Basic Concepts in Machine Learning

Machine Learning is continuously growing in the IT world and gaining strength in different business sectors. Although Machine Learning is in the developing phase, it is popular among all technologies. It is a field of study that makes computers capable of automatically learning and improving from experience. Hence, Machine Learning focuses on the strength of computer programs with the help of collecting data from various observations. In this article, ''Concepts in Machine Learning'', we will discuss a few basic concepts used in Machine Learning such as what is Machine Learning, technologies and algorithms used in Machine Learning, Applications and example of Machine Learning, and much more. So, let's start with a quick introduction to machine learning.

Issues In Machine Learning:

Machine learning, like any technology, comes with its own set of challenges and issues. Some of the key issues associated with machine learning include:

1. **Data Quality and Quantity:** Machine learning models heavily rely on data. Issues such as incomplete, noisy, or biased data can lead to poor model performance and inaccurate predictions.
2. **Bias and Fairness:** Models can inherit biases present in the training data, leading to unfair outcomes or discriminatory decisions, especially in sensitive domains like hiring or lending.
3. **Interpretability:** Many machine learning models, such as deep neural networks, are complex and difficult to interpret. Understanding why a model makes a particular prediction can be crucial, especially in applications where decisions impact individuals' lives.
4. **Overfitting and Underfitting:** These are common problems in machine learning where a model either learns too much from noise in the training data (overfitting) or fails to capture the underlying patterns (underfitting).
5. **Scalability:** As data volumes grow, the computational requirements for training and deploying machine learning models can become prohibitive. Scaling up models to handle big data efficiently is a significant challenge.
6. **Ethical Concerns:** Machine learning raises ethical issues related to privacy (handling sensitive data), accountability (for decisions made by AI systems), and transparency (how decisions are made).
7. **Deployment and Maintenance:** Moving models from development to deployment involves challenges such as integration with existing systems, continuous monitoring for performance degradation, and updating models as new data becomes available.
8. **Lack of Domain Expertise:** Developing effective machine learning solutions often requires deep knowledge of both the domain and the machine learning techniques, which can be a barrier for non-experts.

What Is Machine Learning ?

Machine learning is a branch of artificial intelligence (AI) and computer science which **focuses on the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy**.

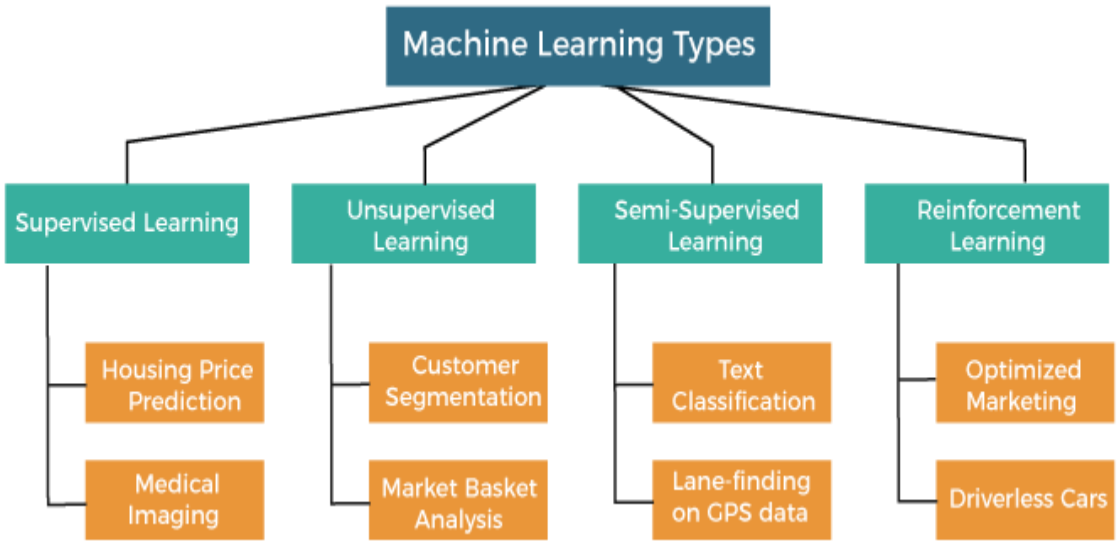
Types of Machine Learning

Machine learning is a subset of AI, which enables the machine to automatically learn from data, improve performance from past experiences, and make predictions. Machine learning contains a set of algorithms that work on a huge amount of data. Data is fed to these algorithms to train them, and on the basis of training, they build the model & perform a specific task.

These ML algorithms help to solve different business problems like Regression, Classification, Forecasting, Clustering, and Associations, etc.

Based on the methods and way of learning, machine learning is divided into mainly four types, which are:

1. Supervised Machine Learning
2. Unsupervised Machine Learning
3. Semi-Supervised Machine Learning
4. Reinforcement Learning



In this topic, we will provide a detailed description of the types of Machine Learning along with their respective algorithms:

1. Supervised Machine Learning

As its name suggests, Supervised machine learning is based on supervision. It means in the supervised learning technique, we train the machines using the "labelled" dataset, and based on the training, the machine predicts the output. Here, the labelled data specifies that some of the inputs are already mapped to the output. More preciously, we can say; first, we train the machine with the input and corresponding output, and then we ask the machine to predict the output using the test dataset.

Let's understand supervised learning with an example. Suppose we have an input dataset of cats and dog images. So, first, we will provide the training to the machine to understand the images, such as the **shape & size of the tail of cat and dog, Shape of eyes, colour, height (dogs are taller, cats are smaller), etc.** After completion of training, we input the picture of a cat and ask the machine to identify the object and predict the output. Now, the machine is well trained, so it will check all the features of the object, such as height, shape, colour, eyes, ears, tail, etc., and find that it's a cat. So, it will put it in the Cat category. This is the process of how the machine identifies the objects in Supervised Learning.

The main goal of the supervised learning technique is to map the input variable(x) with the output variable(y). Some real-world applications of supervised learning are **Risk Assessment, Fraud Detection, Spam filtering,** etc.

Categories of Supervised Machine Learning

Supervised machine learning can be classified into two types of problems, which are given below:

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

a) Classification

Classification algorithms are used to solve the classification problems in which the output variable is categorical, such as "**Yes" or No, Male or Female, Red or Blue, etc**. The classification algorithms predict the categories present in the dataset. Some real-world examples of classification algorithms are **Spam Detection, Email filtering, etc.**

Some popular classification algorithms are given below:

- **Random Forest Algorithm**

- **Decision Tree Algorithm**
- **Logistic Regression Algorithm**
- **Support Vector Machine Algorithm**

b) Regression

Regression algorithms are used to solve regression problems in which there is a linear relationship between input and output variables. These are used to predict continuous output variables, such as market trends, weather prediction, etc.

Some popular Regression algorithms are given below:

- **Simple Linear Regression Algorithm**
- **Multivariate Regression Algorithm**
- **Decision Tree Algorithm**
- **Lasso Regression**

Advantages and Disadvantages of Supervised Learning

Advantages:

- Since supervised learning work with the labelled dataset so we can have an exact idea about the classes of objects.
- These algorithms are helpful in predicting the output on the basis of prior experience.

Disadvantages:

- These algorithms are not able to solve complex tasks.
- It may predict the wrong output if the test data is different from the training data.
- It requires lots of computational time to train the algorithm.

Applications of Supervised Learning

Some common applications of Supervised Learning are given below:

- **Image Segmentation:**
  Supervised Learning algorithms are used in image segmentation. In this process, image classification is performed on different image data with pre-defined labels.

- **Medical Diagnosis:**
  Supervised algorithms are also used in the medical field for diagnosis purposes. It is done by using medical images and past labelled data with labels for disease conditions. With such a process, the machine can identify a disease for the new patients.
- **Fraud Detection -** Supervised Learning classification algorithms are used for identifying fraud transactions, fraud customers, etc. It is done by using historic data to identify the patterns that can lead to possible fraud.
- **Spam detection -** In spam detection & filtering, classification algorithms are used. These algorithms classify an email as spam or not spam. The spam emails are sent to the spam folder.
- **Speech Recognition -** Supervised learning algorithms are also used in speech recognition. The algorithm is trained with voice data, and various identifications can be done using the same, such as voice-activated passwords, voice commands, etc.

2. Unsupervised Machine Learning

Unsupervised learning is different from the Supervised learning technique; as its name suggests, there is no need for supervision. It means, in unsupervised machine learning, the machine is trained using the unlabeled dataset, and the machine predicts the output without any supervision.

In unsupervised learning, the models are trained with the data that is neither classified nor labelled, and the model acts on that data without any supervision.

The main aim of the unsupervised learning algorithm is to group or categories the unsorted dataset according to the similarities, patterns, and differences. Machines are instructed to find the hidden patterns from the input dataset.

Let's take an example to understand it more preciously; suppose there is a basket of fruit images, and we input it into the machine learning model. The images are totally unknown to the model, and the task of the machine is to find the patterns and categories of the objects.

So, now the machine will discover its patterns and differences, such as colour difference, shape difference, and predict the output when it is tested with the test dataset.

Categories of Unsupervised Machine Learning

Unsupervised Learning can be further classified into two types, which are given below:

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

1) Clustering

The clustering technique is used when we want to find the inherent groups from the data. It is a way to group the objects into a cluster such that the objects with the most similarities remain in one group and have fewer or no similarities with the objects of other groups. An example of the clustering algorithm is grouping the customers by their purchasing behaviour.

Some of the popular clustering algorithms are given below:

- **K-Means Clustering algorithm**
- **Mean-shift algorithm**
- **DBSCAN Algorithm**
- **Principal Component Analysis**
- **Independent Component Analysis**

2) Association

Association rule learning is an unsupervised learning technique, which finds interesting relations among variables within a large dataset. The main aim of this learning algorithm is to find the dependency of one data item on another data item and map those variables accordingly so that it can generate maximum profit. This algorithm is mainly applied in **Market Basket analysis, Web usage mining, continuous production**, etc.

Some popular algorithms of Association rule learning are **Apriori Algorithm, Eclat, FP-growth algorithm.**

Advantages and Disadvantages of Unsupervised Learning Algorithm

Advantages:

- These algorithms can be used for complicated tasks compared to the supervised ones because these algorithms work on the unlabeled dataset.
- Unsupervised algorithms are preferable for various tasks as getting the unlabeled dataset is easier as compared to the labelled dataset.

Disadvantages:

- The output of an unsupervised algorithm can be less accurate as the dataset is not labelled, and algorithms are not trained with the exact output in prior.
- Working with Unsupervised learning is more difficult as it works with the unlabelled dataset that does not map with the output.

Applications of Unsupervised Learning

- **Network Analysis:** Unsupervised learning is used for identifying plagiarism and copyright in document network analysis of text data for scholarly articles.
- **Recommendation Systems:** Recommendation systems widely use unsupervised learning techniques for building recommendation applications for different web applications and e-commerce websites.
- **Anomaly Detection:** Anomaly detection is a popular application of unsupervised learning, which can identify unusual data points within the dataset. It is used to discover fraudulent transactions.
- **Singular Value Decomposition:** Singular Value Decomposition or SVD is used to extract particular information from the database. For example, extracting information of each user located at a particular location.

3. Semi-Supervised Learning

Semi-Supervised learning is a type of Machine Learning algorithm that lies between Supervised and Unsupervised machine learning. It represents the intermediate ground between Supervised (With Labelled training data) and Unsupervised learning (with no labelled training data) algorithms and uses the combination of labelled and unlabeled datasets during the training period.

Although Semi-supervised learning is the middle ground between supervised and unsupervised learning and operates on the data that consists of a few labels, it mostly consists of unlabeled data. As labels are costly, but for corporate purposes, they may have few labels. It is completely different from supervised and unsupervised learning as they are based on the presence & absence of labels.

To overcome the drawbacks of supervised learning and unsupervised learning algorithms, the concept of Semi-supervised learning is introduced. The main aim of semi-supervised learning is to effectively use all the available data, rather than only labelled data like in supervised learning. Initially, similar data is clustered along with an unsupervised learning algorithm, and further, it helps to label the unlabeled data into labelled data. It is because labelled data is a comparatively more expensive acquisition than unlabeled data.

We can imagine these algorithms with an example. Supervised learning is where a student is under the supervision of an instructor at home and college. Further, if that student is self-analyzing the same concept without any help from the instructor, it comes under unsupervised learning. Under semi-supervised learning, the student has to revise himself after analyzing the same concept under the guidance of an instructor at college.

Advantages and disadvantages of Semi-supervised Learning

Advantages:

- It is simple and easy to understand the algorithm.
- It is highly efficient.
- It is used to solve drawbacks of Supervised and Unsupervised Learning algorithms.

Disadvantages:

- Iterations results may not be stable.
- We cannot apply these algorithms to network-level data.
- Accuracy is low.

4. Reinforcement Learning

Reinforcement learning works on a feedback-based process, in which an AI agent (A software component) automatically explore its surrounding by hitting & trail, taking action, learning from experiences, and improving its performance. Agent gets rewarded for each good action and gets punished for each bad action; hence the goal of reinforcement learning agent is to maximize the rewards.

In reinforcement learning, there is no labelled data like supervised learning, and agents learn from their experiences only.

The reinforcement learning process is similar to a human being; for example, a child learns various things by experiences in his day-to-day life. An example of reinforcement learning is to play a game, where the Game is the environment, moves of an agent at each step define states, and the goal of the agent is to get a high score. Agent receives feedback in terms of punishment and rewards.

Due to its way of working, reinforcement learning is employed in different fields such as **Game theory, Operation Research, Information theory, multi-agent systems.**

A reinforcement learning problem can be formalized using **Markov Decision Process (MDP).** In MDP, the agent constantly interacts with the environment and performs actions; at each action, the environment responds and generates a new state.

Categories of Reinforcement Learning

Reinforcement learning is categorized mainly into two types of methods/algorithms:

- **Positive Reinforcement Learning:** Positive reinforcement learning specifies increasing the tendency that the required behaviour would occur again by adding something. It enhances the strength of the behaviour of the agent and positively impacts it.
- **Negative Reinforcement Learning:** Negative reinforcement learning works exactly opposite to the positive RL. It increases the tendency that the specific behaviour would occur again by avoiding the negative condition.

Real-world Use cases of Reinforcement Learning

- **Video Games:**
  RL algorithms are much popular in gaming applications. It is used to gain super-human performance. Some popular games that use RL algorithms are **AlphaGO** and **AlphaGO Zero**.
- **Resource Management:**
  The "Resource Management with Deep Reinforcement Learning" paper showed that how to use RL in computer to automatically learn and schedule resources to wait for different jobs in order to minimize average job slowdown.
- **Robotics:**
  RL is widely being used in Robotics applications. Robots are used in the industrial and manufacturing area, and these robots are made more powerful with reinforcement learning. There are different industries that have their vision of building intelligent robots using AI and Machine learning technology.
- **Text Mining**
  Text-mining, one of the great applications of NLP, is now being implemented with the help of Reinforcement Learning by Salesforce company.

Advantages and Disadvantages of Reinforcement Learning

Advantages

- It helps in solving complex real-world problems which are difficult to be solved by general techniques.
- The learning model of RL is similar to the learning of human beings; hence most accurate results can be found.
- Helps in achieving long term results.

Disadvantage

- RL algorithms are not preferred for simple problems
- RL algorithms require huge data and computations.
- Too much reinforcement learning can lead to an overload of states which can weaken the results.

Machine Learning Application:

Image and Speech Recognition: Used in facial recognition systems, image classification, speech-to-text, and text-to-speech applications.

Natural Language Processing (NLP): Applications include sentiment analysis, language translation, chatbots, and text summarization.

Recommendation Systems: Used by companies like Amazon and Netflix to suggest products or content based on user preferences.

Financial Services: Fraud detection, algorithmic trading, credit scoring, and risk management benefit from machine learning models.

Healthcare: Diagnosis prediction, personalized treatment plans, and drug discovery are facilitated by analyzing medical data.

Autonomous Vehicles: Machine learning is crucial for object detection, path planning, and decision-making in self-driving cars.

Manufacturing and Predictive Maintenance: Predicting equipment failures and optimizing processes based on sensor data.

Gaming: Used for creating intelligent NPCs, procedural content generation, and adaptive game AI.

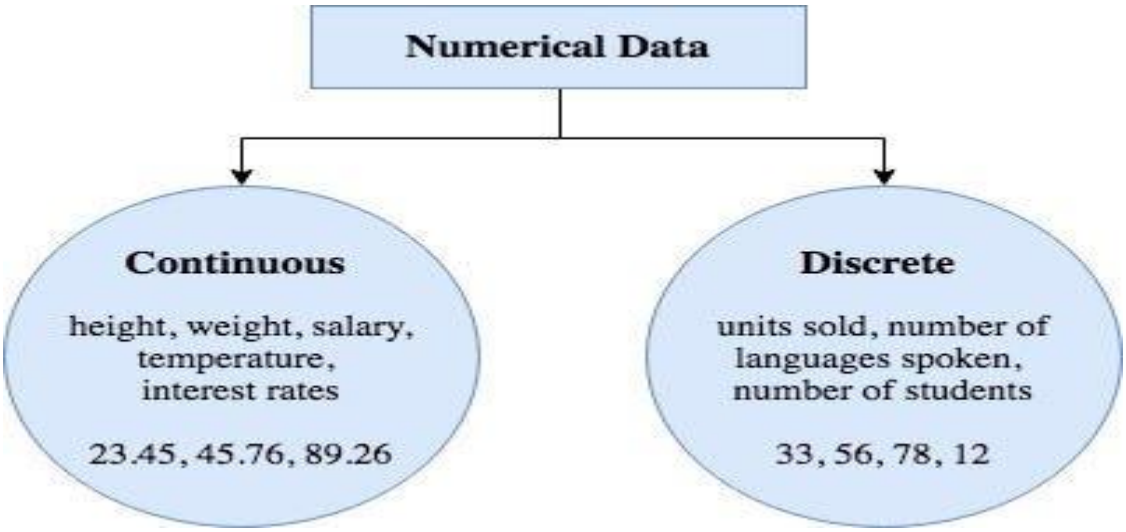
Marketing and Customer Service: Targeted advertising, customer segmentation, and personalized customer experiences.

Data Representation:

The word data refers to constituting people, things, events, ideas. It can be a title, an integer, or any cast. After collecting data the investigator has to condense them in tabular form to study their salient features. Such an arrangement is known as the presentation of data.

It refers to the process of condensing the collected data in a tabular form, Numerical or graphically. This arrangement of data is known as Data Representation.

Numerical Representation: Numerical data is any data where data points are exact numbers. Statisticians also might call numerical data, quantitative data. This data has meaning as a **measurement** such as house prices or as a count, such as a number of residential properties in Los Angeles or how many houses sold in the past year.Numerical data can be characterized by continuous or discrete data. Continuous data can assume any value within a range whereas discrete data has distinct values.



Graphical Representation of Data

Graphical Representation of Data," where numbers and facts become lively pictures and colorful diagrams. Instead of staring at boring lists of numbers, **we use fun charts, cool graphs, and interesting visuals to understand information better.** In this exciting concept of data visualization, **we'll learn about different kinds of graphs, charts, and pictures that help us see patterns and stories hidden in data.**

There is an entire branch in mathematics dedicated to dealing with collecting, analyzing, interpreting, and presenting numerical data in visual form in such a way that it becomes easy to understand and the data becomes easy to compare as well, the branch is known as **Statistics**.

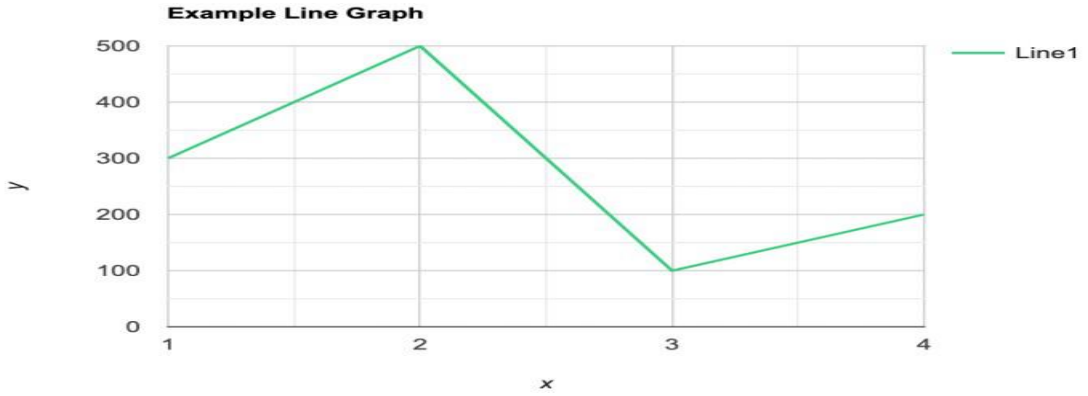
The branch is widely spread and has a plethora of real-life applications such as **Business Analytics, demography, Astor statistics, and so on**. In this article, we have provided everything about the graphical representation of data, including its types, rules, advantages, etc.

Types of Graphical Representations

Comparison between different items is best shown with graphs, it becomes easier to compare the crux of the data about different items. Let's look at all the different types of graphical representations briefly:

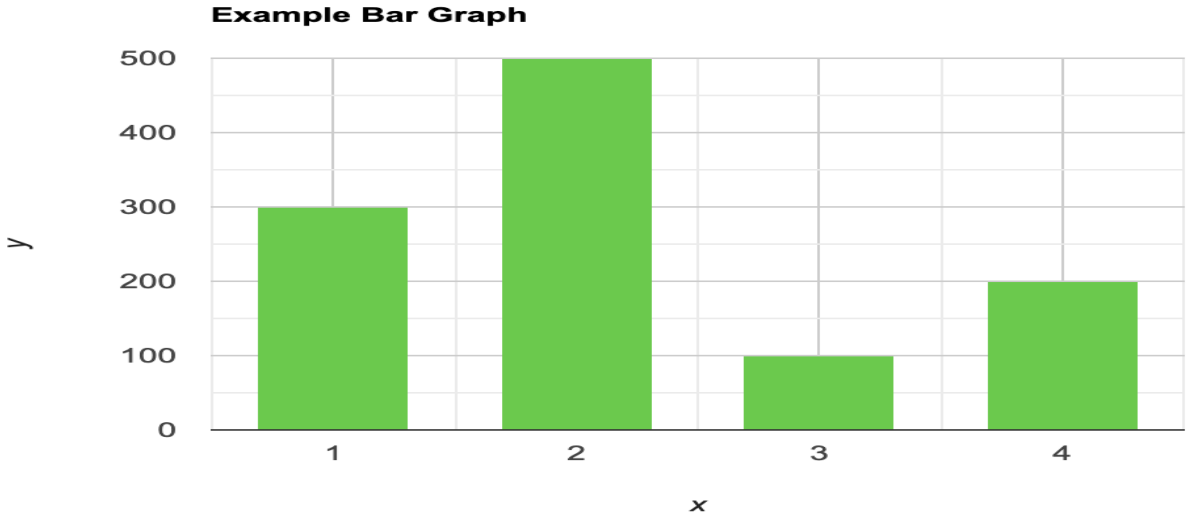
Line Graphs

A **line graph** is used to show how the value of a particular variable changes with time. We plot this graph by connecting the points at different values of the variable. **It can be useful for analyzing the trends in the data and predicting further trends.**



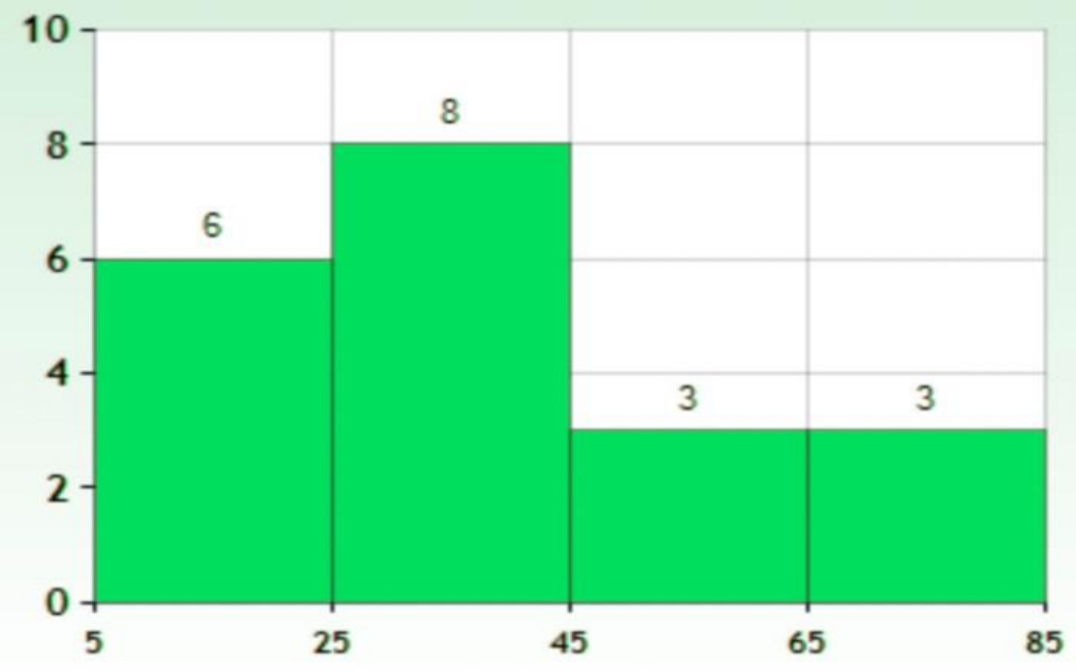
Bar Graphs

A bar graph is a type of graphical representation of the data in which bars of uniform width are drawn with equal spacing between them on one axis (x-axis usually), depicting the variable. **The values of the variables are represented by the height of the bars.**



Histograms

This is similar to bar graphs, but it is based frequency of numerical values rather than their actual values. The data is organized into intervals and the bars represent the frequency of the values in that range. That is, it counts how many values of the data lie in a particular range.

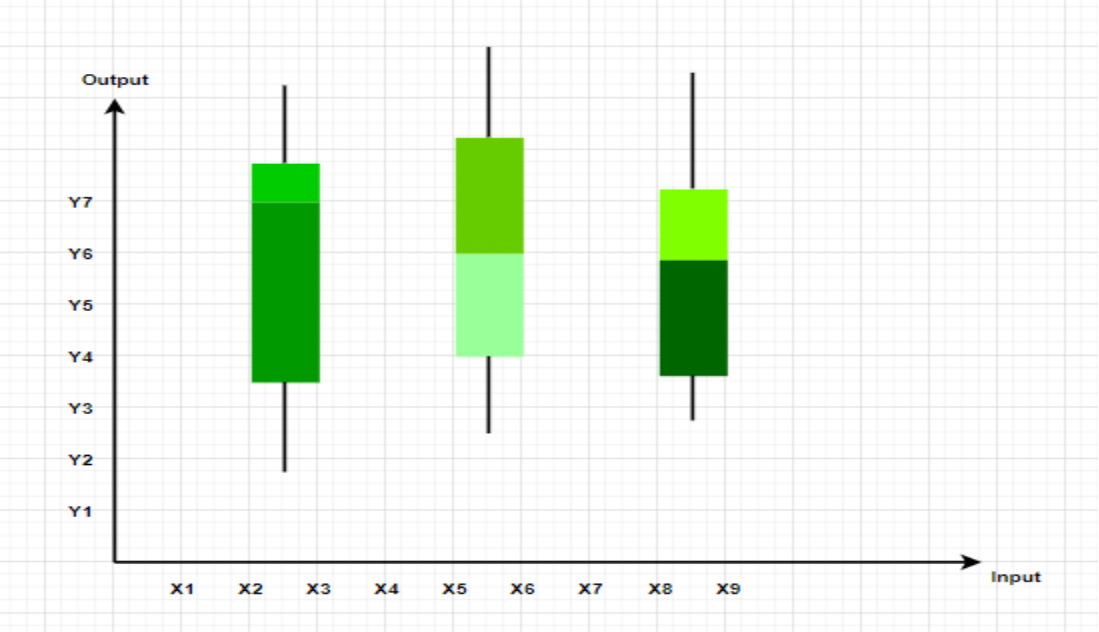


Line Plot

It is a plot that displays data as points and checkmarks above a number line, showing the frequency of the point.

Box and Whisker Plot

These plots divide the data into four parts to show their summary. **They are more concerned about the spread, average, and median of the data.**



Pie Chart

It is a type of graph which represents the data in form of a circular graph. The circle is divided such that each portion represents a proportion of the whole.