-based:** In the model-based approach, a virtual model is created for the environment, and the agent explores that environment to learn it.
- There is no particular solution or algorithm for this approach because the model representation is different for each environment.

- Elements of Reinforcement Learning
- There are four main elements of Reinforcement Learning, which are given below:
- Policy
- Reward Signal
- Value Function
- Model of the environment
- **1) Policy:** A policy can be defined as a way how an agent behaves at a given time. It maps the perceived states of the environment to the actions taken on those states. A policy is the core element of the RL as it alone can define the behavior of the agent. In some cases, it may be a simple function or a

- lookup table, whereas, for other cases, it may involve general computation as a search process. It could be deterministic or a stochastic policy:
- **For deterministic policy: $a = \pi(s)$**
  For stochastic policy: $\pi(a \mid s) = P[A_t = a \mid S_t = s]$
- **2) Reward Signal:** The goal of reinforcement learning is defined by the reward signal.
- At each state, the environment sends an immediate signal to the learning agent, and this signal is known as a **reward signal**.
- These rewards are given according to the good and bad actions taken by the agent. The agent's main objective is to maximize the total number of rewards for good actions.
- The reward signal can change the policy, such as if an action

selected by the agent leads to low reward, then the policy may change to select other actions in the future.

- **3) Value Function:** The value function gives information about how good the situation and action are and how much reward an agent can expect. A reward indicates the **immediate signal for each good and bad action**, whereas a value function specifies **the good state and action for the future**.
- The value function depends on the reward as, without reward, there could be no value. The goal of estimating values is to achieve more rewards.
- **) Model:** The last element of reinforcement learning is the model, which mimics the behavior of the environment. With the help of the model, one can make inferences about how the environment will behave.

- Such as, if a state and an action are given, then a model can predict the next state and reward.
- The model is used for planning, which means it provides a way to take a course of action by considering all future situations before actually experiencing those situations.
- The approaches for solving the RL problems **with the help of the model** are termed as the **model-based approach**.
- Comparatively, an approach **without using a model** is called a **model-free approach**.

- **Types of Reinforcement:** There are two types of Reinforcement:
- **Positive –**
  Positive Reinforcement is defined as when an event, occurs due to a particular behavior, increases the strength and the frequency of the behavior. In other words, it has a positive effect on behavior.
  Advantages of reinforcement learning are:
  - Maximizes Performance

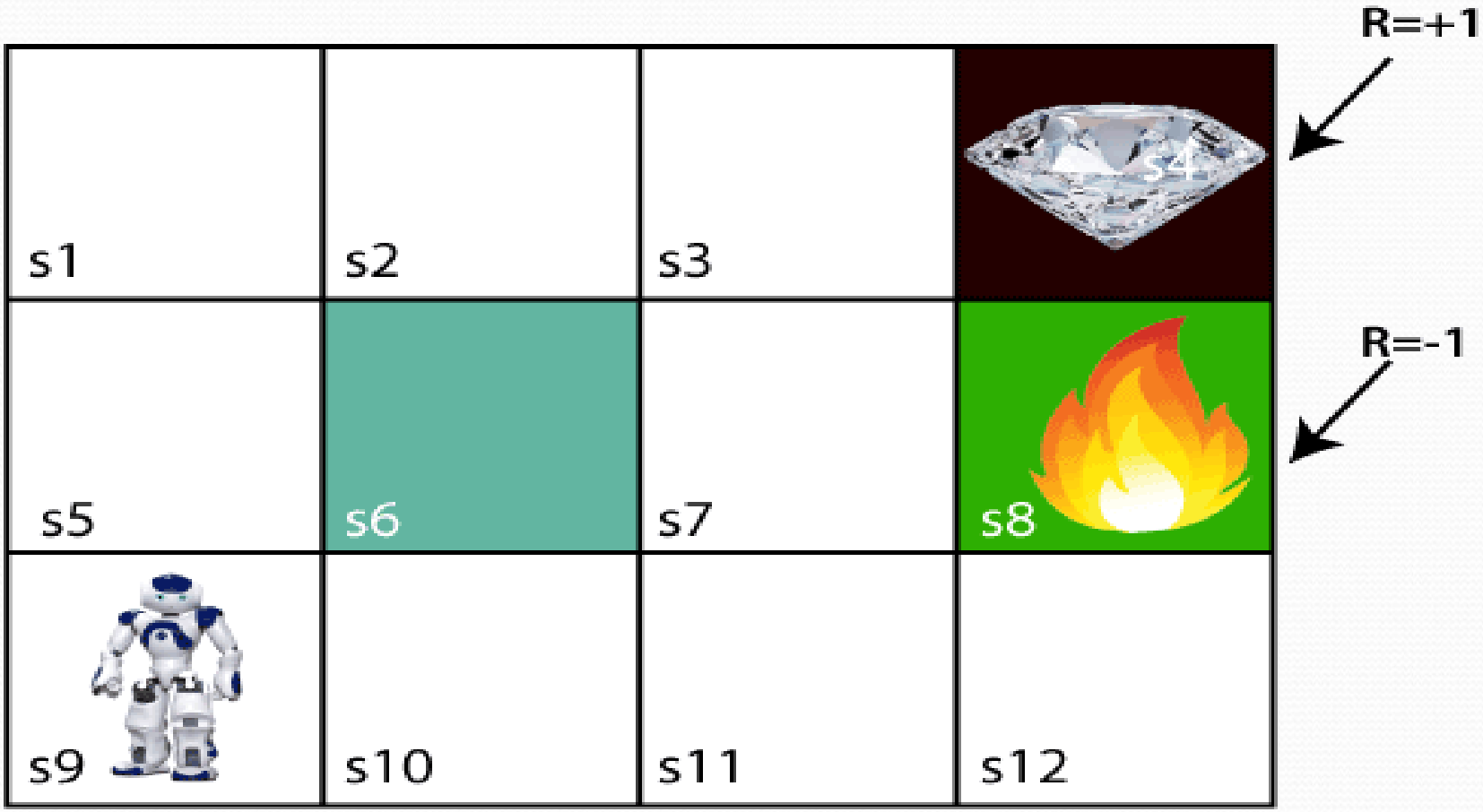
CONT..

- Sustain Change for a long period of time
- Too much Reinforcement can lead to an overload of states which can diminish the results

- **Negative –**
  Negative Reinforcement is defined as strengthening of behavior because a negative condition is stopped or avoided.
  Advantages of reinforcement learning:
  - Increases Behavior
  - Provide defiance to a minimum standard of performance
  - It Only provides enough to meet up the minimum behavior

How does Reinforcement Learning Work?

- To understand the working process of the RL, we need to consider two main things:
- **Environment:** It can be anything such as a room, maze, football ground, etc.
- **Agent:** An intelligent agent such as AI robot.
- Let's take an example of a maze environment that the agent needs to explore. Consider the below image:
- Let's take an example of a maze environment that the agent needs to explore. Consider the below image:

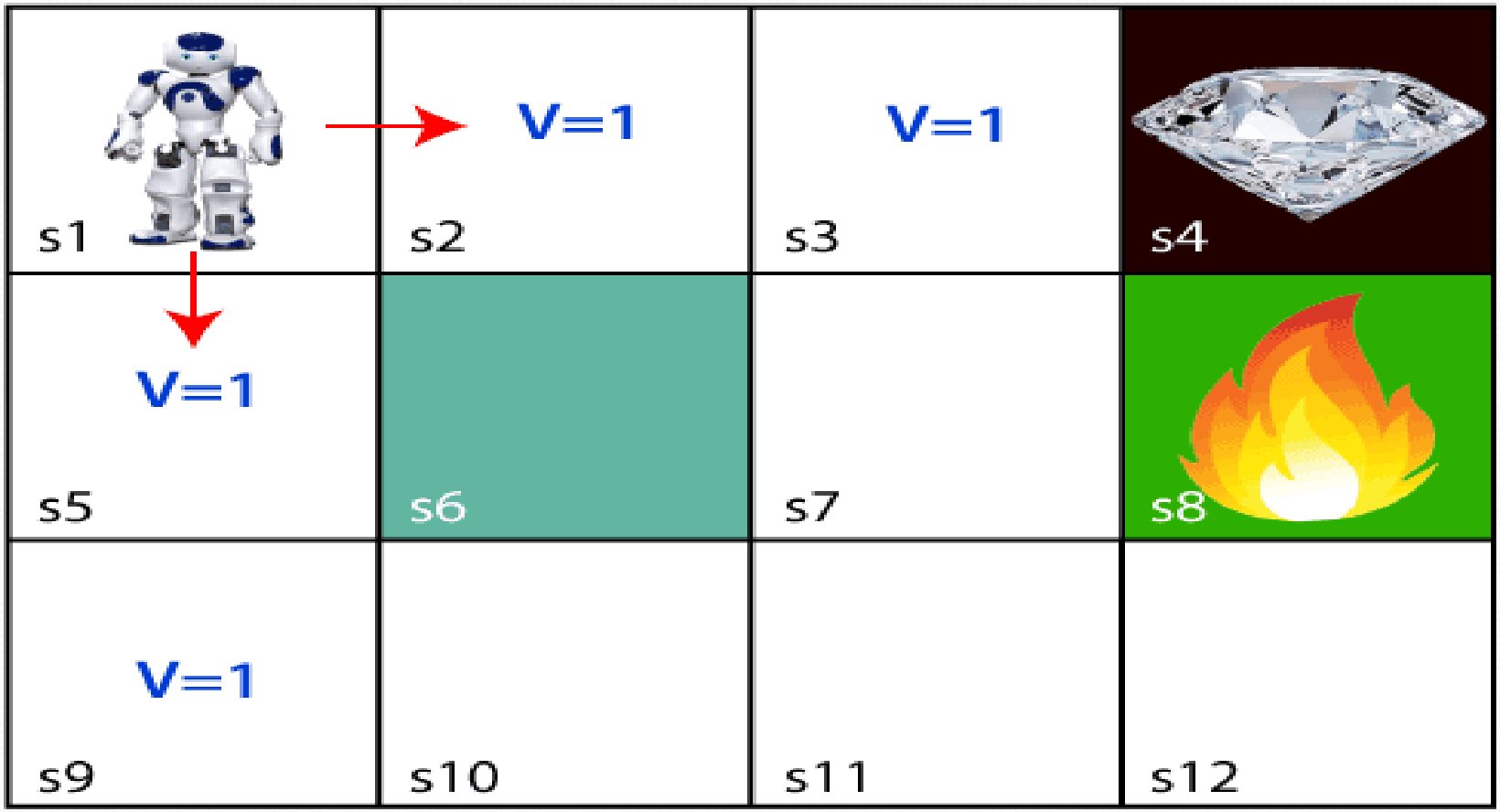


Lorem ipsum

- In the above image, the agent is at the very first block of the maze. The maze is consisting of an S_6 block, which is a **wall**, S_8 a **fire pit**, and S_4 a **diamond block.**
- The agent cannot cross the S_6 block, as it is a solid wall. If the agent reaches the S_4 block, then get the **+1 reward;** if it reaches the fire pit, then gets **-1 reward point**. It can take four actions**: move up, move down, move left, and move right.**
- The agent can take any path to reach to the final point, but he needs to make it in possible fewer steps. Suppose the agent considers the path **S9-S5-S1-S2-S3**, so he will get the +1-reward point.
- The agent will try to remember the preceding steps that it has taken to reach the final step. To memorize the steps, it assigns 1 value to each previous step. Consider the below step:

V=1 s1	V=1 s2	V=1 s3	 s4
V=1 s5	s6	s7	 s8
 V=1 s9	s10	s11	s12

- Now, the agent has successfully stored the previous steps assigning the 1 value to each previous block. But what will the agent do if he starts moving from the block, which has 1 value block on both sides? Consider the below diagram:

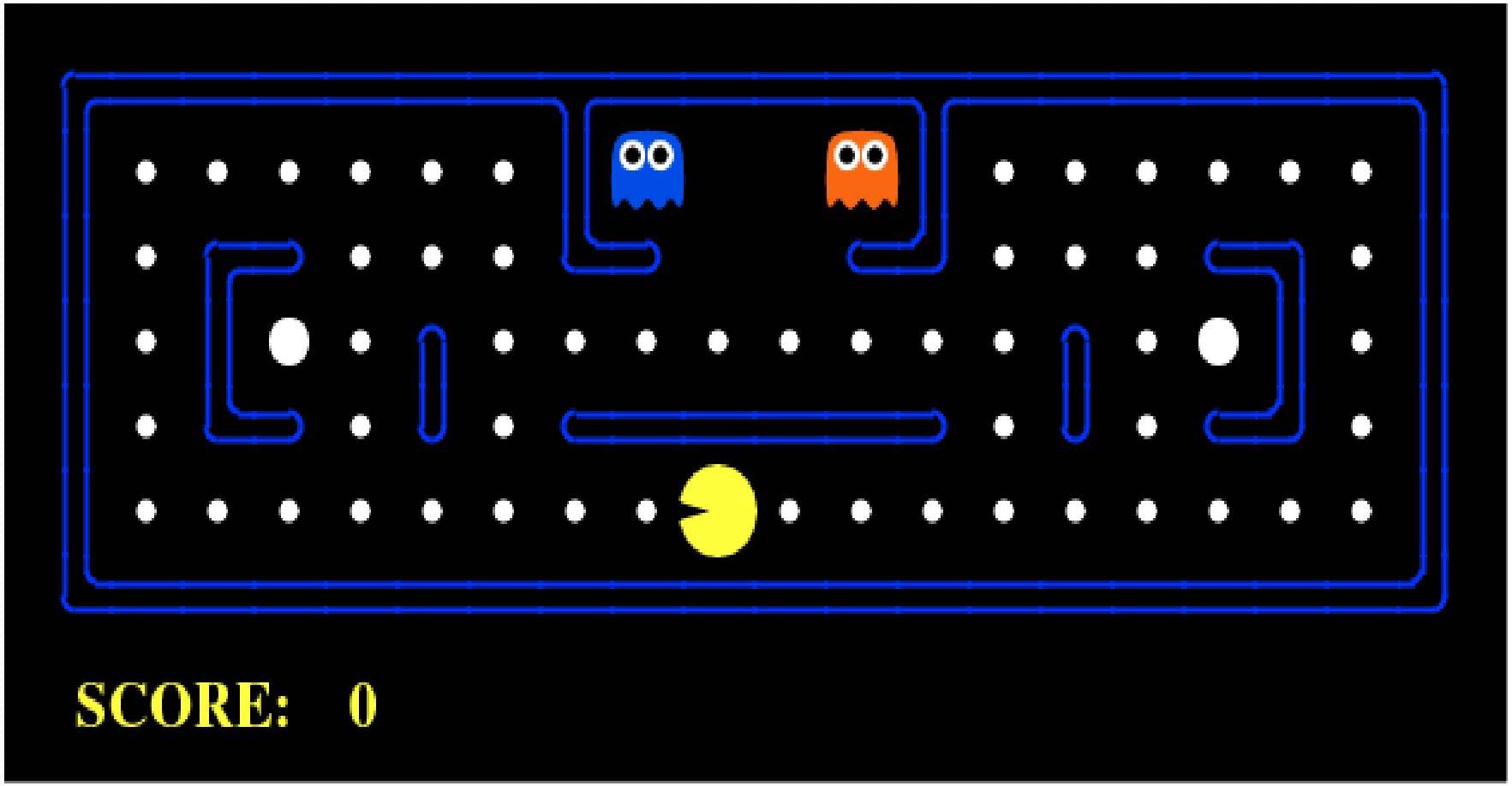

s1
V=1
s2
V=1
s3
s4
V=1
s5
s6
s7
s8
V=1
s9
s10
s11
s12

- It will be a difficult condition for the agent whether he should go up or down as each block has the same value. So, the above approach is not suitable for the agent to reach the destination. Hence to solve the problem, we will use the **Bellman equation**, which is the main concept behind reinforcement learning.

How to formulate a basic Reinforcement Learning problem?

- An RL problem can be best explained through games. Let's take the game of PacMan where the goal of the agent(PacMan) is to eat the food in the grid while avoiding the ghosts on its way.
- In this case, the grid world is the interactive environment for the agent where it acts. Agent receives a reward for eating food and punishment if it gets killed by the ghost (loses the game). The states are the location of the agent in the grid world and the total cumulative reward is the agent winning the game.

PacMan



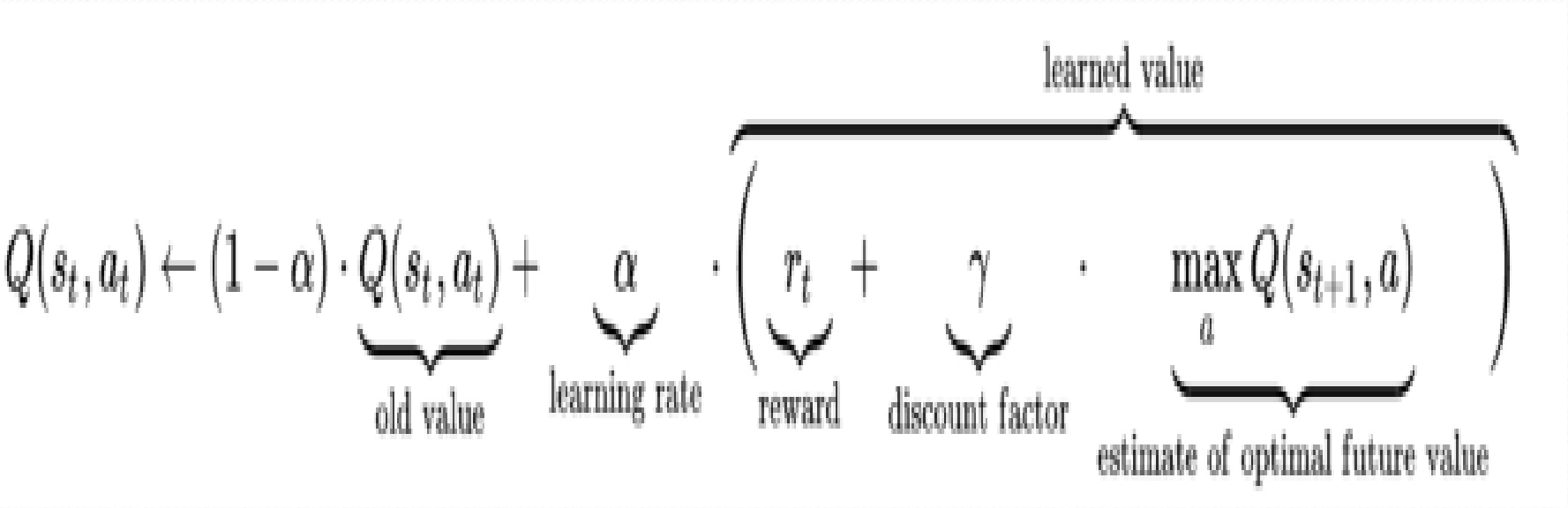
- In order to build an optimal policy, the agent faces the dilemma of exploring new states while maximizing its overall reward at the same time.
- This is called **Exploration vs Exploitation** trade-off. To balance both, the best overall strategy may involve short term sacrifices.
- Therefore, the agent should collect enough information to make the best overall decision in the future.

Markov Decision Processes

- **MDPs** are mathematical frameworks to describe an environment in RL and almost all RL problems can be formulated using MDPs.
- An MDP consists of a set of finite environment states S, a set of possible actions A(s) in each state, a real valued reward function R(s) and a transition model P(s', s | a).
- However, real world environments are more likely to lack any prior knowledge of environment dynamics. Model-free RL methods come handy in such cases.

Q-learning

- **Q-learning** is a commonly used model-free approach which can be used for building a self-playing PacMan agent. It revolves around the notion of updating Q values which denotes value of performing action *a* in state *s*. The following value update rule is the core of the Q-learning algorithm.
- Here's a video demonstration of a PacMan Agent that uses Deep Reinforcement Learning.
- https://towardsdatascience.com/reinforcement-learning-101-e24b50e1d292

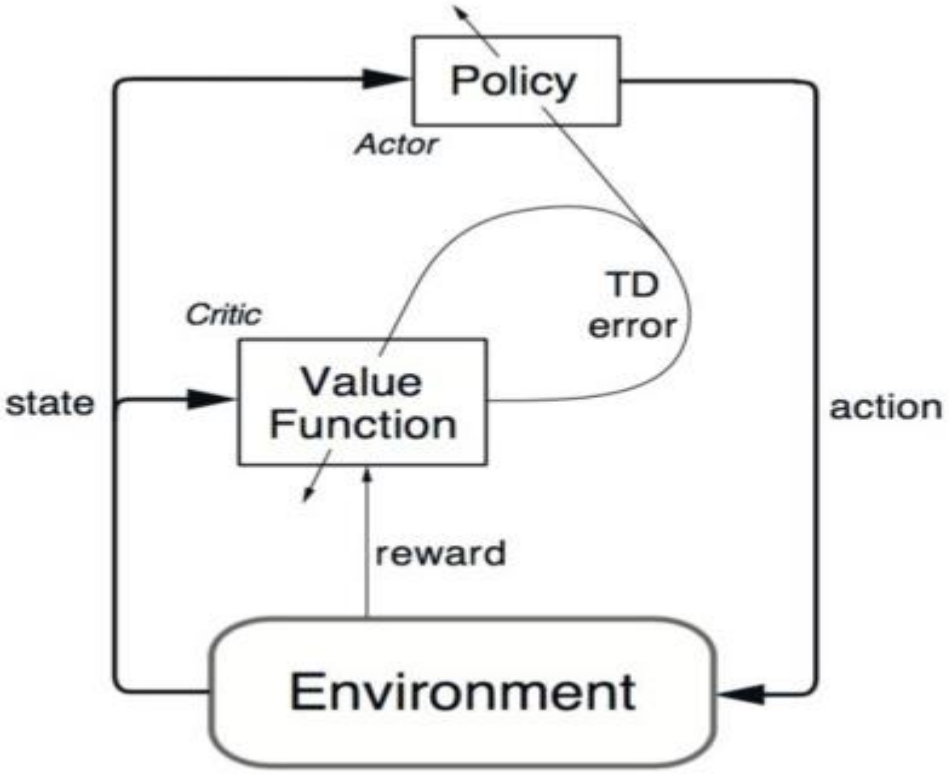

learned value
$Q(s_t, a_t) \leftarrow (1-\alpha) \cdot Q(s_t, a_t) + \alpha \cdot \left(r_t + \gamma \cdot \max_a Q(s_{t+1}, a) \right)$
old value
learning rate
reward
discount factor
estimate of optimal future value

Most used Reinforcement Learning algorithms?

- **Q-learning** and **SARSA** (State-Action-Reward-State-Action) are two commonly used model-free RL algorithms. They differ in terms of their exploration strategies while their exploitation strategies are similar.
- While Q-learning is an off-policy method in which the agent learns the value based on action a* derived from the another policy,
- SARSA is an on-policy method where it learns the value based on its current action *a* derived from its current policy.

CONT..

- These two methods are simple to implement but lack generality as they do not have the ability to estimates values for unseen states.
- This can be overcome by more advanced algorithms such as **Deep Q-Networks(DQNs)** which use Neural Networks to estimate Q-values. But DQNs can only handle discrete, low-dimensional action spaces.
- **Deep Deterministic Policy Gradient(DDPG)** is a model-free, off-policy, actor-critic algorithm that tackles this problem by learning policies in high dimensional, continuous action spaces. The figure below is a representation of **actor-critic** architecture.


Policy
Actor
Critic
TD
error
state
Value
Function
action
reward
Environment

Difference between RL vs SL

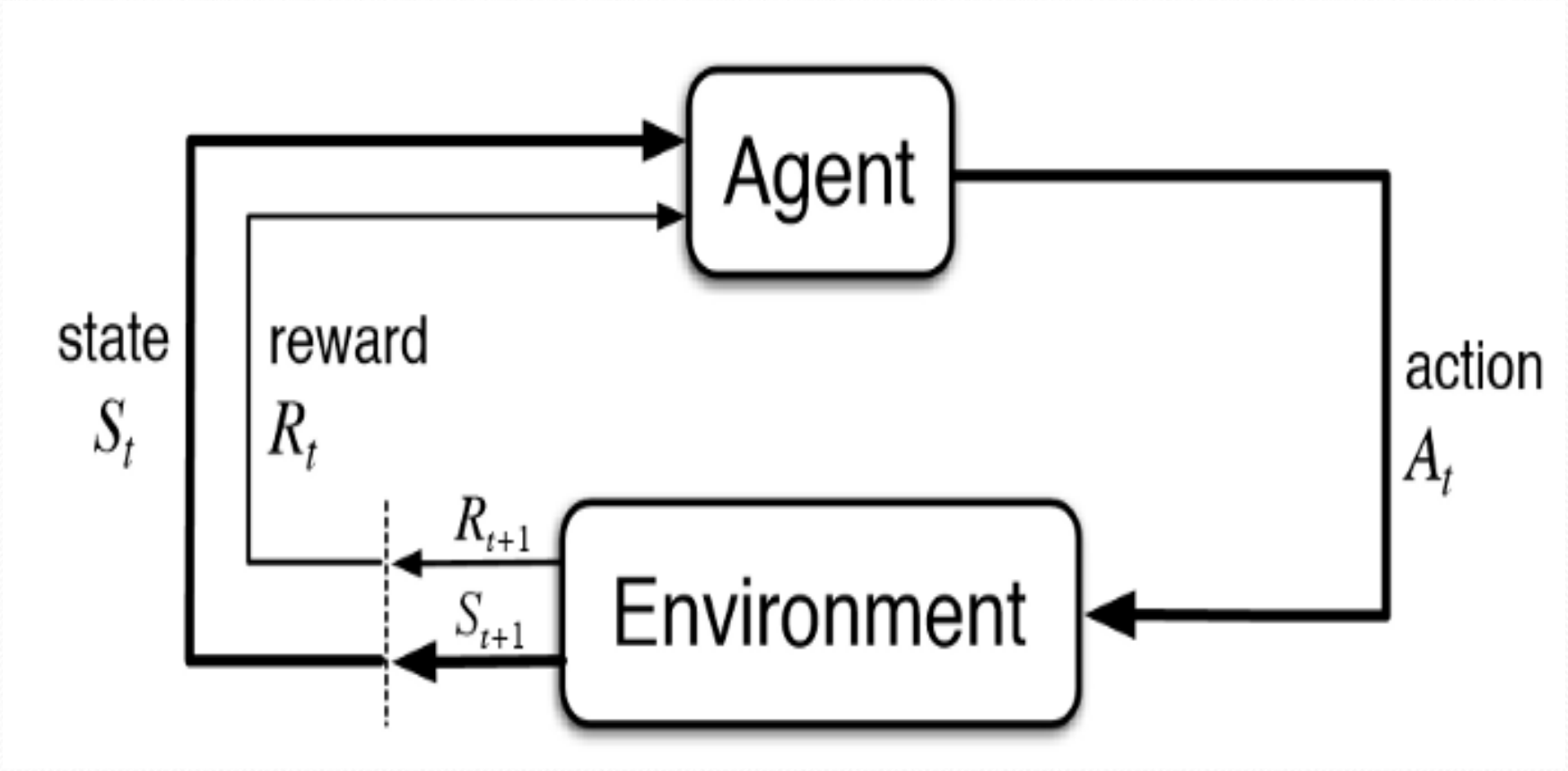
- The Reinforcement Learning and Supervised Learning both are the part of machine learning, but both types of learnings are far opposite to each other. The RL agents interact with the environment, explore it, take action, and get rewarded. Whereas supervised learning algorithms learn from the labeled dataset and, on the basis of the training, predict the output.
- The difference table between RL and Supervised learning is given below:

RL vs SL

Reinforcement Learning	Supervised Learning
RL works by interacting with the environment.	Supervised learning works on the existing dataset.
The RL algorithm works like the human brain works when making some decisions.	Supervised Learning works as when a human learns things in the supervision of a guide.
There is no labeled dataset is present	The labeled dataset is present.
No previous training is provided to the learning agent.	Training is provided to the algorithm so that it can predict the output.
RL helps to take decisions sequentially.	In Supervised learning, decisions are made when input is given.

RL Vs SP, RL Vs UL

- Though both supervised and reinforcement learning use mapping between input and output, unlike supervised learning where the feedback provided to the agent is **correct set of actions** for performing a task, reinforcement learning uses **rewards and punishments** as signals for positive and negative behavior.
- As compared to unsupervised learning, reinforcement learning is different in terms of goals. While the goal in unsupervised learning is to find similarities and differences between data points, in the case of reinforcement learning the goal is to find a suitable action model that would maximize the **total cumulative reward** of the agent. The figure below illustrates the **action-reward feedback loop** of a generic RL model.


Agent
state
S_t
reward
R_t
action
A_t
R_{t+1}
S_{t+1}
Environment

Reinforcement Learning Applications

- **Robotics:**
  - RL is used in **Robot navigation, Robo-soccer, walking, juggling**, etc.
- **Control:**
  - RL can be used for **adaptive control** such as Factory processes, admission control in telecommunication, and Helicopter pilot is an example of reinforcement learning.
- **Game Playing:**
  - RL can be used in **Game playing** such as tic-tac-toe, chess, etc.
- **Chemistry:**
  - RL can be used for optimizing the chemical reactions.
- **Business:**
  - RL is now used for business strategy planning.

CONT..

- **Manufacturing:**
  - In various automobile manufacturing companies, the robots use deep reinforcement learning to pick goods and put them in some containers.
- **Finance Sector:**
- The RL is currently used in the finance sector for evaluating trading strategies.