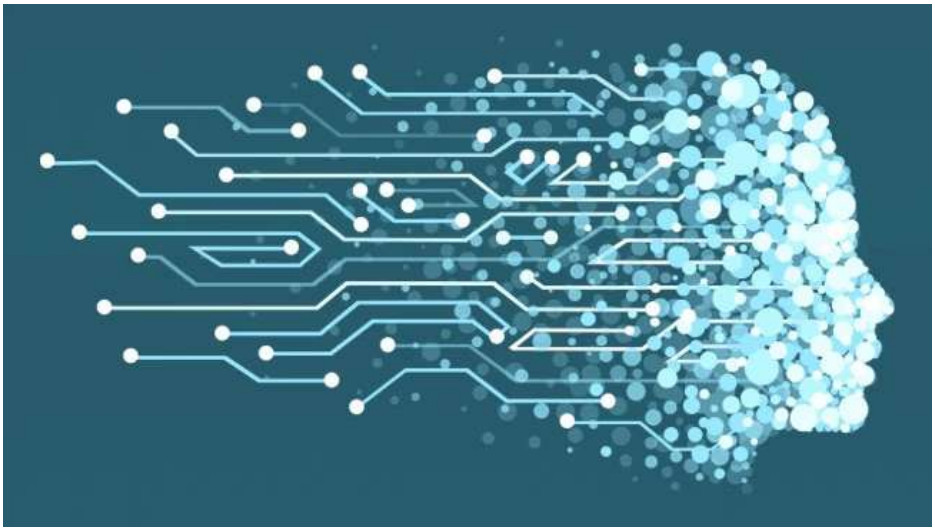
CS-33: Machine Learning with Python

BCA Semester – 6



Unit – 1

Introduction to Machine Learning

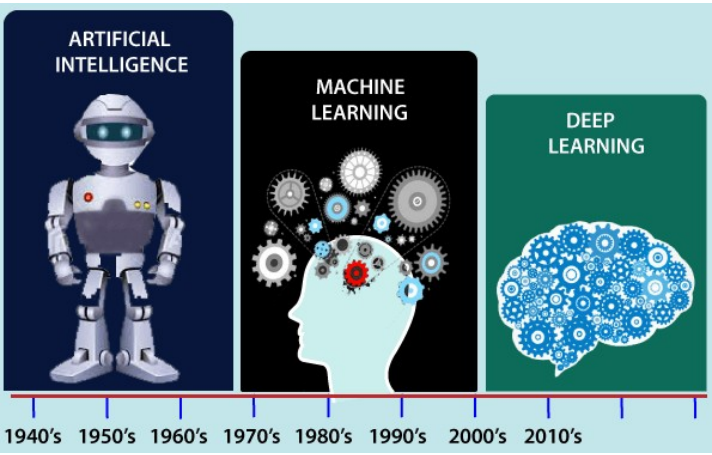
Introduction to ML

We are living in the 'age of data' that is enriched with better computational power and more storage resources. This data or information is increasing day by day, but the real challenge is to make sense of all the data. Businesses & organizations are trying to deal with it by building intelligent systems using the concepts and methodologies from Data Science, Data Mining, and Machine learning. Among them, machine learning is the most exciting field of computer science. It would not be wrong to call machine learning the application and science of algorithms that provide sense to the data.

A rapidly developing field of technology, machine learning allows computers to automatically learn from previous data. For building mathematical models and making predictions based on historical data or information, machine learning employs a variety of algorithms. It is currently being used for a variety of tasks, including speech recognition, email filtering, auto-tagging on Facebook, a recommender system, and image recognition.

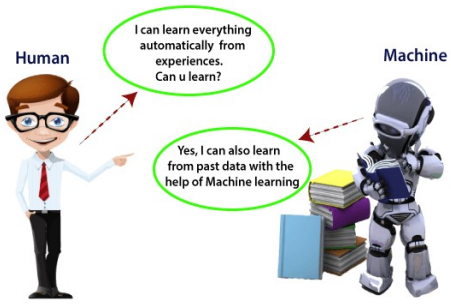
You will learn about the many different methods of machine learning, including reinforcement learning, supervised learning, and unsupervised learning. Regression and classification models, clustering techniques, hidden Markov models, and various sequential models will all be covered.

History of Machine Learning



The history of Machine learning roots back to the year 1959, when Arthur Samuel invented a program that calculates the winning probability in checkers for each side. Well, the evolution of Machine learning through decades started with the question, "Can Machines think?". Then came the rise of neural networks between 1960 and 1970. Machine learning continued to advance through statistical methods such as Bayesian networks and decision tree learning. The revolution of Deep Learning started off in the 2010s with the evolution of tasks such as natural language processing, convolution neural networks and speech recognition. Today, machine learning has turned out to be a revolutionizing technology that has become a part of all fields, ranging from healthcare to finance and transportation.

What is Machine Learning?



Machine learning (ML) is a subfield of artificial intelligence that enables machines to learn from data without being explicitly programmed. In machine learning, algorithm development is core work. These algorithms are trained on data to learn the hidden patterns and make predictions based on what they learned. The whole process of training the algorithms is termed model building. 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.

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.

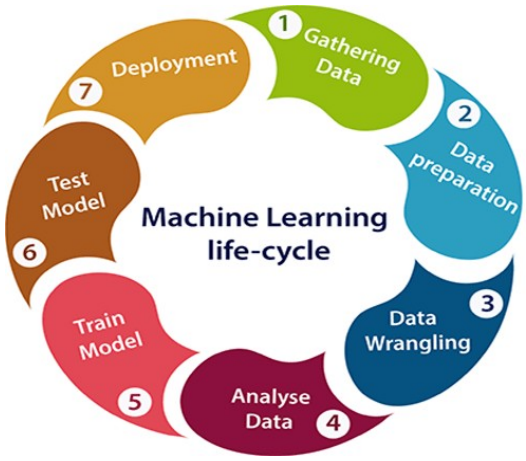
Need for Machine Learning: The demand for machine learning is steadily rising. Because it is able to perform tasks that are too complex for a person to directly implement, machine learning is required. Humans are constrained by our inability to manually access vast amounts of data; as a result, we require computer systems, which is where machine learning comes in to simplify our lives. By providing them with a large amount of data and allowing them to automatically explore the data, build models, and predict the required output, we can train machine learning algorithms. The cost function can be used to determine the amount of data and the machine learning algorithm's performance. We can save both time and money by using machine learning.

The significance of AI can be handily perceived by its utilization's cases, Presently, AI is utilized in self-driving vehicles, digital misrepresentation identification, face acknowledgment, and companion idea by Facebook, and so on. Different top organizations, for example, Netflix and Amazon have constructed AI models that are utilizing an immense measure of information to examine the client interest and suggest item likewise. 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.

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



- **Gathering Data:** Data Gathering is the first step of the machine learning life cycle. The goal of this step is to identify and obtain all data-related problems. 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:
    1. Identify various data sources
    2. Collect data
    3. Integrate the data obtained from different sources

    By performing the above task, we get a coherent set of data, also called as a dataset. It will be used in further steps.
- **Data preparation:** After collecting the data, we need to prepare it for further steps. 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.

- **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, Invalid data, and 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.
- **Data Analysis:** Now the cleaned and prepared data is passed on to the analysis step. This step involves: Selection of analytical techniques, Building models, and 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.
- **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.
- **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.
- **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.

Relation of ML with AI and DL

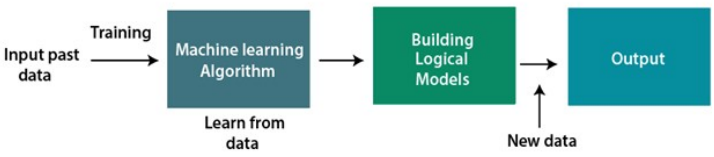
Artificial intelligence and machine learning are the part of computer science that are correlated with each other. These two technologies are the most trending technologies which are used for creating intelligent systems. Although these are two related technologies and sometimes people use them as a synonym for each other, but still both are the two different terms in various cases. On a broad level, we can differentiate both AI and ML as:

- **Artificial Intelligence (AI):** Artificial intelligence is a field of computer science which makes a computer system that can mimic human intelligence. It is comprised of two words "Artificial" and "intelligence", which means "a human-made thinking power. "Hence we can define it as, Artificial intelligence is a technology using which we can create intelligent systems that can simulate human intelligence. The Artificial intelligence system does not require to be pre-programmed, instead of that, they use such algorithms which can work with their own intelligence. It involves machine learning algorithms such as Reinforcement learning algorithm and deep learning neural networks. AI is being used in multiple places such as Siri, Google, AlphaGo, AI in Chess playing, etc. Based on capabilities, AI can be classified into three

types: Weak AI, General AI, and Strong AI. Currently, we are working with weak AI and general AI. The future of AI is Strong AI for which it is said that it will be intelligent than humans. AI is a bigger concept to create intelligent machines that can simulate human thinking capability and behavior, whereas, machine learning is an application or subset of AI that allows machines to learn from data without being programmed explicitly.

- **Machine learning (ML):** Machine learning is about extracting knowledge from the data. It can be defined as, Machine learning is a subfield of artificial intelligence, which enables machines to learn from past data or experiences without being explicitly programmed. Machine learning enables a computer system to make predictions or take some decisions using historical data without being explicitly programmed. Machine learning uses a massive amount of structured and semi-structured data so that a machine learning model can generate accurate result or give predictions based on that data. Machine learning works on algorithm which learn by it's own using historical data. It works only for specific domains such as if we are creating a machine learning model to detect pictures of dogs, it will only give result for dog images, but if we provide a new data like cat image then it will become unresponsive. Machine learning is being used in various places such as for online recommender system, for Google search algorithms, Email spam filter, Facebook Auto friend tagging suggestion, etc.
- **Deep learning (DL):** Deep learning is a subset of machine learning that uses multilayered neural networks, called deep neural networks, to simulate the complex decision-making power of the human brain. Some form of deep learning powers most of the artificial intelligence (AI) applications in our lives today. The chief difference between deep learning and machine learning is the structure of the underlying neural network architecture. “Nondeep,” traditional machine learning models use simple neural networks with one or two computational layers. Deep learning models use three or more layers—but typically hundreds or thousands of layers—to train the models. While supervised learning models require structured, labeled input data to make accurate outputs, deep learning models can use unsupervised learning. With unsupervised learning, deep learning models can extract the characteristics, features and relationships they need to make accurate outputs from raw, unstructured data. Additionally, these models can even evaluate and refine their outputs for increased precision. Deep learning is an aspect of data science that drives many applications and services that improve automation, performing analytical and physical tasks without human intervention. This enables many everyday products and services—such as digital assistants, voice-enabled TV remotes, credit card fraud detection, self-driving cars and generative AI.

How machines learn



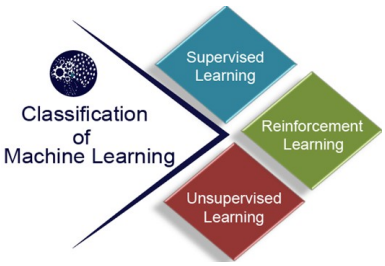
A machine learning system builds prediction models, learns from previous data, and predicts the output of new data whenever it receives it. The amount of data helps to build a better model that accurately predicts the output, which in turn affects the accuracy of the predicted output. Let's say we have a complex problem in which we need to make predictions. Instead of writing code, we just need to feed the data to generic algorithms, which build the logic based on the data and predict the output. Our perspective on the issue has changed as a result of machine learning. The Machine Learning algorithm's operation is depicted in the block diagram. The mechanism of how a machine learns from a model is divided into three main components:

- **Decision Process** − Based on the input data and output labels provided to the model, it will produce a logic about the pattern identified.
- **Cost Function** − It is the measure of error between expected value and predicted value. This is used to evaluate the performance of machine learning.

- **Optimization Process** – Cost function can be minimized by adjusting the weights at the training stage. The algorithm will repeat the process of evaluation and optimization until the error minimizes.

Types (Classification) of machine learning

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



Supervised learning: In supervised learning, sample labeled data are provided to the machine learning system for training, and the system then predicts the output based on the training data. The system uses labeled data to build a model that understands the datasets and learns about each one. After the training and processing are done, we test the model with sample data to see if it can accurately predict the output. The mapping of the input data to the output data is the objective of supervised learning. The managed learning depends on oversight, and it is equivalent to when an understudy learns things in the management of the educator. Spam filtering is an example of supervised learning. Supervised learning can be grouped further in two categories of algorithms: Classification, and Regression.

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, and Association

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.

Applications of machine learning

Machine learning has become the ubiquitous technology that has impacted many aspects of our lives, from business to healthcare to entertainment. Machine learning helps make decisions and find all possible solutions to a problem which improves the efficiency of work in every sector. Some of the successful machine learning applications are chatbots, language translation, face recognition, recommendation systems, autonomous vehicles, object detection, medical image analysis, etc. Here are some popular applications of machine learning:

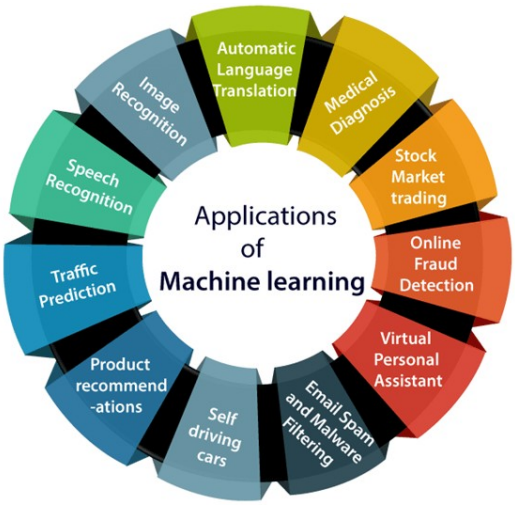


Image and Speech Recognition: Image and speech recognition are two areas where machine learning has significantly improved. Machine learning algorithms are used in applications such as facial recognition, object detection, and speech recognition to accurately identify and classify images and speech.

Natural Language Processing: Natural Language Processing (NLP) is a field of computer science that deals with the interaction between computers and humans using natural language. NLP uses machine learning algorithms to identify parts of speech, sentiment and other aspects of text. It analyzes, understands, and generates human language. It is currently all over the internet which includes translation software, search engines, chatbots, grammar correction software and voice assistants, etc. Here is a list of some applications of machine learning in natural language processing −

- Sentiment Analysis
- Speech synthesis
- Speech recognition
- Text classification
- Chatbots
- Language translation
- Caption generation
- Document summarization
- Question answering
- Autocomplete in search engines

Finance Sector: The role of machine learning in finance is to maintain secure transactions. Also, in trading, the data is converted to information for the decision-making process. Some applications of machine learning in the finance sector are −

1. **Fraud Detection:** Machine learning is widely used in the finance industry for fraud detection. Fraud detection is a process of using a machine learning model to monitor transactions and understand patterns in the dataset to identify fraudulent and suspicious activities. Machine learning algorithms can analyze vast amounts of transactional data to detect patterns and anomalies that may indicate fraudulent activity, helping to prevent financial losses and protect customers.
2. **Algorithmic Trading:** Machine learning algorithms are used to identify complex patterns in the large dataset to discover trading signals which might not be possible for humans. Some other applications of machine learning in the finance sector are as follows −
    - Stock market analysis and forecasting
    - Credit risk assessment and management
    - Security analysis and portfolio optimization
    - Asset evaluation and management

E-commerce and Retail: Machine learning is used to enhance the business in e-commerce and retail sector through recommendation systems and target advertising which improve user experience. Machine learning makes the process of marketing easy by performing repetitive tasks. Some tasks where Machine learning is applied are:

1. **Recommendation Systems:** Recommendation systems are used to provide personalized recommendations to users based on their past behavior and preferences and previous interaction with the website. Machine learning algorithms are used to analyze user data and generate recommendations for products, services, and content.
2. **Demand Forecasting:** Companies use machine learning to understand the future demand for their product or services based on various factors like market trends, customer behavior and historical data regarding sales.
3. **Customer Segmentation:** Machine learning can be used to segment customers into particular groups with similar characteristics. The purpose of customer segmentation is to understand customer behavior and target them with personalized experience.

Automotive Sector: Who would have thought of a car that would move independently without driving? Machine learning enabled manufacturers to improve the performance of existing products and vehicles. One massive innovation is the development of autonomous vehicles also called drive less vehicles which can sense its environment and drive for itself passing the obstacles without human assistance. It uses machine learning algorithms for continuous analysis of the surroundings and predicting possible outcomes.

Computer Vision: Computer vision is an application of machine learning that uses algorithms and neural networks to teach computers to derive meaningful information from digital images and videos. Computer vision is applied in face recognition, to diagnose diseases based on MRI scans, and autonomous vehicles.

- Object detection and recognition
- Image classification and recognition
- Faicial recognition
- Autonomous vehicles
- Object segmentation
- Image reconstruction

Manufacturing and Industries: Machine learning is also used in manufacturing and industries to keep a check on the working conditions of machinery. Predictive Maintenance is used to identify defects in operational machines and equipment to avoid unexpected outages. This detection of anomalies would also help with regular maintenance. Predictive maintenance is a process of using machine learning algorithms to predict when maintenance will be required on a machine, such as a piece of equipment in a factory. By analyzing data from sensors and other sources, machine learning algorithms can detect patterns that indicate when a machine is likely to fail, enabling maintenance to be performed before the machine breaks down.

Healthcare Sector: Machine learning has also found many applications in the healthcare industry. For example, machine learning algorithms can be used to analyze medical images and detect diseases such as cancer or to predict patient outcomes based on their medical history and other factors. Some applications of machine learning in healthcare are discussed below −

1. **Medical Imaging and Diagnostics:** Machine learning in medical imaging is used to analyze the patterns in the image that indicate the presence of a particular disease.
2. **Drug Discovery:** Machine learning techniques are used to analyze vast datasets, to predict the biological activity of compounds, and to identify potential drugs for a disease by analyzing its chemical structures.
3. **Disease Diagnosis:** Machine learning may also be used to identify some types of diseases. Breast cancer, heart failure, Alzheimer's disease, and pneumonia are some examples of such diseases that can be identified using machine learning algorithms. These are just a few examples of the many applications of machine learning. As machine learning continues to evolve and improve, we can expect to see it used in more areas of our lives, improving efficiency, accuracy, and convenience in a variety of industries.

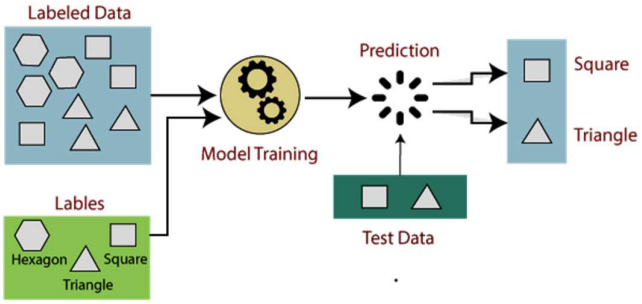
Unit – 2

Supervised Learning

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. In supervised learning, the training data provided to the machines work as the supervisor that teaches the machines to predict the output correctly. It applies the same concept as a student learns in the supervision of the teacher. Supervised learning is a process of providing input data as well as correct output data to the machine learning model. 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. The working of Supervised learning can be easily understood by the below example and diagram. 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.

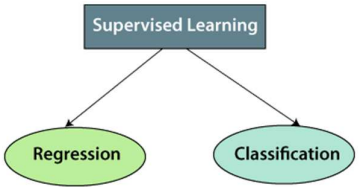


- If the given shape has four sides, and all the sides are equal, then it will be labelled as a Square.
- If the given shape has three sides, then it will be labelled as a triangle.
- If the given shape has six equal sides then it will be labelled as hexagon.

Now, after training, we test our model using the test set, and the task of the model is to identify the shape. The machine is already trained on all types of shapes, and when it finds a new 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.
- 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.

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



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

- Polynomial Regression

- **Linear Regression:** Linear regression is a type of algorithm that tries to find the linear relation between input features and output values for the prediction of future events. This algorithm is widely used to perform stock analysis, weather forecasting and others. Linear regression is also a type of supervised machine-learning algorithm that learns from the labelled datasets and maps the data points with most optimized linear functions which can be used for prediction on new datasets. It computes the linear relationship between the dependent variable and one or more independent features by fitting a linear equation with observed data. It predicts the continuous output variables based on the independent input variable. For example if we want to predict house price we consider various factor such as house age, distance from the main road, location, area and number of room, linear regression uses all these parameter to predict house price as it consider a linear relation between all these features and price of house.

  Why Linear Regression is Important? The interpretability of linear regression is one of its greatest strengths. The model's equation offers clear coefficients that illustrate the influence of each independent variable on the dependent variable, enhancing our understanding of the underlying relationships. Its simplicity is a significant advantage; linear regression is transparent, easy to implement, and serves as a foundational concept for more advanced algorithms.

- **Nonlinear regression:** Nonlinear regression refers to a broader category of regression models where the relationship between the dependent variable and the independent variables is not assumed to be linear. If the underlying pattern in the data exhibits a curve, whether it's exponential growth, decay, logarithmic, or any other non-linear form, fitting a nonlinear regression model can provide a more accurate representation of the relationship. This is because in linear regression it is pre-assumed that the data is linear. A nonlinear regression model can be expressed as:

  $$\mathbf{Y = f(X,\beta)+\epsilon}$$

  Where,
  - $f(X,\beta)$: Regression function
  - X: This is the vector of independent variables, which are used to predict the dependent variable.
  - β :The vector of parameters that the model aims to estimate. These parameters determine the shape and characteristics of the regression function.
  - ϵ : error term

  Many different regressions exist and can be used to fit whatever the dataset looks like such as quadratic, cubic regression, and so on to infinite degrees according to our requirement.

- **Bayesian regression:** Bayesian regression is a type of linear regression that uses Bayesian statistics to estimate the unknown parameters of a model. It uses Bayes' theorem to estimate the likelihood of a set of parameters given observed data. The goal of Bayesian regression is to find the best estimate of the parameters of a linear model that describes the relationship between the independent and the dependent variables. The main difference between traditional linear regression and Bayesian regression is the underlying assumption regarding the data-generating process. Traditional linear regression assumes that data follows a Gaussian or normal distribution, while Bayesian regression has stronger assumptions about the nature of the data and puts a prior probability distribution on the parameters. Bayesian regression also enables more flexibility as it allows for additional parameters or prior distributions, and can be used to construct an arbitrarily complex model that explicitly

expresses prior beliefs about the data. Additionally, Bayesian regression provides more accurate predictive measures from fewer data points and is able to construct estimates for uncertainty around the estimates. On the other hand, traditional linear regressions are easier to implement and generally faster with simpler models and can provide good results when the assumptions about the data are valid.

Bayesian Regression can be very useful when we have insufficient data in the dataset or the data is poorly distributed. The output of a Bayesian Regression model is obtained from a probability distribution, as compared to regular regression techniques where the output is just obtained from a single value of each attribute.

- **Polynomial Regression:** There are some relationships that a researcher will hypothesize is curvilinear. Clearly, such types of cases will include a polynomial term. Inspection of residuals. If we try to fit a linear model to curved data, a scatter plot of residuals (Y-axis) on the predictor (X-axis) will have patches of many positive residuals in the middle. Hence in such a situation, it is not appropriate. An assumption in the usual multiple linear regression analysis is that all the independent variables are independent. In the polynomial regression model, this assumption is not satisfied.

Why Polynomial Regression? Polynomial regression is a type of regression analysis used in statistics and machine learning when the relationship between the independent variable (input) and the dependent variable (output) is not linear. While simple linear regression models the relationship as a straight line, polynomial regression allows for more flexibility by fitting a polynomial equation to the data. When the relationship between the variables is better represented by a curve rather than a straight line, polynomial regression can capture the non-linear patterns in the data.

- **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.
    - Naive Bayes
    - Spam Filtering
    - Logistic Regression
    - Support Vector Machines
    - Decision Trees
    - Random Forest

- **Naive Bayes:** Naive Bayes is used for creating classifiers. Suppose you want to sort out (classify) fruits of different kinds from a fruit basket. You may use features such as color, size, and shape of fruit; for example, any fruit that is red in color, round in shape, and about 10 cm in diameter may be considered an Apple. So to train the model, you would use these features and test the probability that a given feature matches the desired constraints. The probabilities of different features are then combined to arrive at the probability that a given fruit is an Apple. Naive Bayes generally requires a small number of training data for classification.

- **Spam Filtering:** Spam messages refer to unsolicited or unwanted messages/emails that are sent in bulk to users. In most messaging/emailing services, messages are detected as spam automatically so that these messages do not unnecessarily flood the users' inboxes. These messages are usually promotional and peculiar in nature. Thus, it is possible for us to build ML/DL models that can detect Spam messages. Here, we'll build a TensorFlow-based Spam detector; in simpler terms, we will have to classify the texts as Spam or Ham. This implies that Spam detection is a case of a Text Classification problem. So, we'll be performing EDA on our dataset and building a text classification model.

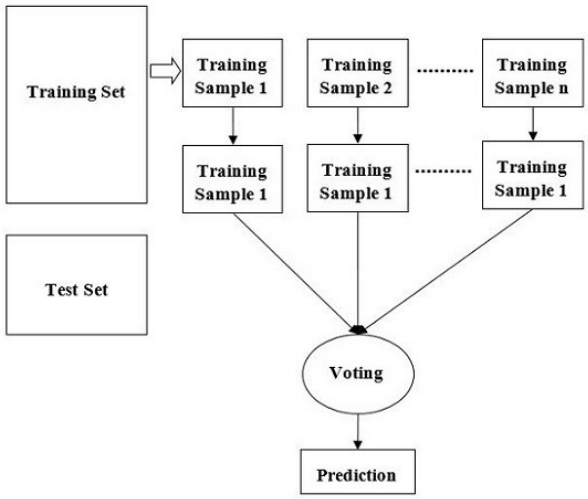
- **Logistic regression:** Logistic regression is a supervised machine learning algorithm used for classification tasks where the goal is to predict the probability that an instance belongs to a given class or not. Logistic regression is a statistical algorithm which analyze the relationship between two data factors. The article explores the fundamentals of logistic regression, it's types and implementations. Logistic regression is used for binary classification where we use sigmoid function, that takes input as independent variables and produces a probability value between 0 and 1. For example, we have two classes Class 0 and Class 1 if the value of the logistic function for an input is greater than 0.5 (threshold value) then it belongs to Class 1 otherwise it belongs to Class 0. It's referred to as regression because it is the extension of linear regression but is mainly used for classification problems.

- **Support Vector Machine (SVM):** Support Vector Machine is a supervised machine learning algorithm used for classification and regression tasks. While it can handle regression problems, SVM is particularly well-suited for classification tasks. SVM aims to find the optimal hyperplane in an N-dimensional space to separate data points into different classes. The algorithm maximizes the margin between the closest points of different classes. Support Vector Machine (SVM) Terminology:
  - **Hyperplane:** A decision boundary separating different classes in feature space, represented by the equation wx + b = 0 in linear classification.
  - **Support Vectors:** The closest data points to the hyperplane, crucial for determining the hyperplane and margin in SVM.
  - **Margin:** The distance between the hyperplane and the support vectors. SVM aims to maximize this margin for better classification performance.
  - **Kernel:** A function that maps data to a higher-dimensional space, enabling SVM to handle non-linearly separable data.
  - **Hard Margin:** A maximum-margin hyperplane that perfectly separates the data without misclassifications.
  - **Soft Margin:** Allows some misclassifications by introducing slack variables, balancing margin maximization and misclassification penalties when data is not perfectly separable.
  - **C:** A regularization term balancing margin maximization and misclassification penalties. A higher C value enforces a stricter penalty for misclassifications.
  - **Hinge Loss:** A loss function penalizing misclassified points or margin violations, combined with regularization in SVM.
  - **Dual Problem:** Involves solving for Lagrange multipliers associated with support vectors, facilitating the kernel trick and efficient computation.

- **Decision Trees:** In the decision trees, we discussed how decision trees model decisions through a tree-like structure, where internal nodes represent feature tests, branches represent decision rules, and leaf nodes contain the final predictions. This basic understanding is crucial for building and interpreting decision trees, which are widely used for classification and regression tasks. Now, let's take this understanding a step further and dive into how decision trees are implemented in machine learning. We will explore how to train a decision tree model, make predictions, and evaluate its performance.

  Why Decision Tree Structure in ML? A decision tree is a supervised learning algorithm used for both classification and regression tasks. It models decisions as a tree-like structure where internal nodes represent attribute tests, branches represent attribute values, and leaf nodes represent final decisions or predictions. Decision trees are versatile, interpretable, and widely used in machine learning for predictive modelling. Now we have covered about the very basic of decision tree but its very important to understand the intuition behind the decision tree so lets move towards it.

- **Random forest:** Random forest is also a supervised learning algorithm that is flexible for classification and regression. This algorithm is a combination of multiple decision trees which are merged to improve the accuracy of prediction . The following diagram illustrates how the Random Forest Algorithm works –



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.

Applications of Supervised learning: Supervised learning models are widely used in many applications in various sectors, including the following:

- **Image recognition:** A model is trained on a labeled dataset of images, where each image is associated with a label. The model is fed with data, which allows it to learn patterns and features. Once trained, the model can now be tested using new, unseen data. This is widely used in applications like facial recognition and object detection.
- **Predictive analytics:** Supervised learning algorithms are used to train labeled historical data, allowing the model to learn patterns and relations between input features and output to identify trends and make accurate predictions. Businesses use this method to make data-driven decisions and enhance strategic planning.

Unit – 3

Unsupervised Learning

Unsupervised Machine Learning

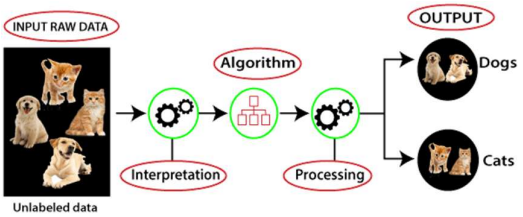
In the previous topic, we learned supervised machine learning in which models are trained using labeled data under the supervision of training data. But there may be many cases in which we do not have labeled data and need to find the hidden patterns from the given dataset. So, to solve such types of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

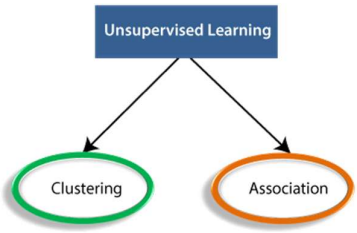


Working of unsupervised learning can be understood by the diagram. Here, we have taken an unlabeled input data, which means it is not categorized and corresponding outputs are also not given. Now, this unlabeled input data is fed to the machine learning model in order to train it. Firstly, it will interpret the raw data to find the hidden patterns from the data and then will apply suitable algorithms such as k-means clustering, Decision tree, 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.



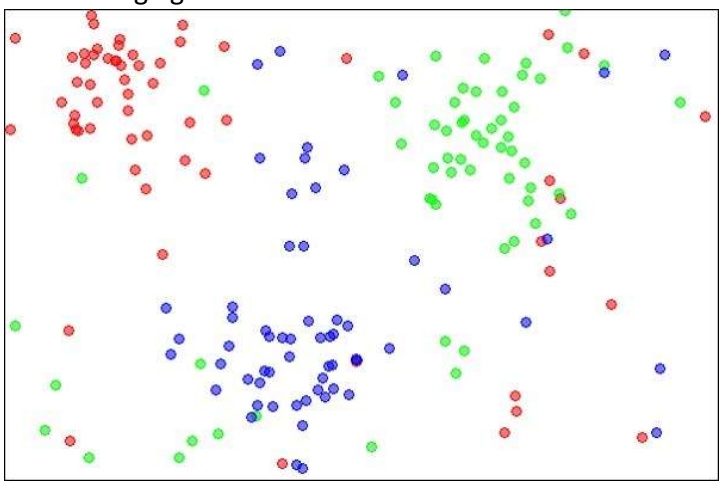
- **Association:** An association rule is an unsupervised learning method which is used for finding the relationships between variables in the large database. It determines the set of items that occurs together in the dataset. Association rule makes marketing strategy more effective. Such as people who 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: Below is the list of some popular unsupervised learning algorithms:

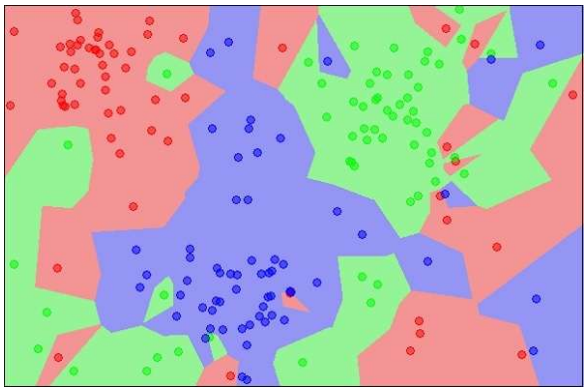
- K-means clustering
- KNN (k-nearest neighbors)
- Hierarchal clustering
- Anomaly detection
- Neural Networks
- Apriorism algorithm
- Principle Component Analysis
- Independent Component Analysis
- Singular value decomposition (SVD)

- **K-Means Clustering:** K-means clustering algorithm computes the centroids and iterates until we it finds optimal centroid. It assumes that the number of clusters are already known. It is also called flat clustering algorithm. The number of clusters identified from data by algorithm is represented by 'K' in K-means. In this algorithm, the data points are assigned to a cluster in such a manner that the sum of the squared distance between the data points and centroid would be minimum. It is to be understood that less variation within the clusters will lead to more similar data points within same cluster.

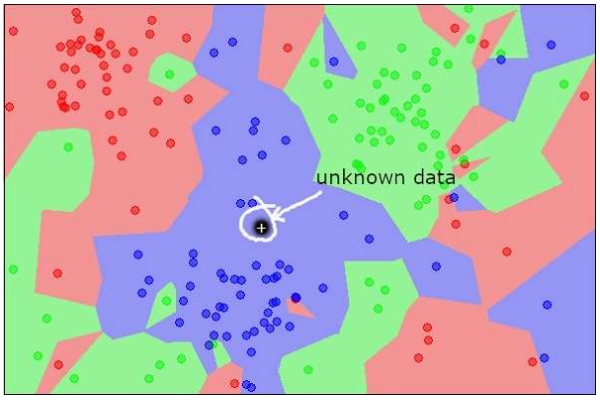
- **K-Nearest Neighbors:** The k-Nearest Neighbors (kNN) is a statistical technique that can be used for solving classification and regression problems. This algorithm classifies or predicts values for new data by mathematically calculating the nearest distance with other points in training data. Let us discuss the case of classifying an unknown object using kNN. Consider the distribution of objects as shown in the image given below –



The diagram shows three types of objects, marked in red, blue and green colors. When you run the kNN classifier on the above dataset, the boundaries for each type of object will be marked as shown below –



Now, consider a new unknown object you want to classify as red, green or blue. This is depicted in the figure below.



As you see it visually, the unknown data point belongs to a class of blue objects. Mathematically, this can be concluded by measuring the distance of this unknown point with every other point in the data set. When you do so, you will know that most of its neighbors are blue in color. The average distance between red and green objects would definitely be more than the average distance between blue objects. Thus, this unknown object can be classified as belonging to blue class. The kNN algorithm can also be used for regression problems. The kNN algorithm is available as ready-to-use in most of the ML libraries.

- **Hierarchical Clustering:** Hierarchical clustering is an unsupervised learning algorithm that is used to group together the unlabeled data points having similar characteristics. Hierarchical clustering algorithms falls into following two categories:
  - Agglomerative hierarchical algorithms − In agglomerative hierarchical algorithms, each data point is treated as a single cluster and then successively merge or agglomerate (bottom-up approach) the pairs of clusters. The hierarchy of the clusters is represented as a dendrogram or tree structure.
  - Divisive hierarchical algorithms − On the other hand, in divisive hierarchical algorithms, all the data points are treated as one big cluster and the process of clustering involves dividing (Top-down approach) the one big cluster into various small clusters.

- **Apriori algorithm:** Apriori is a popular algorithm used for association rule mining in machine learning. It is used to find frequent itemsets in a transaction database and generate association rules based on those itemsets. The algorithm was first introduced by Rakesh Agrawal and Ramakrishnan Srikant in 1994. The Apriori algorithm works by iteratively scanning the database

to find frequent itemsets of increasing size. It uses a "bottom-up" approach, starting with individual items and gradually adding more items to the candidate itemsets until no more frequent itemsets can be found. The algorithm also employs a pruning technique to reduce the number of candidate itemsets that need to be checked.

- **Principal Component Analysis:** Principal Component Analysis (PCA) is a popular unsupervised dimensionality reduction technique in machine learning used to transform high-dimensional data into a lower-dimensional representation. PCA is used to identify patterns and structure in data by discovering the underlying relationships between variables. It is commonly used in applications such as image processing, data compression, and data visualization. PCA works by identifying the principal components (PCs) of the data, which are linear combinations of the original variables that capture the most variation in the data. The first principal component accounts for the most variance in the data, followed by the second principal component, and so on. By reducing the dimensionality of the data to only the most significant PCs, PCA can simplify the problem and improve the computational efficiency of downstream machine learning algorithms. The steps involved in PCA are as follows:
  - Standardize the data − PCA requires that the data be standardized to have zero mean and unit variance.
  - Compute the covariance matrix − PCA computes the covariance matrix of the standardized data.
  - Compute the eigenvectors and eigenvalues of the covariance matrix − PCA then computes the eigenvectors and eigenvalues of the covariance matrix.
  - Select the principal components − PCA selects the principal components based on their corresponding eigenvalues, which indicate the amount of variation in the data explained by each component.
  - Project the data onto the new feature space − PCA projects the data onto the new feature space defined by the selected principal components.

- **Independent Component Analysis:** Independent Component Analysis is a technique used to separate mixed signals into their independent sources. The application of ICA ranges from audio and image processing to biomedical signal analysis. The article discusses about the fundamentals of ICA. **What is Independent Component Analysis?** Independent Component Analysis (ICA) is a statistical and computational technique used in machine learning to separate a multivariate signal into its independent non-Gaussian components. The goal of ICA is to find a linear transformation of the data such that the transformed data is as close to being statistically independent as possible. The heart of ICA lies in the principle of statistical independence. ICA identify components within mixed signals that are statistically independent of each other.

- **Singular Value Decomposition:** SVD (Singular Value Decomposition) is a method used in linear algebra to decompose a matrix into three simpler matrices, making it easier to analyze and manipulate. Imagine you have a table of data, like a set of ratings where rows are people, and columns are products. The numbers in the table show how much each person likes each product. SVD helps you split that table into three parts:
  - U: This part tells you about the people (like their general preferences).
  - Σ: This part shows how important each factor is (how much each rating matters).
  - V^T: This part tells you about the products (how similar they are to each other)

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.

Applications of Unsupervised Learning: Unsupervised learning provides a path for businesses to identify patterns in large volumes of data. Some real-world applications of unsupervised learning are:

- **Customer Segmentation** − In business and retail analysis, unsupervised learning is used to group customers into segments based on their purchases, past activity, or preferences.
- **Anomaly Detection** − Unsupervised learning algorithms are used in anomaly detection to identify unusual patterns, which is crucial for fraud detection in financial transactions and network security.
- **Recommendation Engines** − Unsupervised learning algorithms help to analyze large customer data to gain valuable insights and understand patterns. This can help in target marketing and personalization.
- **Natural Language Processing**− Unsupervised learning algorithms are used for various applications. For example, google used to categorize articles in the news section.

Differences between Supervised and Unsupervised learning

Supervised Learning	Unsupervised Learning
Supervised learning algorithms are trained using labeled data.	Unsupervised learning algorithms are trained using unlabeled data.
Supervised learning model takes direct feedback to check if it is predicting correct output or not.	Unsupervised learning model does not take any feedback.
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 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.

Unit – 4

Natural Language Processing

Natural Language Processing

The meaning of NLP is Natural Language Processing (NLP) which is a fascinating and rapidly evolving field that intersects computer science, artificial intelligence, and linguistics. NLP focuses on the interaction between computers and human language, enabling machines to understand, interpret, and generate human language in a way that is both meaningful and useful. With the increasing volume of text data generated every day, from social media posts to research articles, NLP has become an essential tool for extracting valuable insights and automating various tasks.

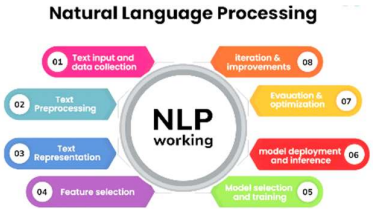
Natural Language Processing, shedding light on how it transforms raw text into actionable information. From tokenization and parsing to sentiment analysis and machine translation, NLP encompasses a wide range of applications that are reshaping industries and enhancing human-computer interactions. Whether you are a seasoned professional or new to the field, this overview will provide you with a comprehensive understanding of NLP and its significance in today's digital age.

What is Natural Language Processing? Natural language processing (NLP) is a field of computer science and a subfield of artificial intelligence that aims to make computers understand human language. NLP uses computational linguistics, which is the study of how language works, and various models based on statistics, machine learning, and deep learning. These technologies allow computers to analyze and process text or voice data, and to grasp their full meaning, including the speaker's or writer's intentions and emotions.

NLP powers many applications that use language, such as text translation, voice recognition, text summarization, and chatbots. You may have used some of these applications yourself, such as voice-operated GPS systems, digital assistants, speech-to-text software, and customer service bots. NLP also helps businesses improve their efficiency, productivity, and performance by simplifying complex tasks that involve language.

Working of Natural Language Processing (NLP)

Working in natural language processing (NLP) typically involves using computational techniques to analyze and understand human language. This can include tasks such as language understanding, language generation, and language interaction.



NLP Techniques

NLP encompasses a wide array of techniques that aimed at enabling computers to process and understand human language. These tasks can be categorized into several broad areas, each addressing different aspects of language processing. Here are some of the key NLP techniques:

1. Text Processing and Pre-processing In NLP:

- Tokenization: Dividing text into smaller units, such as words or sentences.
- Stemming and Lemmatization: Reducing words to their base or root forms.
- Stopword Removal: Removing common words (like "and", "the", "is") that may not carry significant meaning.
- Text Normalization: Standardizing text, including case normalization, removing punctuation, and correcting spelling errors.

2. Syntax and Parsing In NLP

- Part-of-Speech (POS) Tagging: Assigning parts of speech to each word in a sentence (e.g., noun, verb, adjective).
- Dependency Parsing: Analyzing the grammatical structure of a sentence to identify relationships between words.

- Constituency Parsing: Breaking down a sentence into its constituent parts or phrases (e.g., noun phrases, verb phrases).

3. Semantic Analysis

- Named Entity Recognition (NER): Identifying and classifying entities in text, such as names of people, organizations, locations, dates, etc.
- Word Sense Disambiguation (WSD): Determining which meaning of a word is used in a given context.
- Coreference Resolution: Identifying when different words refer to the same entity in a text (e.g., "he" refers to "John").

4. Information Extraction

- Entity Extraction: Identifying specific entities and their relationships within the text.
- Relation Extraction: Identifying and categorizing the relationships between entities in a text.

5. Text Classification in NLP

- Sentiment Analysis: Determining the sentiment or emotional tone expressed in a text (e.g., positive, negative, neutral).
- Topic Modeling: Identifying topics or themes within a large collection of documents.
- Spam Detection: Classifying text as spam or not spam.

6. Language Generation

- Machine Translation: Translating text from one language to another.
- Text Summarization: Producing a concise summary of a larger text.
- Text Generation: Automatically generating coherent and contextually relevant text.

7. Speech Processing

- Speech Recognition: Converting spoken language into text.
- Text-to-Speech (TTS) Synthesis: Converting written text into spoken language.

8. Question Answering

- Retrieval-Based QA: Finding and returning the most relevant text passage in response to a query.
- Generative QA: Generating an answer based on the information available in a text corpus.

9. Dialogue Systems

- Chatbots and Virtual Assistants: Enabling systems to engage in conversations with users, providing responses and performing tasks based on user input.

10. Sentiment and Emotion Analysis in NLP

- Emotion Detection: Identifying and categorizing emotions expressed in text.
- Opinion Mining: Analyzing opinions or reviews to understand public sentiment toward products, services, or topics.

Applications of Natural Language Processing (NLP)

- Spam Filters: One of the most irritating things about email is spam. Gmail uses natural language processing (NLP) to discern which emails are legitimate and which are spam. These spam filters look at the text in all the emails you receive and try to figure out what it means to see if it's spam or not.
- Algorithmic Trading: Algorithmic trading is used for predicting stock market conditions. Using NLP, this technology examines news headlines about companies and stocks and attempts to comprehend their meaning in order to determine if you should buy, sell, or hold certain stocks.

- Questions Answering: NLP can be seen in action by using Google Search or Siri Services. A major use of NLP is to make search engines understand the meaning of what we are asking and generate natural language in return to give us the answers.
- Summarizing Information: On the internet, there is a lot of information, and a lot of it comes in the form of long documents or articles. NLP is used to decipher the meaning of the data and then provides shorter summaries of the data so that humans can comprehend it more quickly.

Future Scope

- Bots: Chatbots assist clients to get to the point quickly by answering inquiries and referring them to relevant resources and products at any time of day or night. To be effective, chatbots must be fast, smart, and easy to use, To accomplish this, chatbots employ NLP to understand language, usually over text or voice-recognition interactions
- Supporting Invisible UI: Almost every connection we have with machines involves human communication, both spoken and written. Amazon's Echo is only one illustration of the trend toward putting humans in closer contact with technology in the future. The concept of an invisible or zero user interface will rely on direct communication between the user and the machine, whether by voice, text, or a combination of the two. NLP helps to make this concept a real-world thing.
- Smarter Search: NLP's future also includes improved search, something we've been discussing at Expert System for a long time. Smarter search allows a chatbot to understand a customer's request can enable "search like you talk" functionality (much like you could query Siri) rather than focusing on keywords or topics. Google recently announced that NLP capabilities have been added to Google Drive, allowing users to search for documents and content using natural language.

ML v/s NLP

Machine learning models are great at recognizing entities and overall sentiment for a document, but they struggle to extract themes and topics, and they're not very good at matching sentiment to individual entities or themes.

Alternatively, you can teach your system to identify the basic rules and patterns of language. In many languages, a proper noun followed by the word "street" probably denotes a street name. Similarly, a number followed by a proper noun followed by the word "street" is probably a street address. And people's names usually follow generalized two- or three-word formulas of proper nouns and nouns.

Unfortunately, recording and implementing language rules takes a lot of time. What's more, NLP rules can't keep up with the evolution of language. The Internet has butchered traditional conventions of the English language. And no static NLP codebase can possibly encompass every inconsistency and meme-ified misspelling on social media.

Very early text mining systems were entirely based on rules and patterns. Over time, as natural language processing and machine learning techniques have evolved, an increasing number of companies offer products that rely exclusively on machine learning. But as we just explained, both approaches have major drawbacks.

Unit – 5

Computer Vision with OpenCV

OpenCV, short for Open Source Computer Vision Library, is an open-source computer vision and machine learning software library. Originally developed by Intel, it is now maintained by a community of developers under the OpenCV Foundation.

OpenCV is a huge open-source library for computer vision, machine learning, and image processing. OpenCV supports a wide variety of programming languages like Python, C++, Java, etc. It can process images and videos to identify objects, faces, or even the handwriting of a human. When it is integrated with various libraries, such as Numpy which is a highly optimized library for numerical operations, then the number of weapons increases in your Arsenal i.e. whatever operations one can do in Numpy can be combined with OpenCV. This OpenCV tutorial will help you learn Image-processing from Basics to advanced, like operations on Images and videos using a huge set of Programs and projects.

OpenCV is one of the most popular computer vision libraries. If you want to start your journey in the field of computer vision, then a thorough understanding of the concepts of OpenCV is of paramount importance. In this unit, to understand the basic functionalities of Python OpenCV module, we will cover the most basic and important concepts of OpenCV intuitively:

- Reading an image
- Extracting the RGB values of a pixel
- Extracting the Region of Interest (ROI)
- Resizing the Image
- Rotating the Image
- Drawing a Rectangle
- Displaying text

This is the original image that we will manipulate throughout the course of this unit.

Let's start with the simple task of reading an image using OpenCV. For the implementation, we need to install the OpenCV library using the following command:

```
pip install opencv-python
```

Reading an Image: First of all, we will import cv2 module and then read the input image using cv2's imread() method. Then extract the height and width of the image.

```
# Importing the OpenCV library
import cv2
# Reading the image using imread() function
image = cv2.imread('image.jpg')
# Extracting the height and width of an image
h, w = image.shape[:2]
# Displaying the height and width
print("Height = {}, Width = {}".format(h, w))
```

Output:

```
Height = 1603, Width = 2400
```

Extracting the RGB Values of a Pixel: Now we will focus on extracting the RGB values of an individual pixel. OpenCV arranges the channels in BGR order. So the 0th value will correspond to the Blue pixel and not the Red.

```
# Extracting RGB values.
# Here we have randomly chosen a pixel
# by passing in 100, 100 for height and width.
(B, G, R) = image[100, 100]
# Displaying the pixel values
print("R = {}, G = {}, B = {}".format(R, G, B))
# We can also pass the channel to extract
# the value for a specific channel
B = image[100, 100, 0]
print("B = {}".format(B))
```

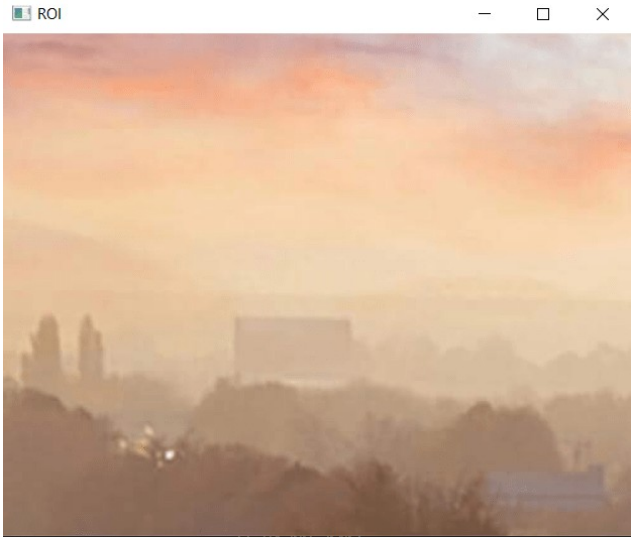
Output:

```
R = 211, G = 172, B = 165B = 165
```

Extracting the Region of Interest (ROI) : Sometimes we want to extract a particular part or region of an image. This can be done by slicing the pixels of the image.

```
# We will calculate the region of interest
# by slicing the pixels of the image
roi = image[100 : 500, 200 : 700]
cv2.imshow("ROI", roi)
cv2.waitKey(0)
```

Output:



Drawing a Rectangle: We can draw a rectangle on the image using rectangle() method. It takes in 5 arguments: Image, Top-left corner co-ordinates, Bottom-right corner co-ordinates, Color (in BGR format), Line width.

```
# We are copying the original image,
# as it is an in-place operation.
output = image.copy()
# Using the rectangle() function to create a rectangle.
rectangle = cv2.rectangle(output, (1500, 900),
                          (600, 400), (255, 0, 0), 2)
```

Output:

Displaying text: It is also an in-place operation that can be done using the putText() method of OpenCV module. It takes in 7 arguments: Image, Text to be displayed, Bottom-left corner co-ordinates, from where the text should start, Font, Font size, Color (BGR format), Line width.

```
# Copying the original image
output = image.copy()
# Adding the text using putText() function
text = cv2.putText(output, 'OpenCV Demo', (500, 550),
                   cv2.FONT_HERSHEY_SIMPLEX, 4, (255, 0, 0), 2)
```

Output:

Python OpenCV object detection

OpenCV is the huge and open-source library for image processing, machine learning and computer vision. It is also playing an important role in real-time operation. With the help of the OpenCV library, we can easily process the images as well as videos to identify the objects, faces or even handwriting of a human present in the file. We will only focus to object detection from images using OpenCV in this tutorial. We will learn about how we can use OpenCV to do object detection from a given image using a Python program.

Object Detection: Basically, object detection is a modern computer technology that is related to image processing, deep learning and computer vision to detect the objects present in an image file. All the technologies used in the Object detection technique (as we mentioned earlier) deals with detecting instances of the object in the image or video.

Object Detection using OpenCV: We have learned about object detection in the previous section, and in this section, we will learn that how we can do object detection in an image or video using the OpenCV library. We will first import the OpenCV library in the Python program, and then we will use functions to perform object detection on an image file given to us. But, before using and importing the library functions, let's first install the requirements for using the Object detection technique. In this unit, we will use the Haar cascade technique to do object detection. Let's learn in brief about the Haar cascade technique first.

Haar cascade: Basically, the Haar cascade technique is an approach based on machine learning where we use a lot of positive and negative images to train the classifier to classify between the images. Haar cascade classifiers are considered as the effective way to do object detection with the OpenCV library. Now, let's understand the concept of positive and negative images that we have discussed earlier:

- Positive images: These are the images that contain the objects which we want to be identified from the classifier.
- Negative Images: These are the images that do not contain any object that we want to be detected by the classifier, and these can be images of everything else.

Requirements for object detection with Python OpenCV: We have to install first some important libraries in our system as it is an important requirement for doing object detection tasks. We have to install the following libraries into our system as the requirement for performing object detection:

1. Installation of OpenCV library: First and foremost, the requirement to perform object detection using the OpenCV library is that the OpenCV library should be present in our device so that we can import it into a Python program and use its object detection functions. If this library is not present in our system, we can use the following command in our command prompt terminal to install it:

```
pip install opencv-python
```

When we press the enter key after writing this command in the terminal, the pip installer in the command prompt will start installing the OpenCV library into our system. As we can see that, the OpenCV library is successfully installed in our system, and now we can import it into a Python program to use its functions.

2. Installation of matplotlib library: Matplotlib is very helpful in the opening, closing, reading etc., images in a Python program, and that's why the installation of this library for object detection becomes an important requirement. If the matplotlib library is not present in our system, we have to use the following command in our command prompt terminal to install it:

```
pip install matplotlib
```

When we press the enter key after writing this command in the terminal, the pip installer in the command prompt will start installing it into our system. As we can see that, the matplotlib library is successfully installed in our system, and now we can import it into a Python program to use its

functions for opening, reading etc., images. We have installed all the required libraries for performing object detection, and now we can move ahead with the implementation part of this task.

Play a video using OpenCV

OpenCV (Open Source Computer Vision) is a computer vision library that contains various functions to perform operations on Images or videos. OpenCV library can be used to perform multiple operations on videos. Let's see how to play a video using the OpenCV Python. To capture a video, we need to create a VideoCapture object. VideoCapture have the device index or the name of a video file. Device index is just the number to specify which camera. If we pass 0 then it is for first camera, 1 for second camera so on. We capture the video frame by frame. Syntax

```
cv2.VideoCapture(0): Means first camera or webcam.
cv2.VideoCapture(1):  Means second camera or webcam.
cv2.VideoCapture("file name.mp4"): Means video file
```

Step 1: Import the required modules,

```
import cv2
```

Step 2: Creating the object of the VideoCapture and read the input file

```
cap = cv2.VideoCapture('Test.mp4')
```

Step 3: Check if the camera is opened or not,

```
if (cap.isOpened()== False):
# Give a error message
```

Step 4: Entire file is read frame by frame,

```
# Read the entire file until it is completed
while(cap.isOpened()):
  # Capture each frame
    ret, frame = cap.read()
      if ret == True:
      # Display the resulting frame
```

Below is the complete implementation

```
# importing libraries
import cv2
# Create a VideoCapture object and read from input file
cap = cv2.VideoCapture('Test.mp4')

# Check if camera opened successfully
if (cap.isOpened()== False):
    print("Error opening video file")

# Read until video is completed
while(cap.isOpened()):

# Capture frame-by-frame
    ret, frame = cap.read()
    if ret == True:
    # Display the resulting frame
        cv2.imshow('Frame', frame)
    # Press Q on keyboard to exit
        if cv2.waitKey(25) & 0xFF == ord('q'):
            break

# Break the loop
```

```
    else:
        break

# When everything done, release
# the video capture object
cap.release()

# Closes all the frames
cv2.destroyAllWindows()
```