# 21CS305PC INTRODUCTION TO MACHINE LEARNING

II YEAR B.TECH I-SEM

## Course Objectives:

- Introduce basic concepts of Probability and Machine Learning
- Introduce descriptive Statistics and data analysis along with visualization
- Gain knowledge on Regression Analysis
- Gain knowledge on Classification Techniques
- Gain knowledge on non parametric machine learning algorithms and SVMs.

## Course Outcomes:

After learning the contents of this course the student is able to

• Understand the basic concepts of Probability and Machine Learning.

• Develop the statistics and data analysis along with visualization.

• Implement the different types of regression models.

• Implement the classification model for categorical data.

• Analyze and develop the non-parametric models.

## UNIT – I

**SYLLABUS**

Introduction: What is Probability? Machine Learning, Use Machine Learning, and Types of Machine Learning Systems: supervised, unsupervised, semi-supervised, Reinforcement Learning, Batch and Online Learning, Main Challenges of Machine Learning.

### 1.1 Introduction

**Machine Learning** is the field of study that gives computers the capability to learn without being explicitly programmed. As it is evident from the name, it gives the computer that makes it more similar to humans: ***The ability to learn***.

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

A subset of machine learning is closely related to computational statistics, which focuses on making predictions using computers; but not all machine learning is statistical learning. The study of mathematical optimization delivers methods, theory and application domains to the field of machine learning

Machine learning is an important component of the growing field of data science. Through the use of statistical methods, algorithms are trained to make classifications or predictions.

The term Machine Learning was coined by Arthur Samuel in 1959, an American pioneer in the field of computer gaming and artificial intelligence, and stated that “it gives computers the ability to learn without being explicitly programmed”.

And in 1997, Tom Mitchell gave a “well-posed” mathematical and relational definition that “A computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.

for example, traffic patterns at a busy intersection (task T), you can run it through a machine learning algorithm with data about past traffic patterns (experience E) and, if it has successfully "learned", it will then do better at predicting future traffic patterns (performance measure P).

**Example:** playing checkers.

**E** =the experience of playing many games of checkers

**T** = the task of playing checkers.

**P** = the probability that the program will win the next game

The highly complex nature of many real-world problems, though, often means that inventing specialized algorithms that will solve them perfectly every time is impractical, if not impossible. Examples of machine learning problems include, "Is this cancer?", "Which of these people are good friends with each other?", "Will this person like this movie?" such problems are excellent targets for Machine Learning, and in fact, machine learning has been applied to such problems with great success.

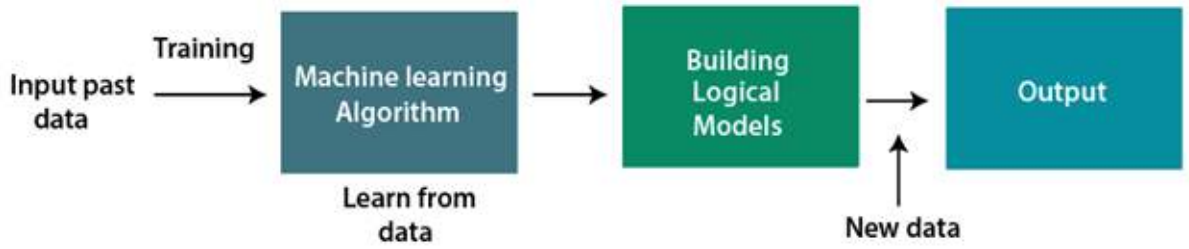
**Machine Learning Definitions**

- **Algorithm:** A Machine Learning algorithm is a set of rules and statistical techniques used to learn patterns from data and draw significant information from it. It is the logic behind a Machine Learning model. An example of a Machine Learning algorithm is the Linear Regression algorithm.
- **Model:** A model is the main component of Machine Learning. A model is trained by using a Machine Learning Algorithm. An algorithm maps all the decisions that a model is supposed to take based on the given input, in order to get the correct output.
- **Predictor Variable:** It is a feature(s) of the data that can be used to predict the output.
- **Response Variable:** It is the feature or the output variable that needs to be predicted by using the predictor variable(s).
- **Training Data:** The Machine Learning model is built using the training data. The training data helps the model to identify key trends and patterns essential to predict the output.
- **Testing Data:** After the model is trained, it must be tested to evaluate how accurately it can predict an outcome. This is done by the testing data set.

**How does Machine Learning work:**

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

Suppose we have a complex problem, where we need to perform some predictions, so instead of writing a code for it, we just need to feed the data to generic algorithms, and with the help of these algorithms, machine builds the logic as per the data and predict the output. Machine learning has changed our way of thinking about the problem.




**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.

## 1.2 Need for Machine Learning

The need for machine learning is increasing day by day. The reason behind the need for machine learning is that it is capable of doing tasks that are too complex for a person to implement directly. As a human, we have some limitations as we cannot access the huge amount of data manually, so for this, we need some computer systems and here comes the machine learning to make things easy for us.

We can train machine learning algorithms by providing them the huge amount of data and let them explore the data, construct the models, and predict the required output automatically. The performance of the machine learning algorithm depends on the amount of data, and it can be

determined by the cost function. With the help of machine learning, we can save both time and money.

1. **Image Recognition:**

Image recognition is one of the most common applications of machine learning. It is used to identify objects, persons, places, digital images, etc. The popular use case of image recognition and face detection is, **Automatic friend tagging suggestion**:

Facebook provides us a feature of auto friend tagging suggestion. Whenever we upload a photo with our Facebook friends, then we automatically get a tagging suggestion with name, and the technology behind this is machine learning's **face detection** and **recognition algorithm**.

It is based on the Facebook project named "**Deep Face**," which is responsible for face recognition and person identification in the picture.

2. **Speech Recognition**

While using Google, we get an option of "**Search by voice**," it comes under speech recognition, and it's a popular application of machine learning.

Speech recognition is a process of converting voice instructions into text, and it is also known as "**Speech to text**", or "**Computer speech recognition**." At present, machine learning algorithms are widely used by various applications of speech recognition. **Google assistant**, **Siri**, **Cortana**, and **Alexa** are using speech recognition technology to follow the voice instructions.

3. **Traffic prediction:**

If we want to visit a new place, we take help of Google Maps, which shows us the correct path with the shortest route and predicts the traffic conditions.

4. **Product recommendations:**

Machine learning is widely used by various e-commerce and entertainment companies such as **Amazon**, **Netflix**, etc., for product recommendation to the user. Whenever we search for some product on Amazon, then we started getting an advertisement for the same product while internet surfing on the same browser and this is because of machine learning.

Google understands the user interest using various machine learning algorithms and suggests the product as per customer interest.

As similar, when we use Netflix, we find some recommendations for entertainment series, movies, etc., and this is also done with the help of machine learning.

5. **Self-driving cars:**

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

6. **Email Spam and Malware Filtering:**

Whenever we receive a new email, it is filtered automatically as important, normal, and spam. We always receive an important mail in our inbox with the important symbol and spam emails in our spam box, and the technology behind this is Machine learning.

7. **Virtual Personal Assistant:**

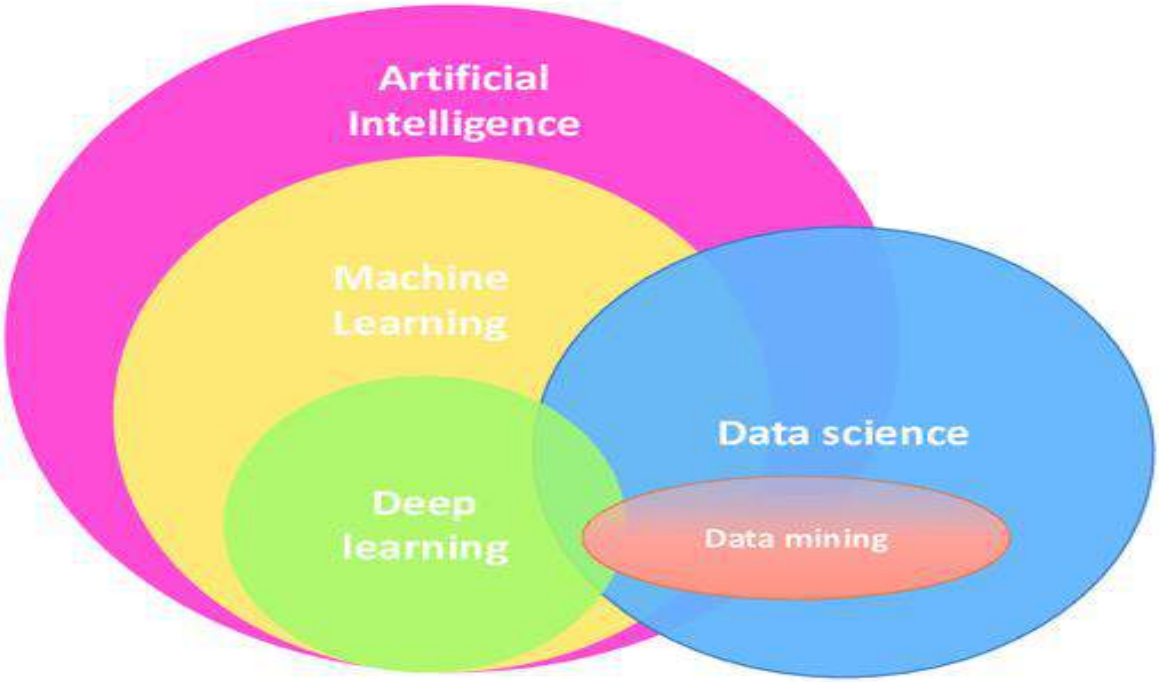
We have various virtual personal assistants such as **Google assistant**, **Alexa**, **Cortana**, **Siri**. As the name suggests, they help us in finding the information using our voice instruction. These assistants can help us in various ways just by our voice instructions such as Play music, call someone, Open an email, Scheduling an appointment, etc.

8. **Online Fraud Detection:**

Machine learning is making our online transaction safe and secure by detecting fraud transaction. Whenever we perform some online transaction, there may be various ways that a fraudulent transaction can take place such as **fake accounts**, **fake ids**, and **steal money** in the middle of a transaction. So to detect this, **Feed Forward Neural network** helps us by checking whether it is a genuine transaction or a fraud transaction.

**Difference between Data Science, AI, ML, DL, DM**

As data become the driving force of the modern world, pretty much everyone has stumbled upon such terms as data science, machine learning, artificial intelligence, deep learning, and data mining at some point. But what exactly do these terms mean? What differences and relationships exist between them?

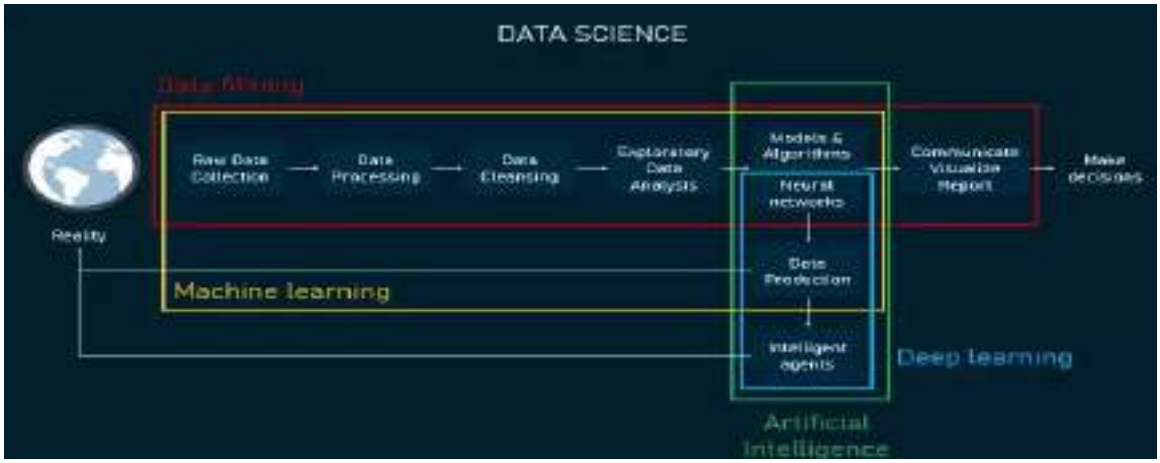



**Data science** is the broad scientific study that focuses on making sense of data. Think of, say, recommendation systems used to provide personalized suggestions to customers based on their search history. If, say, one customer searches for a rod and a lure and the other looks for a fishing line in addition to the other products, there's a decent chance that the first customer will also be interested in purchasing a fishing line. Data science is a broad field that envelops all activities and technologies that help build such systems, particularly those we discuss below.

**Data mining** is commonly a part of the data science pipeline. But unlike the latter, data mining is more about techniques and tools used to unfold patterns in data that were previously unknown and make data more usable for analysis. Taking you back to the example with fishing supplies, data mining is about studying the last 2 years of data to find correlations between the number of sales of fishing rods before and during fishing seasons in shops located in different states.

**Machine learning** aims at training machines on historical data so that they can process new inputs based on learned patterns without explicit programming, meaning without manually written out instructions for a system to do an action. If it weren't for machine learning, the recommendation engines we already mentioned above would be out of reach as it is difficult for a human to process millions of search queries, likes, and reviews to discover which customers commonly buy rods with lures and which purchase fishing line on top of that.

**Illustration of relations between data science, machine learning, artificial intelligence, deep learning,*datamining***

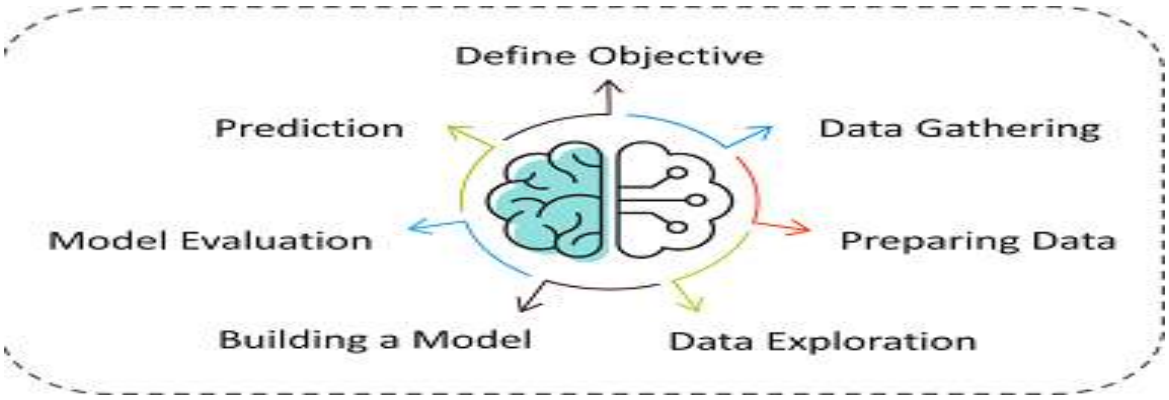



**Deep learning** is the most hyped branch of machine learning that uses complex algorithms of deep neural networks that are inspired by the way the human brain works. DL models can draw accurate results from large volumes of input data without being told which data characteristics to look at. Imagine you need to determine which fishing rods generate positive online reviews on your website and which cause the negative ones. In this case, deep neural nets can extract meaningful characteristics from reviews and perform sentiment analysis.

**Artificial intelligence** is a complex topic. But for the sake of simplicity, let's say that any real-life data product can be called AI. Let's stay with our fishing-inspired example. You want to buy a certain model fishing rod but you only have a picture of it and don't know the brand name. An AI system is a software product that can examine your image and provide suggestions as to a product name and shops where you can buy it. To build an AI product you need to use data mining, machine learning, and sometimes deep learning

**Process of Machine Learning**

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




*The problem is to predict the occurrence of rain in your local area by using Machine Learning.*

The below steps are followed in a Machine Learning process:

**Step 1:** Define the objective of the Problem Statement

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

**Step 2:** Data Gathering

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

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

Once you know the types of data that is required, you must understand how you can derive this data. Data collection can be done manually or by web scraping. However, if you're a beginner and you're just looking to learn Machine Learning you don't have to worry about getting the data. There are 1000s of data resources on the web, you can just download the data set and get going.

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

**Step 3**: Data Preparation

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

**Step 4:** Exploratory Data Analysis

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

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

**Step 5:** Building a Machine Learning Model

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

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

Choosing the right algorithm depends on the type of problem you're trying to solve, the data set and the level of complexity of the problem. In the upcoming sections, we will discuss the different types of problems that can be solved by using Machine Learning.

**Step 6:** Model Evaluation & Optimization

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

**Step 7:** Predictions

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

In our case, for predicting the occurrence of rainfall, the output will be a categorical variable.

So that was the entire Machine Learning process. Now it's time to learn about the different ways in which Machines can learn.

### 1.3 Types of Machine Learning Systems

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

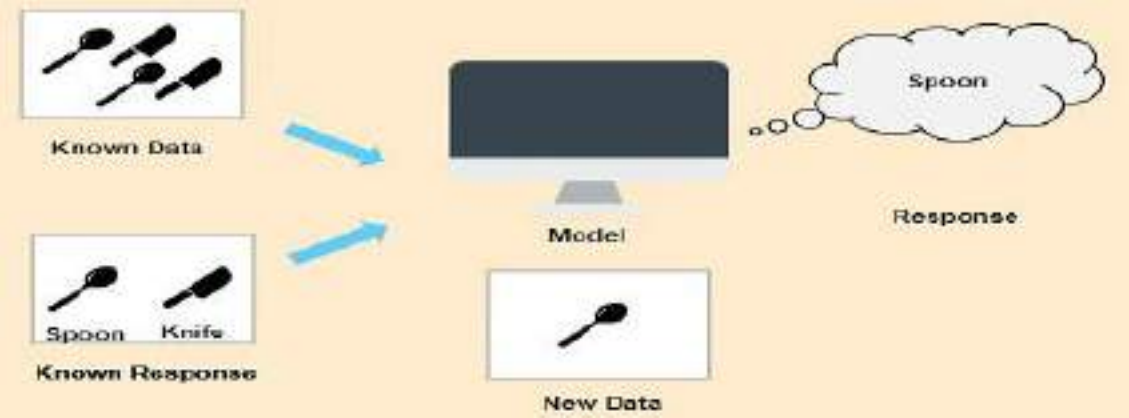
1. **Supervised learning**
2. **Unsupervised learning**
3. **Semi supervised learning**
4. **Reinforcement learning**

#### 1) Supervised Learning

Supervised learning is a type of machine learning method in which we provide sample labeled data to the machine learning system in order to train it, and on that basis, it predicts the output.
The system creates a model using labeled data to understand the datasets and learn about each data, once the training and processing are done then we test the model by providing a sample data to check whether it is predicting the exact output or not.

**For Example:**

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




The goal of supervised learning is to map input data with the output data. The supervised learning is based on supervision, and it is the same as when a student learns things in the supervision of the teacher. The example of supervised learning is **spam filtering**.

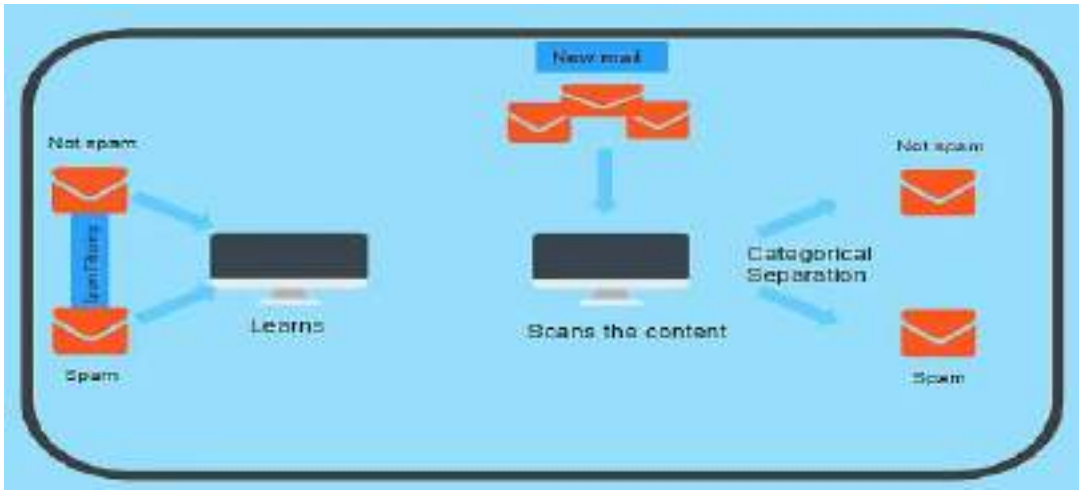
Supervised learning can be grouped further in two categories of algorithms:

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

**Classification - Supervised Learning**

- Classification is used when the output variable is categorical i.e. with 2 or more classes.
- For example, yes or no, male or female, true or false, etc.

**Example: Spam Filtering**



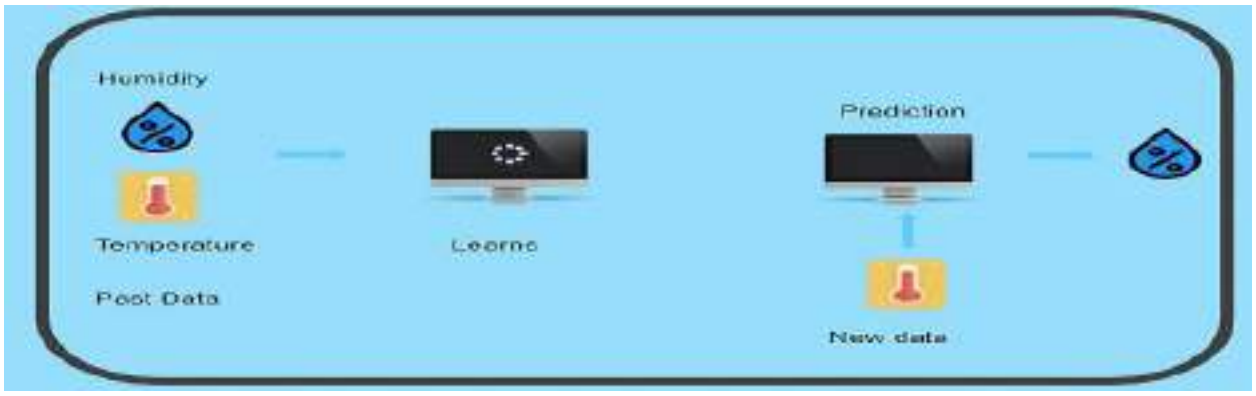

- In order to predict whether a mail is spam or not, we need to first teach the machine what a spam mail is.

- This is done based on a lot of spam filters - reviewing the content of the mail, reviewing the mail header, and then searching if it contains any false information.
- Certain keywords and blacklist filters that blackmails are used from already blacklisted spammers.
- All of these features are used to score the mail and give it a spam score. The lower the total spam score of the email, the more likely that it is not a scam.
- Based on the content, label, and the spam score of the new incoming mail, the algorithm decides whether it should land in the inbox or spam folder.

**Regression - Supervised Learning**

- Regression is used when the output variable is a real or continuous value. In this case, there is a relationship between two or more variables i.e., a change in one variable is associated with a change in the other variable.
- For example, salary based on work experience or weight based on height, etc.

**Example: humidity and temperature**




Let’s consider two variables -humidity and temperature. Here, ‘temperature’ is the independent variable and ‘humidity' is the dependent variable. If the temperature increases, then the humidity decreases.

These two variables are fed to the model and the machine learns the relationship between them. After the machine is trained, it can easily predict the humidity based on the given temperature.

**Some of the supervised learning applications are:**

- Sentiment analysis (Twitter, Facebook, Netflix, YouTube, etc)

- Natural Language Processing
- Image classification
- Predictive analysis
- Pattern recognition
- Spam detection
- Speech/Sequence processing

**Supervised Learning: Uses**

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

**Supervised Learning: Limitations**

- Slow -it requires human experts to manually label training examples one by one
- Costly -a model should be trained on the large volumes of hand-labeled data to provide accurate predictions.

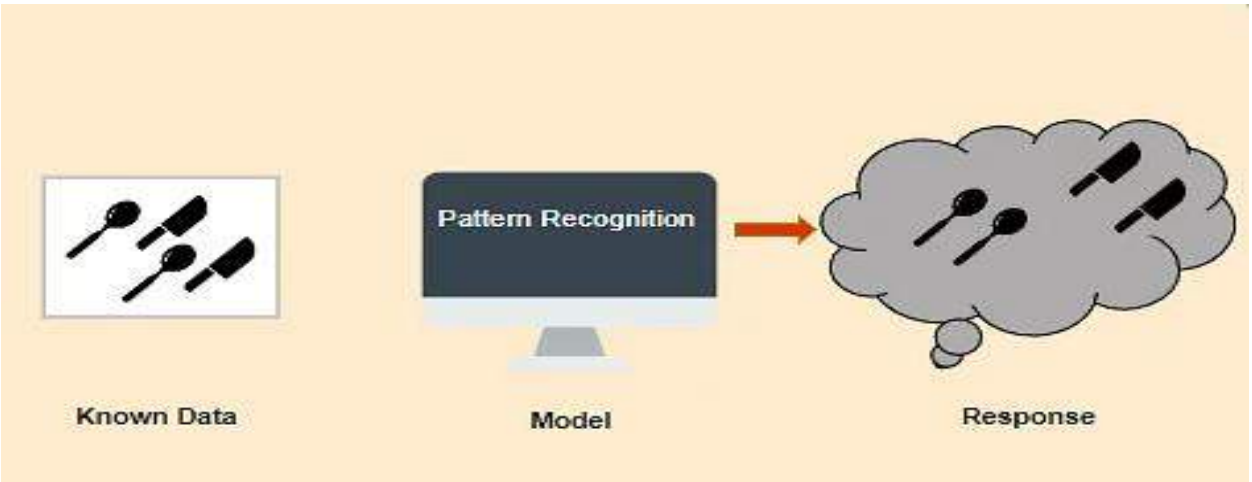
**2) Unsupervised Learning**

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.

**Example:**

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



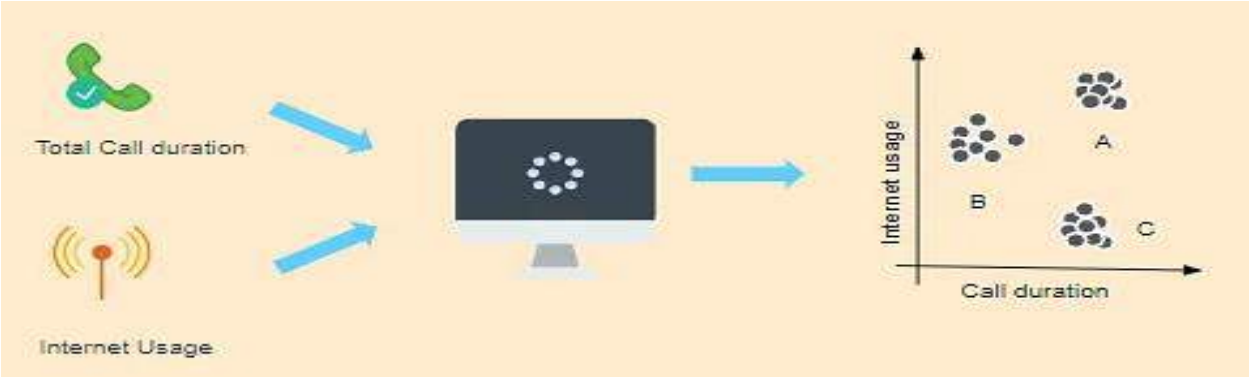

In unsupervised learning, we don't have a predetermined result. The machine tries to find useful insights from the huge amount of data. It can be further classifieds into two categories of algorithms:

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

**Clustering - Unsupervised Learning**

- Clustering is the method of dividing the objects into clusters that are similar between them and are dissimilar to the objects belonging to another cluster.
- For example, finding out which customers made similar product purchases.

**Example:**



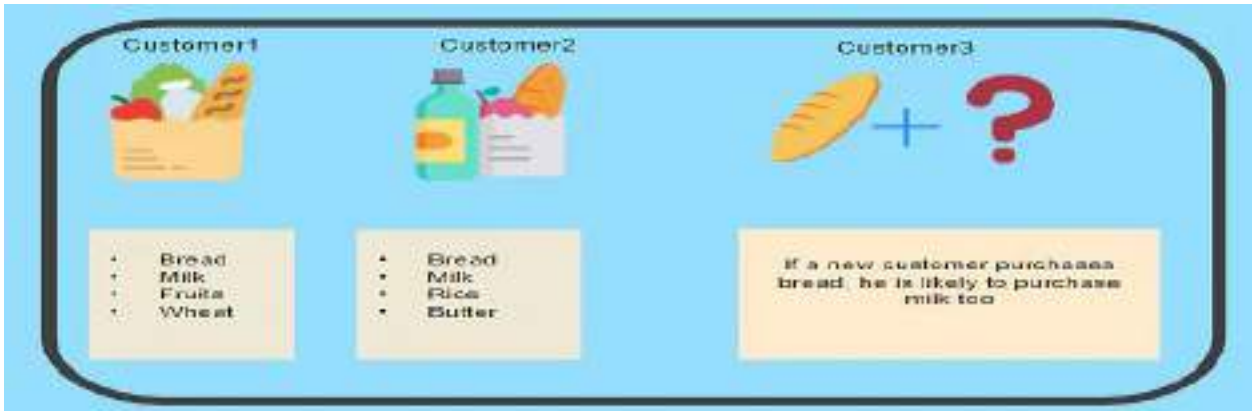

- Suppose a telecom company wants to reduce its customer churn rate by providing personalized call and data plans.
- The behavior of the customers is studied and the model segments the customers with similar traits.

- Group A customers use more data and also have high call durations. Group B customers are heavy Internet users, while Group C customers have high call duration.
- So, Group B will be given more data benefit plants, while Group C will be given cheaper called call rate plans and group A will be given the benefit of both.

**Association - Unsupervised Learning**

- Association is a rule-based machine learning to discover the probability of the co-occurrence of items in a collection.
- For example, finding out which products were purchased together.

**Example:**




- Let’s say that a customer goes to a supermarket and buys bread, milk, fruits, and wheat. Another customer comes and buys bread, milk, rice, and butter.
- Now, when another customer comes, it is highly likely that if he buys bread, he will buy milk too.
- Hence, a relationship is established based on customer behavior and recommendations are made.

**Uses 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.

**Unsupervised Learning- Limitations**

- It has a limited area of applications, mostly for clustering purposes.
- It provides less accurate results.

An example of a clustering algorithm is k-Means where *k* refers to the number of clusters to discover in the data.

**Unsupervised Learning applications are:**

1. Similarity detection
2. Automatic labeling
3. Object segmentation (such as Person, Animal, Films)

The goal in such unsupervised learning problems may be to discover groups of similar examples within the data, where it is called clustering, or to determine the distribution of data within the input space, known as density estimation, or to project the data from a high-dimensional space down to two or three dimensions for the purpose of visualization.

3) Semi supervised Learning

**Semi-Supervised Learning**

Semi-supervised learning is supervised learning where the training data contains very few labeled examples and a large number of unlabeled examples.

The goal of a semi-supervised learning model is to make effective use of all of the available data, not just the labeled data like in supervised learning.

- *Semi-supervised learning is an important category that lies between the Supervised and Unsupervised machine learning.*
- ***To overcome the drawbacks of supervised learning and unsupervised learning algorithms, the concept of Semi-supervised learning is introduced****.*
- *Labeled data exists with a very small amount while it consists of a huge amount of unlabeled data.*
- *Initially, similar data is clustered along with an unsupervised learning algorithm, and further, it helps to label the unlabeled data into labeled data.*
- *It is why label data is a comparatively, more expensive acquisition than unlabeled data.*

*"Semisupervised" learning attempts to improve the accuracy of supervised learning by exploiting information in unlabeled data. This sounds like magic, but it can work!*

**Real-world applications of Semi-supervised Learning**

- Speech Analysis
- Web content classification

- Protein sequence classification
- Text document classifier

4) Reinforcement Learning

Reinforcement learning is learning what to do — how to map situations to actions—so as to maximize a numerical reward signal. The learner is not told which actions to take, but instead must discover which actions yield the most reward by trying them.

**Terms used in Reinforcement Learning**

- Environment — Physical world in which the agent operates
- State — Current situation of the agent
- Reward — Feedback from the environment
- Policy — Method to map agent's state to actions
- Value — Future reward that an agent would receive by taking an action in a particular state

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.

An example of a reinforcement problem is playing a game where the agent has the goal of getting a high score and can make moves in the game and received feedback in terms of punishments or rewards.

In many complex domains, reinforcement learning is the only feasible way to train a program to perform at high levels. For example, in game playing, it is very hard for a human to provide accurate and consistent evaluations of large numbers of positions, which would be needed to train an evaluation function directly from examples. Instead, the program can be told when it has won or lost, and it can use this information to learn an evaluation function that gives reasonably accurate estimates of the probability of winning from any given position.


- Suppose there is an AI agent present within a maze environment, and his goal is to find the diamond.
- The agent interacts with the environment by performing some actions, and based on those actions, the state of the agent gets changed, and it also receives a reward or penalty as feedback.
- The agent continues doing these three things (**take action, change state/remain in the same state, and get feedback**), and by doing these actions, he learns and explores the environment.
- The agent learns that what actions lead to positive feedback or rewards and what actions lead to negative feedback penalty.
- As a positive reward, the agent gets a positive point, and as a penalty, it gets a negative point.

### 1.4 Batch and Online Learning

Batch learning represents the training of machine learning models in a batch manner. In other words, batch learning represents the training of the models at regular intervals such as weekly, bi-weekly, monthly, quarterly, etc. The data gets accumulated over a period of time. The models then get trained with the accumulated data from time to time at periodic intervals. Batch learning is also called **offline learning**. The models trained using batch or offline learning are moved into production only at regular intervals based on the performance of models trained with new data.
Building offline models or models trained in a batch manner requires training the models with the entire training data set. Improving the model performance would require re-training all over again with the entire training data set. These models are static in nature which means that once they get trained, their performance will not improve until a new model gets re-trained. Offline

models or models trained using batch learning are deployed in the production environment by replacing the old model with the newly trained model.

There can be various reasons why we can choose to adopt batch learning for training the models. Some of these reasons are the following:

- The business requirements do not require frequent learning of models.
- The data distribution is not expected to change frequently. Therefore, batch learning is suitable.
- The software systems (big data) required for batch learning is not available due to various reasons including the cost. The fact that the model is trained with a lot of accumulated data takes a lot of time and resources (CPU, memory space, disk space, disk I/O, network I/O, etc.).
- The expertise required for creating the system for incremental learning is not available.

If the models trained using batch learning needs to learn about new data, the models need to be retrained using the new data set and replaced appropriately with the model already in production based on different criteria such as model performance. The whole process of batch learning can be automated as well. The disadvantage of batch learning is it takes a lot of time and resources to re-training the model.

The criteria based on which the machine learning models can be decided to train in a batch manner depends on the model performance. Red-amber-green statuses can be used to determine the health of the model based on the prediction accuracy or error rates. Accordingly, the models can be chosen to be retrained or otherwise. The following stakeholders can be involved in reviewing the model performance and leveraging batch learning:

- Business/product owners
- Product managers
- Data scientists
- ML engineers

In online learning, the training happens in an incremental manner by continuously feeding data as it arrives or in a small group. Each learning step is fast and cheap, so the system can learn about new data on the fly, as it arrives.

**Online learning is great for machine learning systems that receive data as a continuous flow** (e.g., stock prices) and need to adapt to change rapidly or autonomously. **It is also a good option if you have limited computing resources:** once an online learning system has learned about new data instances, it does not need them anymore, so you can discard them (unless you want to be able to roll back to a previous state and "replay" the data) or move the data to another form of storage (warm or cold storage) if you are using the data lake. This can save a huge amount of space and cost.

Online learning algorithms can also be used to train systems on huge datasets that cannot fit in one machine's main memory (this is also called ***out-of-core learning***). The algorithm loads part of the data runs a training step on that data and repeats the process until it has run on all of the data.

One of the key aspects of online learning is the **learning rate.** The rate at which you want your machine learning to adapt to new data set is called the learning rate. A system with a high learning rate will tend to forget the learning quickly. A system with a low learning rate will be more like batch learning.

One of the big disadvantages of an online learning system is that if it is fed with bad data, the system will have bad performance and the user will see the impact instantly. Thus, it is very important to come up with appropriate data governance strategy to ensure that the data fed is of high quality. In addition, it is very important to monitor the performance of the machine learning system in a very close manner.

Data governance needs to be put in place across different levels such as the following when choosing to go with online learning:

- Feature extraction
- Predictions

The following are some of the challenges for adopting an online learning method:

- Data governance
- Model governance includes appropriate algorithm and model selection on-the-fly

Online models require only a single deployment in the production setting and they evolve over a period of time. The disadvantage that the online models have is that they don't have the entire dataset available for the training. The models are trained in an incremental manner based on the assumptions made using the available data and the assumptions at times can be sub-optimal.

## 1.5 Main Challenges of Machine Learning

There are a lot of challenges in machine learning

### 1. Poor Quality of Data

Data plays a significant role in the machine learning process. One of the significant issues that machine learning professionals face is the absence of good quality data. Unclean and noisy data can make the whole process extremely exhausting. We don't want our algorithm to make inaccurate or faulty predictions. Hence the quality of data is essential to enhance the output. Therefore, we need to ensure that the process of data preprocessing which includes removing outliers, filtering missing values, and removing unwanted features, is done with the utmost level of perfection.

### 2. Underfitting of Training Data

This process occurs when data is unable to establish an accurate relationship between input and output variables. It simply means trying to fit in undersized jeans. It signifies the data is too simple to establish a precise relationship. To overcome this issue:

- *Maximize the training time*
- *Enhance the complexity of the model*
- *Add more features to the data*
- *Reduce regular parameters*
- *Increasing the training time of model*

### 3. Overfitting of Training Data

Overfitting refers to a machine learning model trained with a massive amount of data that negatively affect its performance. It is like trying to fit in Oversized jeans. Unfortunately, this is one of the significant issues faced by machine learning professionals. This means that the algorithm is trained with noisy and biased data, which will affect its overall performance. Let's understand this with the help of an example. Let's consider a model trained to differentiate between a cat, a rabbit, a dog, and a tiger. The training data contains 1000 cats, 1000 dogs, 1000 tigers, and 4000 Rabbits. Then there is a considerable probability that it will identify the cat as a

rabbit. In this example, we had a vast amount of data, but it was biased; hence the prediction was negatively affected.

We can tackle this issue by:

- *Analyzing the data with the utmost level of perfection*
- *Use data augmentation technique*
- *Remove outliers in the training set*
- *Select a model with lesser* features

### 4. Machine Learning is a Complex Process

The machine learning industry is young and is continuously changing. Rapid hit and trial experiments are being carried on. The process is transforming, and hence there are high chances of error which makes the learning complex. It includes analyzing the data, removing data bias, training data, applying complex mathematical calculations, and a lot more. Hence it is a really complicated process which is another big challenge for Machine learning professionals.

### 5. Lack of Training Data

The most important task you need to do in the machine learning process is to train the data to achieve an accurate output. Less amount training data will produce inaccurate or too biased predictions. Let us understand this with the help of an example. Consider a machine learning algorithm similar to training a child. One day you decided to explain to a child how to distinguish between an apple and a watermelon. You will take an apple and a watermelon and show him the difference between both based on their color, shape, and taste. In this way, soon, he will attain perfection in differentiating between the two. But on the other hand, a machine-learning algorithm needs a lot of data to distinguish. For complex problems, it may even require millions of data to be trained. Therefore we need to ensure that Machine learning algorithms are trained with sufficient amounts of data.

### 6. Slow Implementation

This is one of the common issues faced by machine learning professionals. The machine learning models are highly efficient in providing accurate results, but it takes a tremendous amount of time. Slow programs, data overload, and excessive requirements usually take a lot of time to

provide accurate results. Further, it requires constant monitoring and maintenance to deliver the best output.

### 7. Imperfections in the Algorithm When Data Grows

The best model of the present may become inaccurate in the coming Future and require further rearrangement. So you need regular monitoring and maintenance to keep the algorithm working. This is one of the most exhausting issues faced by machine learning professionals.

**Conclusion:** Machine learning is all set to bring a big bang transformation in technology. It is one of the most rapidly growing technologies used in medical diagnosis, speech recognition, robotic training, product recommendations, video surveillance, and this list goes on. This continuously evolving domain offers immense job satisfaction, excellent opportunities, global exposure, and exorbitant salary. It is a high risk and a high return technology.