Unit-1

Introduction to machine learning

Syllabus: Introduction to machine learning:
Definition, traditional programming vs machine learning algorithms, learning a system, supervised learning, unsupervised learning and reinforcement Learning, application areas

Introduction to machine learning:

The term Machine learning was coined in 1959 by Arthur Samuel, an IBM employee and pioneer in the field of computer gaming and artificial intelligence.

Definition-1: Tom M. Mitchell: "Machine learning is the study of computer algorithms that allow computer programs to automatically improve through experience.

Definition-2: Machine Learning is the field of study that gives computers the capability to learn without being explicitly programmed.

Definition-3: Machine learning is programming computers to optimize a performance criterion using example data or past experience.

An algorithm can be thought of as a set of rules/instructions that a computer programmer specifies which a computer can process. Simply put, machine learning algorithms learn by experience, similar to how humans do.

> For example, after having seen multiple examples of an object, a compute-employing machine learning algorithm can become able to recognize that object in new, previously unseen scenarios.

Machine learning behaves similarly to the growth of a child. As a child grows, her experience E in performing task T increases, which results in higher performance measure (P).

For instance, we give a "shape sorting block" toy to a child. (Now we all know that in this toy, we have different shapes and shape holes). In this case, our task T is to find an appropriate shape hole for a shape. Afterward, the child observes the shape and tries to fit it in a shaped hole. Let us say that this toy has three shapes: a circle, a triangle, and a square. In her first attempt at finding a shaped hole, her performance measure(P) is 1/3, which means that the child found 1 out of 3 correct shape holes.

Second, the child tries it another time and notices that she is a little experienced in this task. Considering the experience gained (E), the child tries this task another time, and when measuring the performance(P), it turns out to be 2/3. After repeating this task (T) 100 times, the baby now figured out which shape goes into which shape hole.

So her experience (E) increased, her performance(P) also increased, and then we noticed that as the number of attempts at this toy increased. The performance also increases, which results in higher accuracy.

Such execution is similar to machine learning. What a machine does is, it takes a task (T), executes it, and measures its performance (P). Now a machine has a large number of data, so as it processes that data, its experience (E) increases over time, resulting in a higher performance measure (P). So after going through all the data, our machine learning model's accuracy increases, which means that the predictions made by our model will be very accurate.

Shape sorting blocks

Why do we need machine learning?

- **Continuous Improvement**
  - As new data is provided, the model's accuracy and efficiency to make decisions improve with subsequent training.
  - Amazon, Walmart, etc collect a huge volume of new data every day. The accuracy of finding associated products or product recommendation.
- **Automation for everything**
  - A very powerful utility of Machine Learning is its ability to automate various decision-making tasks.
  - Ex. Automatic Loan processing system in the bank
- **Trends and patterns identification**
  - Amazon analyzes the buying patterns and search trends of its customers and predicts products for them using Machine Learning algorithms.
- **Wide range of applications**
  - Machine Learning is used in every industry these days. Companies generate profits, cut costs, automate, predict the future, analyze trends and patterns from the past data, and many more.
  - Applications like GPS Tracking for traffic, Email spam filtering, text prediction, spell check and correction, etc

Machine learning models help us in many tasks, such as:

- Object Recognition
- Summarization
- Prediction
- Classification`
- Clustering
- Recommender systems and others

What Is Machine Learning?

Machine learning is programming computers to optimize a performance criterion using example data or past experience. We have a model defined up to some parameters, and learning is the execution of a computer program to optimize the parameters of the model using the training data or past experience. The model may be predictive to make predictions in the future, or descriptive to gain knowledge from data, or both.

Arthur Samuel, an early American leader in the field of computer gaming and artificial intelligence, coined the term "Machine Learning" in 1959 while at IBM. He defined machine learning as "the field of study that gives computers the ability to learn without being explicitly programmed." However, there is no universally accepted definition for machine learning. Different authors define the term differently. Definition of learning

Definition

A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks T, as measured by P, improves with experience E.

Examples

i) Handwriting recognition learning problem

- Task T: Recognising and classifying handwritten words within images
- Performance P: Percent of words correctly classified
- Training experience E: A dataset of handwritten words with given classifications

ii) A robot driving learning problem

- Task T: Driving on highways using vision sensors
- Performance measure P: Average distance traveled before an error
- training experience: A sequence of images and steering commands recorded while observing a human driver

iii) A chess learning problem

- Task T: Playing chess
- Performance measure P: Percent of games won against opponents
- Training experience E: Playing practice games against itself

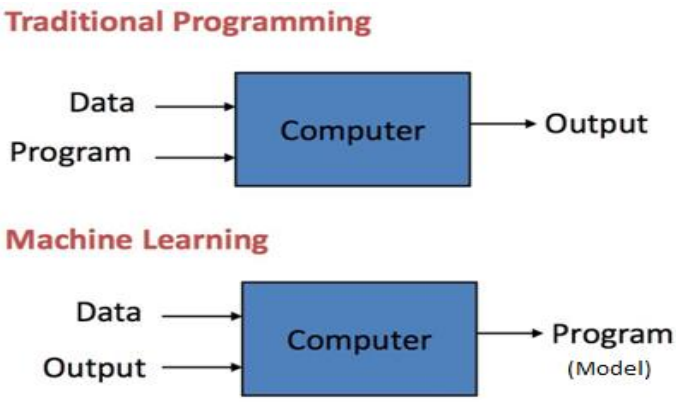
Traditional programming vs Machine learning algorithms:

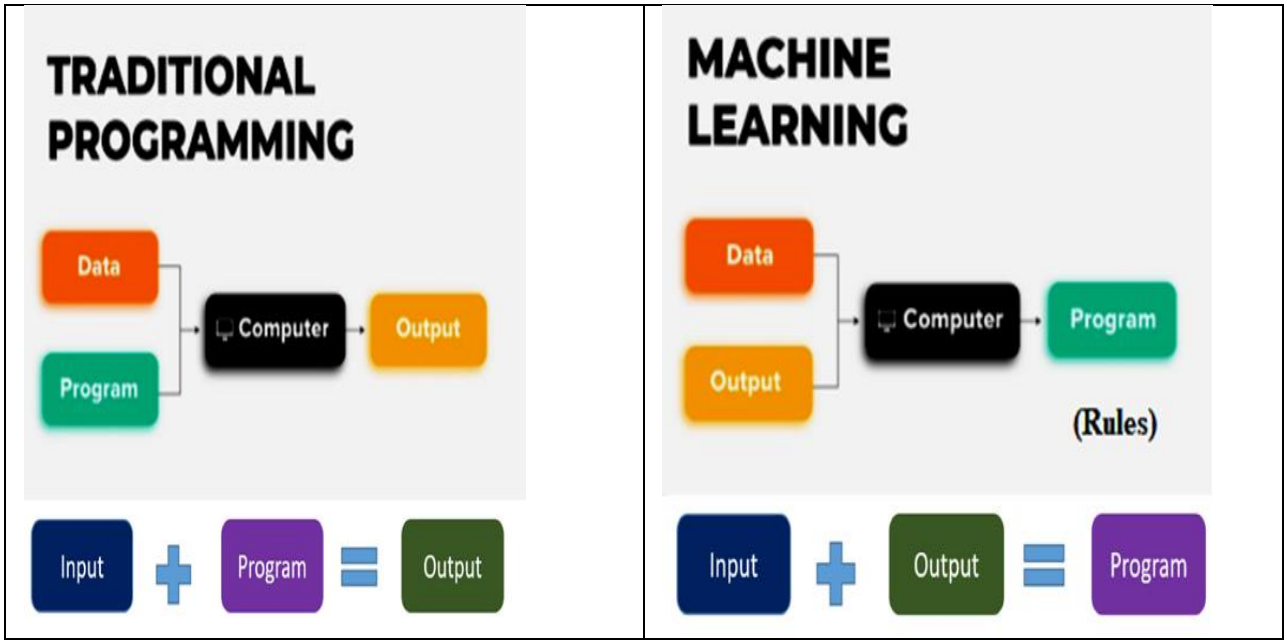
Traditional programming:

Traditional programming is a manual process—meaning a person (programmer) creates the program. However, without anyone programming the logic, one has to manually formulate or code rules. Which means A traditional algorithm takes some input and some logic in the form of code and drums up the output

Machine Learning:

In machine learning, the algorithm automatically formulates the rules from the data. Which means a Machine Learning Algorithm takes an input and an output and gives the some logic, which can then be used to work with new input to give one an output. The logic generated is what makes it ML.





Traditional programming Approach:

S.No	Traditional Software	Machine Learning
1	In traditional software, the primary objective is to meet functional and non-functional requirements.	In machine learning models, the primary goal is to optimize the metric (accuracy, precision/recall etc) of the models. Every 0.1 % improvement in the model metrics could result in significant business value creation.
2	The quality of the software primary depends on the quality of the code.	The quality of the model depends upon various parameters which are mainly related to the input data and hyper parameters tuning.
3	Traditional software is created using one software stack such as MEAN, Java, etc.	Machine learning models could be created using different algorithms and associated libraries. Each of these algorithms could result in different performance.

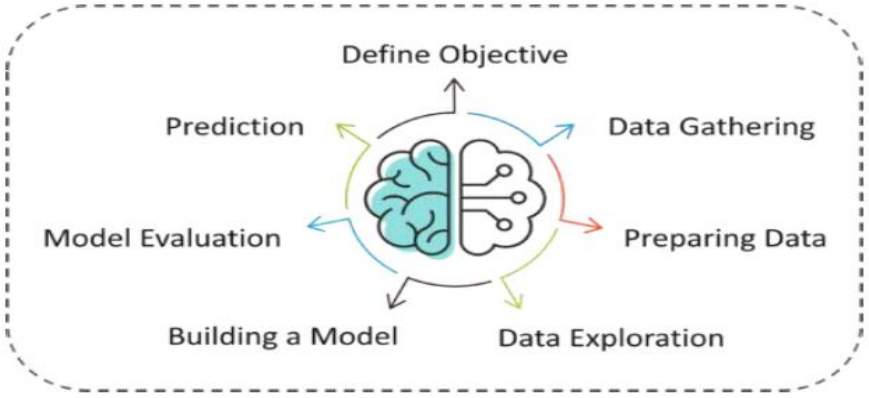
ML Vs Classical Algorithms:

- ML algorithms do not depend on rules defined by human experts. Instead, they process data in raw form — for example text, emails, documents, social media content, images, voice and video.
- An ML system is truly a learning system if it is not programmed to perform a task, but is programmed to learn to perform the task
- ML is also more prediction-oriented, whereas Statistical Modeling is generally interpretation-oriented. Not a hard and fast distinction especially as the disciplines converge, but in my experience most historical differences between the two schools of thought fallout from this distinction
- In classical algorithms, statisticians emphasis on p-value more and a solid but comprehensible model
- Most ML models are uninterruptable, and for these reasons they are usually unsuitable when the purpose is to understand relationships or even causality. The mostly work well where one only needs predictions.
- Traditional learning methodologies such as training a model-based on historic training data and evaluating the resulting model against incoming data is not feasible as the environment is in a constant change.

- As compared to the classical approach, traditional ML approaches as in most cases these approaches are too expensive within web scale environments and their results are too static to cope with dynamically changing service environments
- As opposed to classical approach, spending a lot of computational power on learning a very complex model of a highly dynamic network environment is not cost-effective.
- One of the key differences is that classical approaches have a more rigorous mathematical approach while machine learning algorithms are more data-intensive

learning a system (or) Machine Learning Process (or) How does machine learning works?

The Machine Learning process involves building a Predictive model that can be used to find a solution for a Problem Statement.



The below steps are followed in a Machine Learning process:

Step 1: Define the objective of the Problem Statement

At this step, we must understand what exactly needs to be predicted. In our case, the objective is to predict the possibility of rain by studying weather conditions. At this stage, it is also essential to take mental notes on what kind of data can be used to solve this problem or the type of approach you must follow to get to the solution.

Step 2: Data Gathering

At this stage, you must be asking questions such as,

- What kind of data is needed to solve this problem?
- Is the data available?
- How can I get the data?

Once you know the types of data that is required, you must understand how you can derive this data. Data collection can be done manually or by web scraping.

In our problem, the data needed for weather forecasting includes measures such as humidity level, temperature, pressure, locality, whether or not you live in a hill station, etc. Such data must be collected and stored for analysis.

Step 3: Data Preparation

The data you collected is almost never in the right format. You will encounter a lot of inconsistencies in the data set such as missing values, redundant variables, duplicate values, etc. Removing such inconsistencies is very essential because they might lead to wrongful computations and predictions. Therefore, at this stage, you scan the data set for any inconsistencies and you fix them then and there.

Step 4: Exploratory Data Analysis

Grab your detective glasses because this stage is all about diving deep into data and finding all the hidden data mysteries. EDA or Exploratory Data Analysis is the brainstorming stage of Machine Learning. Data Exploration involves understanding the patterns and trends in the data. At this stage, all the useful insights are drawn and correlations between the variables are understood.

For example, in the case of predicting rainfall, we know that there is a strong possibility of rain if the temperature has fallen low. Such correlations must be understood and mapped at this stage.

Step 5: Building a Machine Learning Model

All the insights and patterns derived during Data Exploration are used to build the Machine Learning Model. This stage always begins by splitting the data set into two parts, training data, and testing data. The training data will be used to build and analyze the model. The logic of the model is based on the Machine Learning Algorithm that is being implemented.

In the case of predicting rainfall, since the output will be in the form of True (if it will rain tomorrow) or False (no rain tomorrow), we can use a Classification Algorithm such as Logistic Regression.

Step 6: Model Evaluation & Optimization

After building a model by using the training data set, it is finally time to put the model to a test. The testing data set is used to check the efficiency of the model and how accurately it can predict the outcome. Once the accuracy is calculated, any further improvements in the model can be implemented at this stage. Methods like parameter tuning and cross-validation can be used to improve the performance of the model.

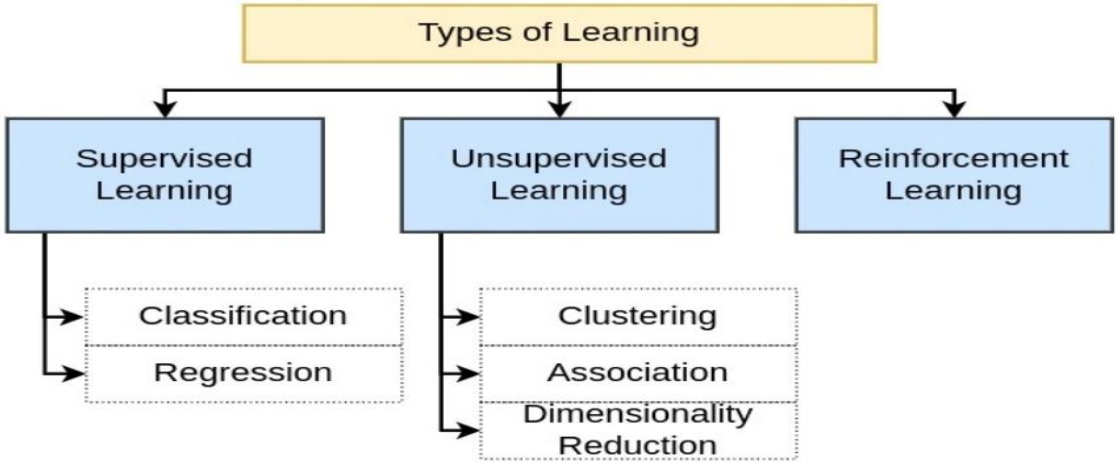
Step 7: Predictions

Once the model is evaluated and improved, it is finally used to make predictions. The final output can be a Categorical variable (eg. True or False) or it can be a Continuous Quantity (eg. the predicted value of a stock).

Types of Machine Learning

Classical machine learning is often categorized by how an algorithm learns to become more accurate in its predictions.

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

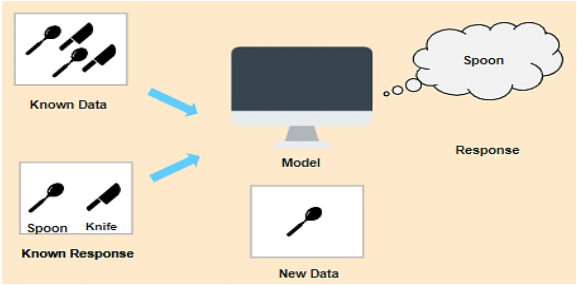


Supervised learning:

Supervised learning is a process of providing input data as well as correct output data to the machine learning model

In Supervised Learning, the machine learns under supervision. It contains a model that is able to predict with the help of a labeled dataset. A labeled dataset is one where you already know the target answer.

Eg.
In this case, we have images that are labeled a spoon or a knife.
This known data is fed to the machine, which analyzes and learns the association of these images based on its features such as shape, size, sharpness, etc.
Now when a new image is fed to the machine without any label, the machine is able to predict accurately that it is a spoon with the help of the past data.



Types of Supervised Learning

Supervised learning classified into two categories of algorithms:.
1.Classification
2.Regression

Classification algorithms are used to predict/Classify the discrete values such as Male or Female, True or False, Spam or Not Spam, etc.
Regression algorithms are used to predict the continuous values such as price, salary, age, etc

1. Classification:

- Its a process of categorizing a given set of data into classes.
- Classification is used when the **output variable is discrete or categorical** i.e. with 2 or more classes.

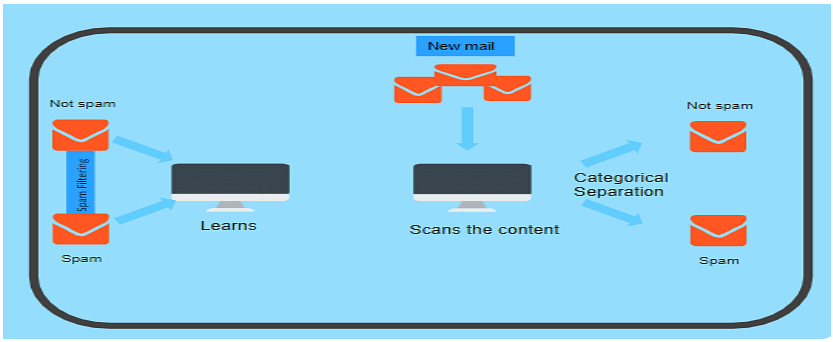
For example, yes or no, male or female, true or false, etc.

Eg.
In order to **predict whether a mail is spam or not,** we need to first teach the machine what a spam mail is.
This is **done based on a lot of spam filters**

- reviewing the **content** of the mail,
- reviewing the **mail header**, and then searching

if it contains any **false information**.

- Certain **keywords** and blacklist filters that blackmails are used from already blacklisted spammers.
- All of these features are used to score the mail and give it a spam score.
- The **lower the total spam score** of the email, the **more likely that it is not a scam.**
- Based on the content, label, and the spam score of the new incoming mail, the algorithm decides whether it should land in the inbox or spam folder.



Applications of Supervised Learning:

- Signature recognition
  - Does a signature belongs to a specific person or not.
- Text Categorization (multi category)
  - Categorize text documents into predefined categories . For example, categorize news into ‘sports’, ‘politics’, ‘science’, etc.
- Image Classification
  - Image classification is one of the key use cases of demonstrating supervised machine learning. For example, Facebook can recognize your friend in a picture from an album of tagged photos
- Fraud Detection

- To identify whether the transactions made by the user are authentic or not.

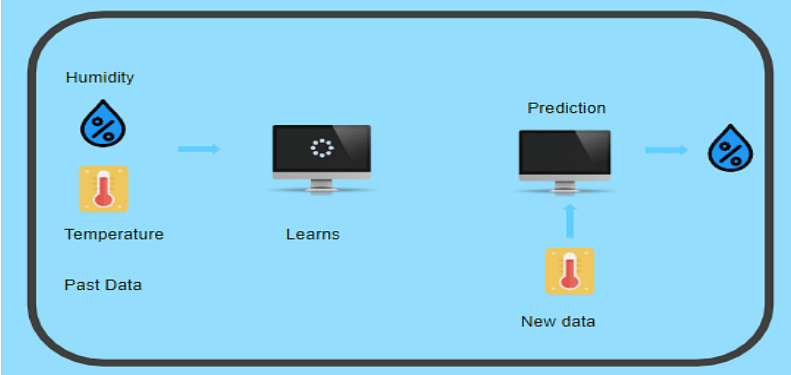
- Visual Recognition
  - The ability of a machine learning model to identify objects, places, people, actions, and images.

Regression:

- It's a statistical method
- Regression is used when the output variable is a real or continuous value
- Relationship between a dependent (target) and independent (predictor) variables with one or more independent variables..
- i.e., a change in one variable is associated with a change in the other variable.

Example:

- Let's consider **two variables** - humidity and temperature.
- Here, 'temperature' is the independent variable and 'humidity' is the dependent variable.
- If the **temperature increases, then the humidity decreases**.
- These two variables are fed to the model and the machine learns the relationship between them.
- After the machine is trained, it can easily predict the humidity based on the given temperature.

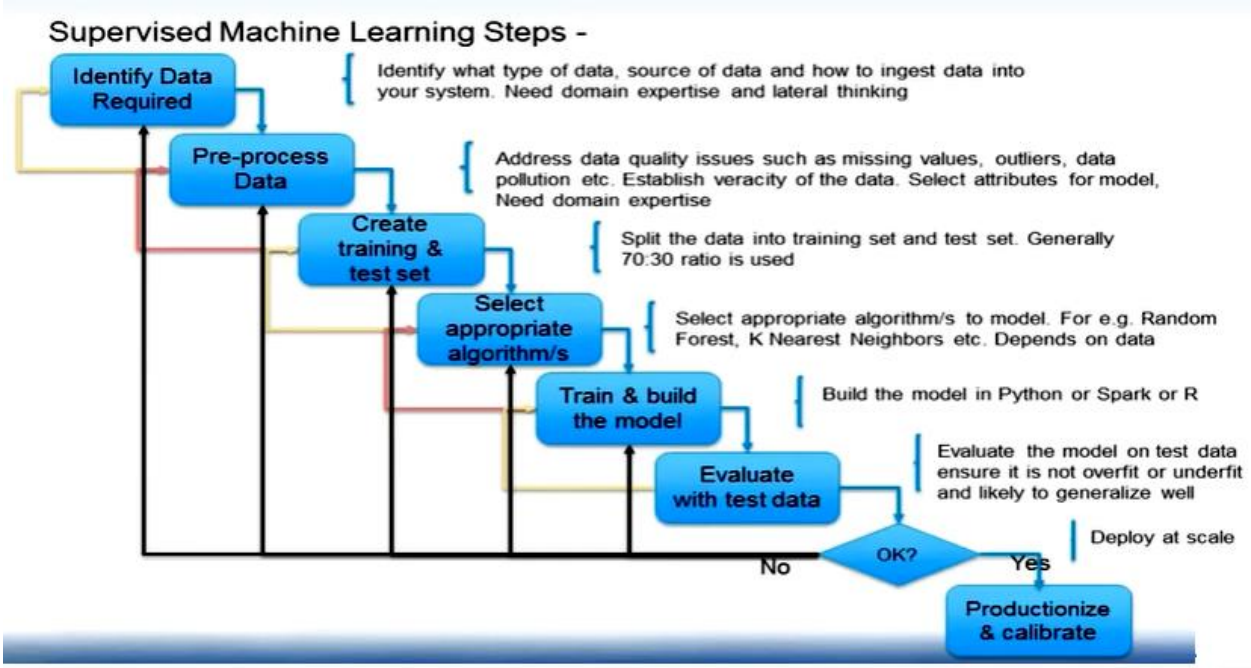


Real-Life Applications of Regression

- salary based on work experience
- weight based on height
- House price prediction
- Forecasting rainfall, stock markets

How Supervised Learning works:

- The system is fed with massive amounts of data during its training phase, which instruct the system what output should be obtained from each specific input value.
- The trained model is then presented with test data to verify the result of the training and measure the accuracy.
- The level of accuracy obtainable depends on two things: the data available and the algorithm in use.
- The aim of a supervised learning algorithm is to **find a mapping function to map the input variable(x) with the output variable(y)**.



Algorithms/Techniques used in Supervised Learning:

- Decision tree
- Linear Regression
- Logistic regression
- Support vector machine(SVM)
- Naive Bayes algorithm
- KNN algorithm
- Random Forests etc.

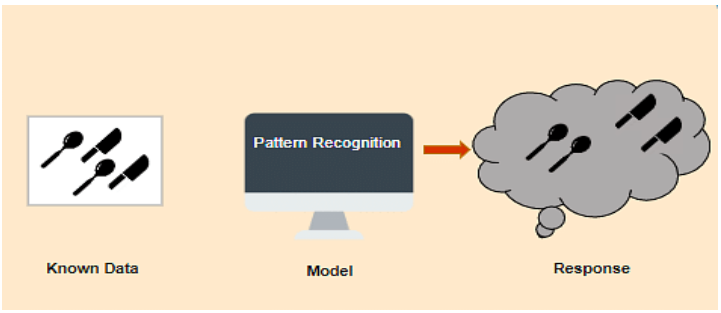
Unsupervised Learning

In Unsupervised Learning, the **machine uses unlabeled data** and learns on itself without any supervision. The machine tries to find a pattern in the unlabeled data and gives a response.

- Let's take a similar example is before, but this time we do not tell the machine whether it's a spoon or a knife.
- The machine identifies patterns from the given set and groups them based on their patterns, similarities, etc.

Unsupervised learning can be further grouped into types:

- **Clustering**
- **Association**

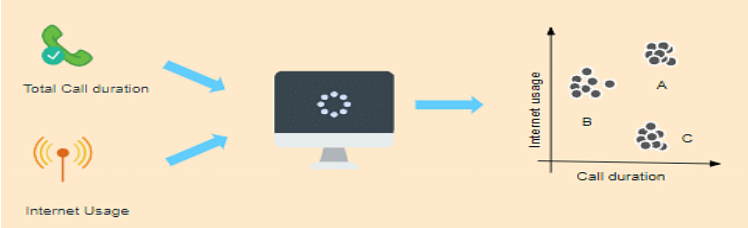


1. Clustering - Unsupervised Learning

- Clustering is the method of dividing the objects into clusters that are similar between them and are dissimilar to the objects belonging to another cluster.

Example:

- Suppose a telecom company wants to reduce its customer churn rate by providing personalized call and data plans.
- Several strategies are adopted to minimize churn rate and maximize profit through suitable promotions and campaigns.
- Group A customers use more data and also have high call durations.
- Group B customers are heavy Internet users, while Group C customers have high call duration.
- So, Group B will be given more data benefit plants, while Group C will be given cheaper called call rate plans and group A will be given the benefit of both.

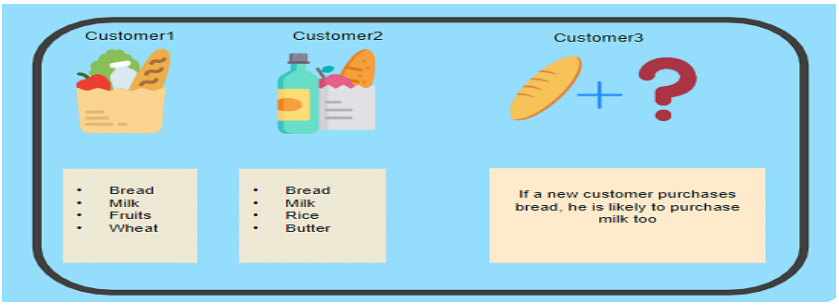


2. Association - Unsupervised Learning

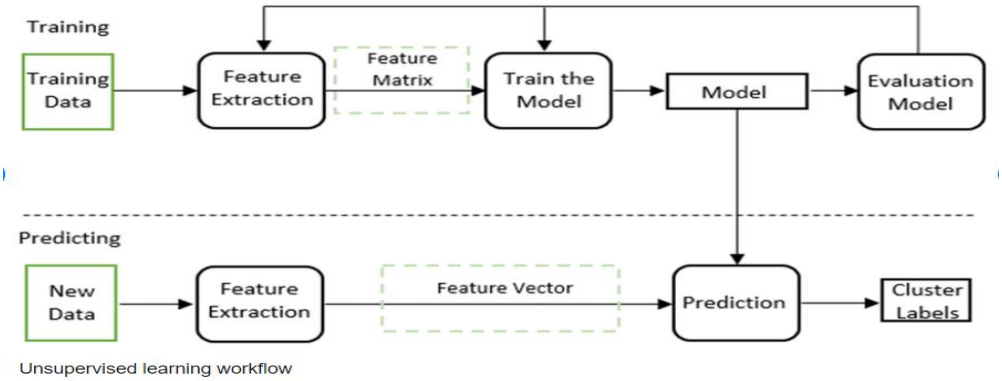
Association is a rule-based machine learning to discover the probability of the co-occurrence of items in a collection.

For example, finding out which products were purchased together. a customer goes to a supermarket and buys bread, milk, fruits, and wheat. Another customer comes and buys bread, milk, rice, and butter. Now, when another customer comes, it is highly likely that if he buys bread, he will buy milk too.

Hence, a relationship is established based on customer behavior and recommendations are made.



How Unsupervised Learning works:



Unsupervised learning workflow

Real-Life Applications of Unsupervised Learning

- **Market Basket Analysis**
  - It is a machine learning model based on the algorithm that if you buy a certain group of items, you are less or more likely to buy another group of items.
- **Semantic Clustering**
  - Semantically similar words share a similar context. Semantic clustering groups all these responses with the same meaning in a cluster to ensure that the customer finds the information they want quickly and easily.
  - It plays an important role in information retrieval, good browsing experience, and comprehension.
- **Identifying Accident Prone Areas**
  - Unsupervised machine learning models can be used to identify accident-prone areas and introduce safety measures based on the intensity of those accidents.

Algorithms/Techniques used in Unsupervised Learning:

- K-means clustering
- Hierarchical clustering
- DBSCAN
- Apriori algorithm etc.

Difference Between Supervised and Unsupervised Learning

Supervised Learning	Unsupervised Learning
It uses known and labeled data as input	It uses unlabeled data as input
External supervision	No supervision
Solves problems by mapping labeled input to unknown output	Solves problems by understanding patterns and discovering output
The most commonly used supervised learning algorithms are: Decision tree Linear Regression Logistic regression Support vector machine(SVM) Naive Bayes algorithm KNN algorithm Random Forests	The most commonly used unsupervised learning algorithms are: K-means clustering Hierarchical clustering DBSCAN Apriori algorithm
Number of classes is known.	Number of classes is not known.
Supervised learning is a simpler method.	Unsupervised learning is computationally complex
Highly accurate and trustworthy method.	Less accurate and trustworthy method.

Reinforcement Learning:

Need for Reinforcement Learning:

- A major drawback of machine learning is that a tremendous amount of data is needed to train models.
- The more complex a model, the more data it may require.

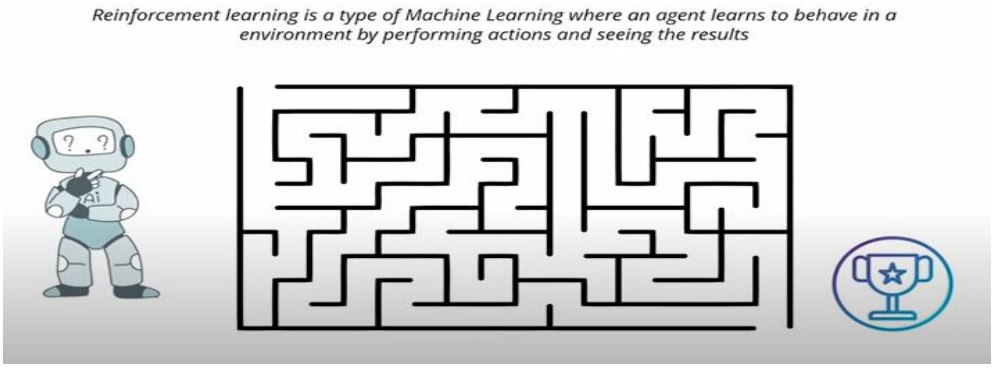
- But this data may not be available to us.
- It may not exist or we simply may not have access to it.
- Further, the data collected might not be reliable.
- It may have false or missing values or it might be outdated.
- All of these problems are overcome by reinforcement learning.
- **When not to use RL:** When you have enough data to solve the problem, and it is computing-heavy and time-consuming

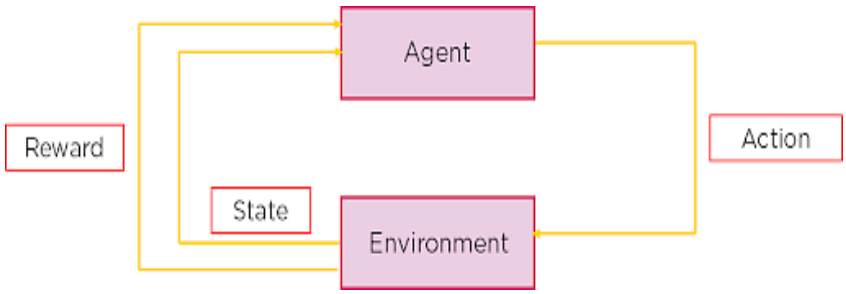
Reinforcement Learning:

- In some applications, the output of the system is a sequence of actions. In such a case, a single action is not important; what is important is the policy that is the sequence of correct actions to reach the goal.
- An action is good if it is part of a good policy.
- In such a case, the machine learning program should be able to assess the goodness of policies and learn from past good action sequences to be able to generate a policy. Such learning methods are called reinforcement learning algorithms.
    - A good example is game playing where a single move by itself is not that important; it is the sequence of right moves that is good. A move is good if it is part of a good game playing policy. A game like chess has a small number of rules but it is very complex because of the large number of possible moves at each state and the large number of moves that a game contains. Once we have good algorithms that can learn to play games well.

What is Reinforcement Learning?

The computer employs trial and error to come up with a solution to the problem.
Reinforcement learning is a sub-branch of Machine Learning that trains a model to return an optimum solution for a problem by taking a sequence of decisions by itself.





Working of Reinforcement Learning: Example

- We have an agent and a reward, with many hurdles in between. The agent is supposed to find the best possible path to reach the reward.
- The image shows the robot, diamond, and fire.
- The goal of the robot is to get the reward that is the diamond and avoid the hurdles that are fire.
- The robot learns by trying all the possible paths and then choosing the path which gives him the reward with the least hurdles.
- Each right step will give the robot a reward and each wrong step will subtract the reward of the robot.
- The total reward will be calculated when it reaches the final reward that is the diamond.

Types of Reinforcement Learning:

- Reinforcement learning classified into two categories of problems:
  1.Positive
  2.Negative
- **Positive**:
  Positive Reinforcement is defined as when an event, occurs due to a particular behavior, increases the strength and the frequency of the behavior.
- **Negative:**
  It is defined as strengthening of a behavior because a negative condition is stopped or avoided

Algorithms/Techniques used in Reinforcement Learning:

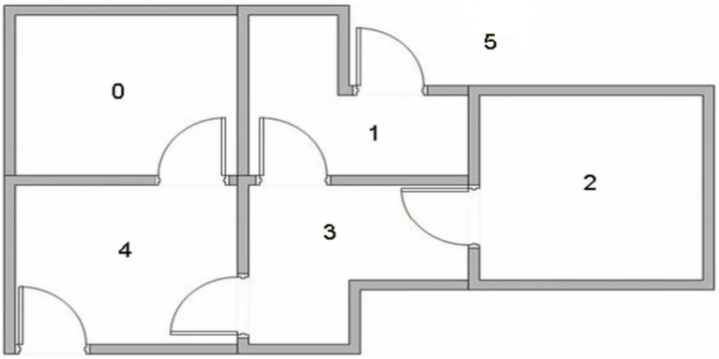
- Q learning
- Markov Decision Process

Applications of Reinforcement Learning:

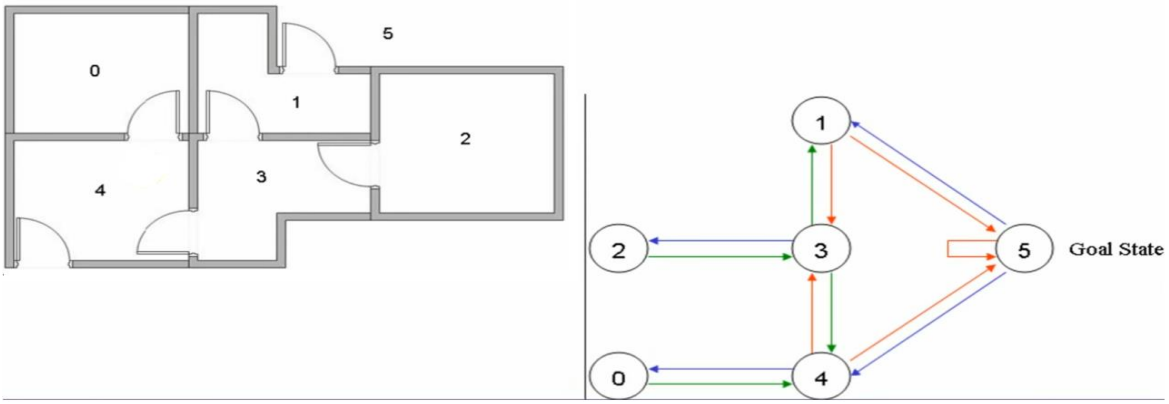
- **Robotics:** Robots can learn to perform tasks in the physical world using this technique.
- **Video gameplay:** Reinforcement learning has been used to teach bots to play a number of video games.
- **Resource management:** Given finite resources and a defined goal, reinforcement learning can help enterprises plan how to allocate resources

ii) Q-Learning-- Reinforcement Learning:

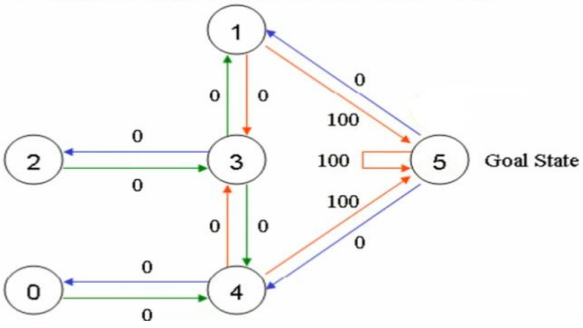
- Suppose we have 5 rooms in a building connected by doors as shown in the figure below. We'll number each room 0 through 4. The outside of the building can be thought of as one big room (5). Notice that doors 1 and 4 lead into the building from room 5 (outside).



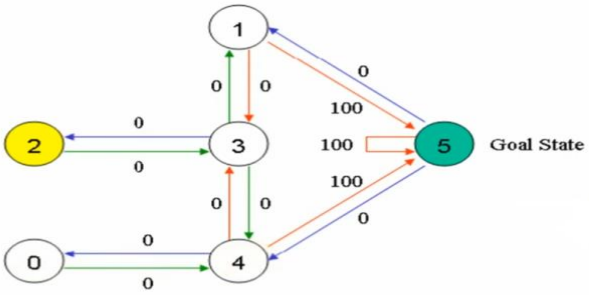
- We can represent the rooms on a graph, each room as a node, and each door as a link.



- The goal room is number 5
- The doors that lead immediately to the goal have an instant reward of 100. Other doors not directly connected to the target room have zero reward.
- Each arrow contains an instant reward value, as shown below:



- We can put the state diagram and the instant reward values into the following reward table, "matrix R". The -1's in the table represent null values (i.e.; where there isn't a link between nodes). For example, State 0 cannot go to State 1.



$$R = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \text{Action} \\ \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} -1 & -1 & -1 & -1 & 0 & -1 \\ -1 & -1 & -1 & 0 & -1 & 100 \\ -1 & -1 & -1 & 0 & -1 & -1 \\ -1 & 0 & 0 & -1 & 0 & -1 \\ 0 & -1 & -1 & 0 & -1 & 100 \\ -1 & 0 & -1 & -1 & 0 & 100 \end{bmatrix} \end{array} \quad \text{State}$$

- Learning rate = 0.8 and the initial state as Room 1.
- Initialize matrix Q as a zero matrix:

$$R = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \text{Action} \\ \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} -1 & -1 & -1 & -1 & 0 & -1 \\ -1 & -1 & -1 & 0 & -1 & 100 \\ -1 & -1 & -1 & 0 & -1 & -1 \\ -1 & 0 & 0 & -1 & 0 & -1 \\ 0 & -1 & -1 & 0 & -1 & 100 \\ -1 & 0 & -1 & -1 & 0 & 100 \end{bmatrix} \end{array} \quad \text{State}$$

$$Q = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

- Look at the second row (state 1) of matrix R.
- There are two possible actions for the current state 1: go to state 3, or go to state 5.
- By random selection, we select to go to 5 as our action.

$$R = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \text{Action} \\ \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} -1 & -1 & -1 & -1 & 0 & -1 \\ -1 & -1 & -1 & 0 & -1 & 100 \\ -1 & -1 & -1 & 0 & -1 & -1 \\ -1 & 0 & 0 & -1 & 0 & -1 \\ 0 & -1 & -1 & 0 & -1 & 100 \\ -1 & 0 & -1 & -1 & 0 & 100 \end{bmatrix} \end{array} \quad \text{State}$$

- Now let's imagine what would happen if our agent were in state 5.
- Look at the sixth row of the reward matrix R (i.e. state 5).
- It has 3 possible actions: go to state 1, 4 or 5.
- Q(state, action) = R(state, action) + Gamma * Max[Q(next state, all actions)]
- Q(1, 5) = R(1, 5) + 0.8 * Max[Q(5, 1), Q(5, 4), Q(5, 5)] = 100 + 0.8 * 0 = 100

$$R = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \text{Action} \\ \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} -1 & -1 & -1 & -1 & 0 & -1 \\ -1 & -1 & -1 & 0 & -1 & 100 \\ -1 & -1 & -1 & 0 & -1 & -1 \\ -1 & 0 & 0 & -1 & 0 & -1 \\ 0 & -1 & -1 & 0 & -1 & 100 \\ -1 & 0 & -1 & -1 & 0 & 100 \end{bmatrix} \end{array} \quad \text{State}$$

$$Q = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array} \quad Q = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 100 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

- The next state, 5, now becomes the current state.
- Because 5 is the goal state, we've finished one episode.
- Our agent's brain now contains an updated matrix Q as:

$$Q = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 100 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

- For the next episode, we randomly choose the initial state – say 3 (can go to 1, 2 & 4)

$$R = \begin{array}{c} \text{State} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{cccccc} \multicolumn{6}{c}{\text{Action}} \\ 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} -1 & -1 & -1 & -1 & 0 & -1 \\ -1 & -1 & -1 & 0 & -1 & 100 \\ -1 & -1 & -1 & 0 & -1 & -1 \\ -1 & 0 & 0 & -1 & 0 & -1 \\ 0 & -1 & -1 & 0 & -1 & 100 \\ -1 & 0 & -1 & -1 & 0 & 100 \end{bmatrix} \end{array}$$

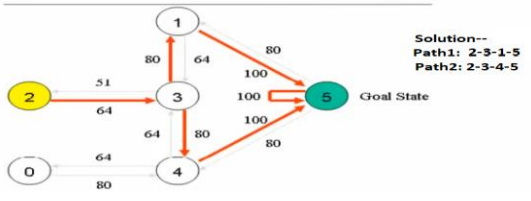
- Now we imagine that we are in state 1 (next state).
- Now we imagine that we are in state 1 (next state).
- Look at the second row of reward matrix R (i.e. state 1).
- It has 2 possible actions: go to state 3 or state 5.
- Then, we compute the Q value:
- Q(state, action) = R(state, action) + Gamma * Max[Q(next state, all actions)]
- Q(3, 1) = R(3, 1) + 0.8 * Max[Q(1, 3), Q(1, 5)] = 0 + 0.8 * Max(0, 100) = 80

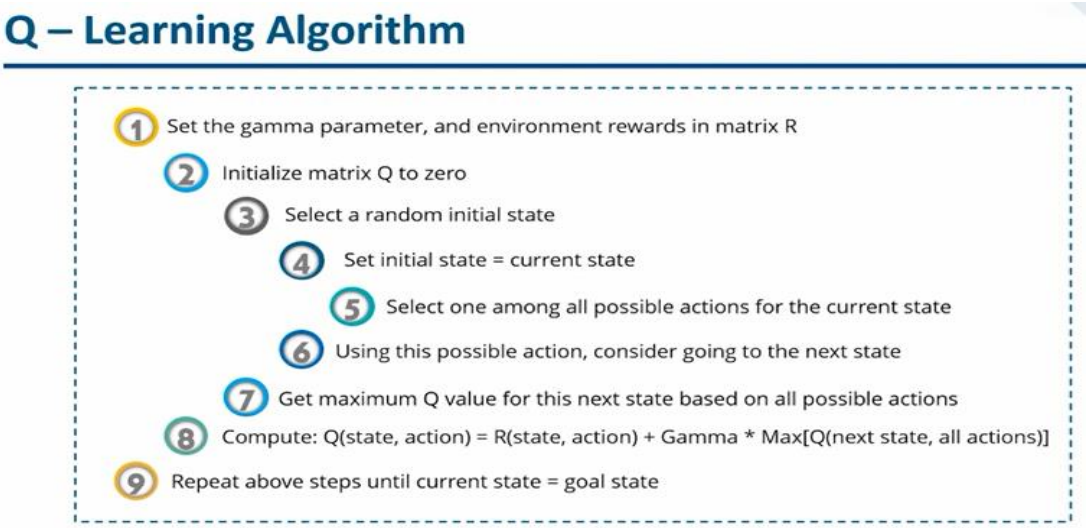
$$R = \begin{array}{c} \text{State} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{cccccc} \multicolumn{6}{c}{\text{Action}} \\ 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} -1 & -1 & -1 & -1 & 0 & -1 \\ -1 & -1 & -1 & 0 & -1 & 100 \\ -1 & -1 & -1 & 0 & -1 & -1 \\ -1 & 0 & 0 & -1 & 0 & -1 \\ 0 & -1 & -1 & 0 & -1 & 100 \\ -1 & 0 & -1 & -1 & 0 & 100 \end{bmatrix} \end{array} \qquad Q = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 100 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

- If our agent learns more through further episodes, it will finally reach convergence values in matrix Q like:

$$Q = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 80 & 0 \\ 0 & 0 & 0 & 64 & 0 & 100 \\ 0 & 0 & 0 & 64 & 0 & 0 \\ 0 & 80 & 51 & 0 & 80 & 0 \\ 64 & 0 & 0 & 64 & 0 & 100 \\ 0 & 80 & 0 & 0 & 80 & 100 \end{bmatrix} \end{array}$$

- Tracing the best sequences of states is as simple as following the links with the highest values at each state.





Supervised Vs Unsupervised Vs Reinforcement Learning

Supervised Learning	Unsupervised Learning	Reinforcement Learning
Data provided is labeled data, with output values specified	Data provided is unlabeled data, the outputs are not specified, machine makes its own prediction	The machine learns from its environment using rewards and errors
Used to solve Regression and classification problems	Used to solve Association and clustering problems	Used to solve Reward based problems
Labeled data is used	Unlabeled data is used	No predefined data is used
External Supervision	No supervision	No supervision
Solves problems by mapping labeled input to known output	Solves problems by understanding patterns and discovering output	Follows Trail and Error problem solving approach

Advantages and Disadvantages of ML:

Advantages:

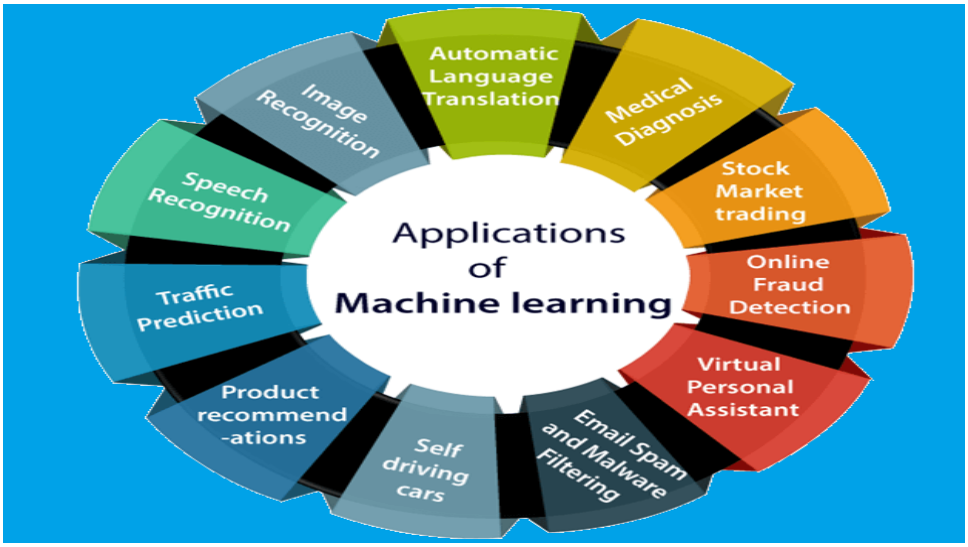
- By collecting customer data and correlating it with behaviors over time, machine learning algorithms can learn associations and help teams to product development and marketing initiatives to customer demand.
- Some internet companies use machine learning as a primary driver in their business models.
  for example Uber uses algorithms to match drivers with riders.
  Google uses machine learning to surface the right advertisements in searches.

Disadvantages:

- First and foremost, it can be expensive. Machine learning projects are typically driven by data scientists, who command high salaries. These projects also require software infrastructure that can be high-cost.
- Algorithms that trained on data sets that exclude certain populations or contain errors can lead to inaccurate models of the world that, at best, fail and, at worst, are discriminatory.

Applications of Machine learning:

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.
Below are some most trending real-world applications of Machine Learning:



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.

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.

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.

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.