INDIAN SCHOOL AL WADI AL KABIR

ARTIFICIAL INTELLIGENCE

CLASS X (417)

Part B Unit 2:Advanced concepts of Modeling in AI

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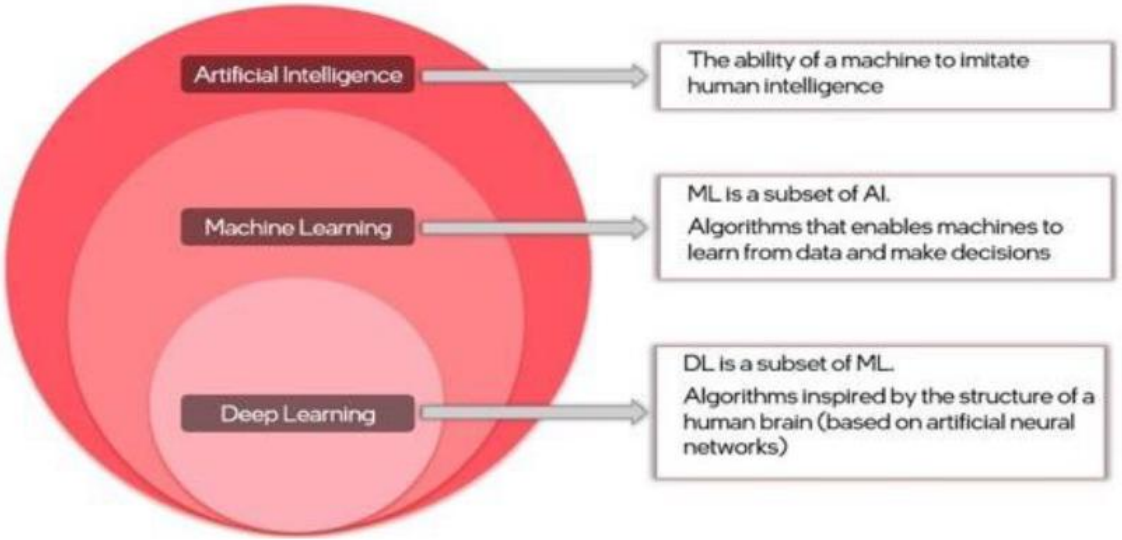
Revisiting AI, ML, DL

Differentiate between AI, ML, and DL :

- *Artificial Intelligence, or AI for short, refers to any technique that enables computers to mimic human intelligence. An artificially intelligent machine works on algorithms and data fed to it and gives the desired output.*
- *Machine Learning, or ML for short, enables machines to improve at tasks with experience. The machine here learns from the new data fed to it while testing and uses it for the next iteration. It also takes into account the times when it went wrong and considers the exceptions too.*
- *Deep Learning, or DL for short, enables software to train itself to perform tasks with vast amounts of data. Since the system has got huge set of data, it is able to train itself with the help of multiple machine learning algorithms working altogether to perform a specific task. Such machines are intelligent enough to develop algorithms for themselves.*

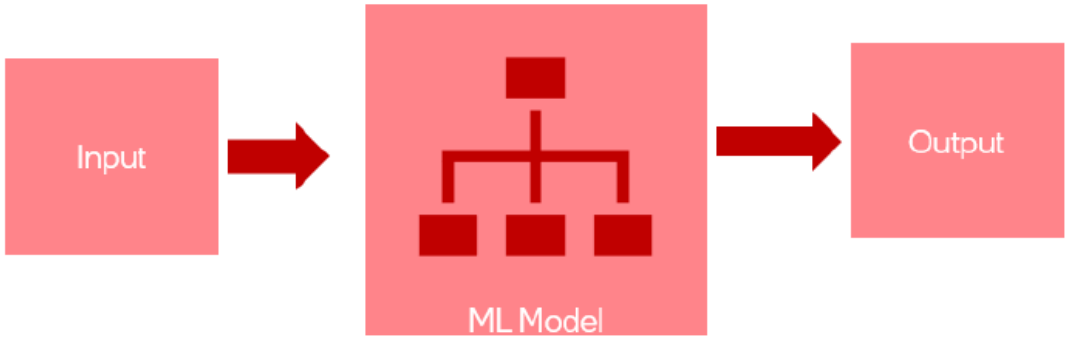
Revisiting AI, ML, DL

Artificial Intelligence is the umbrella term which holds both Deep Learning as well as Machine Learning. Deep Learning, on the other hand, is the very specific learning approach which is a subset of Machine Learning as it comprises of multiple Machine Learning algorithms."



Revisiting AI, ML, DL

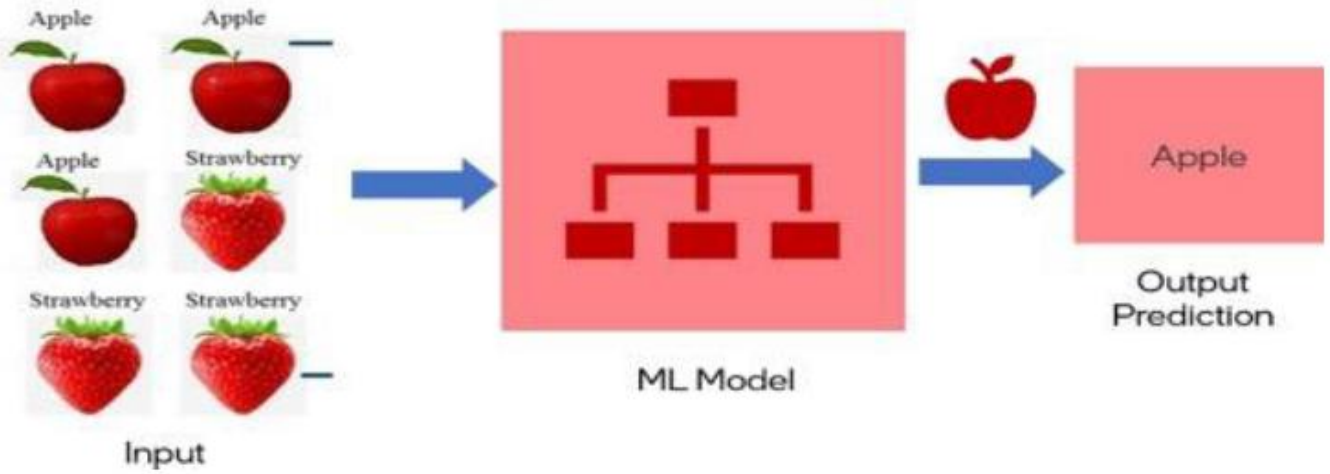
- **Machine Learning**, or ML, enables machines to improve at tasks with experience. The machine learns from its mistakes and takes them into consideration in the next execution. It improvises itself using its own experiences.



Block Representation – Machine Learning (ML)

Revisiting AI, ML, DL

Here is an example which shows labelled images (every image is tagged either as apple or strawberry) are given as input to the ML model. ML model learns from the input data to classify between apples and strawberries and predicts the correct output as shown.



Revisiting AI, ML, DL

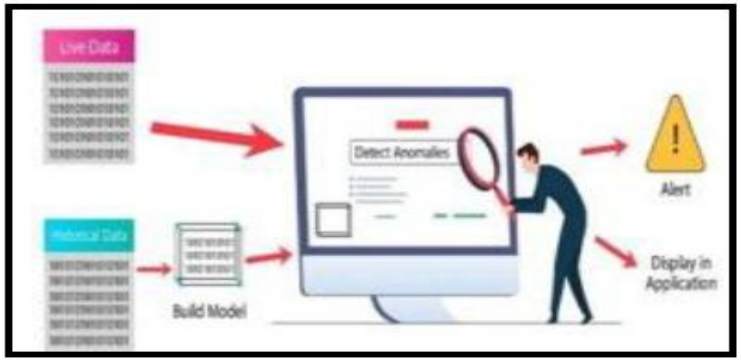
Examples of Machine Learning (ML)

Object Classification

Identifies and labels objects present withinan image or data point. It determines the category an object belongs to.

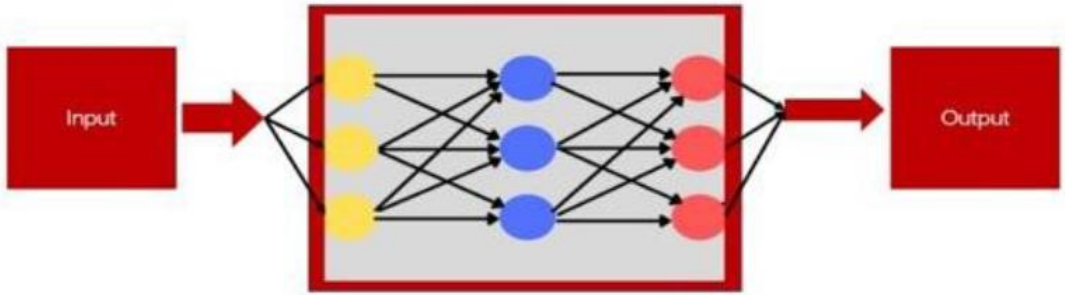
Anomaly Detection

Anomaly detection helps us find the unexpected things hiding in our data. For example, tracking your heart rate, and finding a sudden spike could be an anomaly, flagging a potential issue.



Revisiting AI, ML, DL

- **Deep Learning**, or DL, enables software to train itself to perform tasks with vast amounts of data. In deep learning, the machine is trained with huge amounts of data which helps it into training itself around the data. Such machines are intelligent enough to develop algorithms for themselves. Deep Learning is the most advanced form of Artificial Intelligence out of these three.



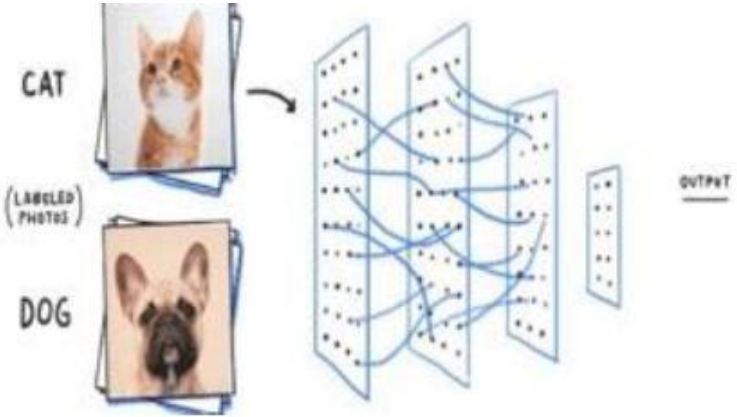
Block Representation- Deep Learning (DL)

Revisiting AI, ML, DL

Examples of Deep Learning (DL)

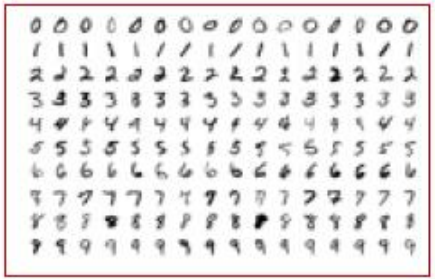
Object Identification

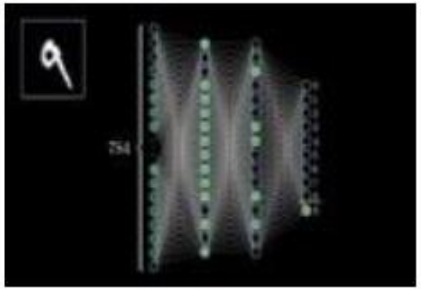
Object classification in deep learning tackles the task of identifying and labeling objects within an image. It essentially uses powerful algorithms to figure out what's ina picture and categorize those things.



Digit Recognition

Digit recognition in deep learning tackles the challenge of training computers to identify handwritten digits (0-9) within images.





Common terminologies used with data

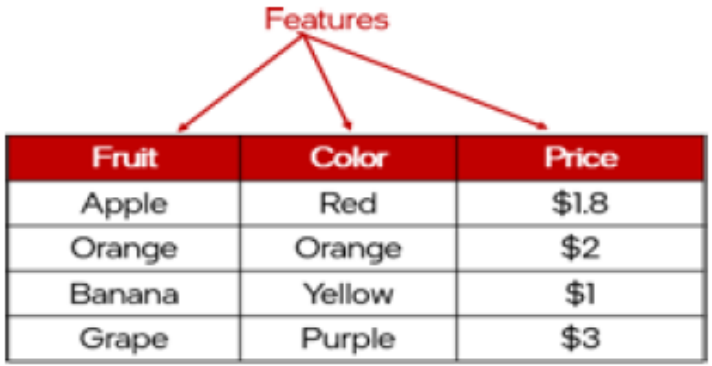
What is Data?

- Data is information in any form
- For e.g. A table with information about fruits is data
- Each row will contain information about different fruits
- Each fruit is described by certain features

Fruit	Color	Price
Apple	Red	$1.8
Orange	Orange	$2
Banana	Yellow	$1
Grape	Purple	$3

What do you mean by Features?

- Columns of the tables are called features
- In the fruit dataset example, features may be name, color, size, etc.
- Some features are special, they are called labels



Common terminologies used with data

What are Labels?

Data Labeling is the process of attaching meaning to data

- It depends on the context of the problem we are trying to solve
- For e.g. if we are trying to predict what fruit it is based on the color of the fruit, then color is the feature, and fruit name is the label.
- Data can be of two types – Labeled and Unlabeled

Label Feature

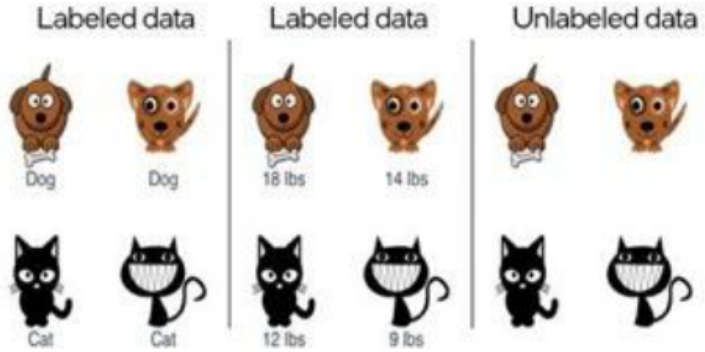
Fruit	Color	Price
Apple	Red	$1.8
Orange	Orange	$2
Banana	Yellow	$1
Grape	Purple	$3

Labeled Data

- Data to which some tag/label is attached.
- For e.g. Name, type, number, etc.

Unlabeled Data

- The raw form of data
- Data to which no tag is attached.



Common terminologies used with data

Training data set :

- The training data set is a collection of examples given to the model to analyze and learn.
- Just like how a teacher teaches a topic to the class through a lot of examples and illustrations.
- Similarly, a set of labeled data is used to train the AI model.

Testing data set :

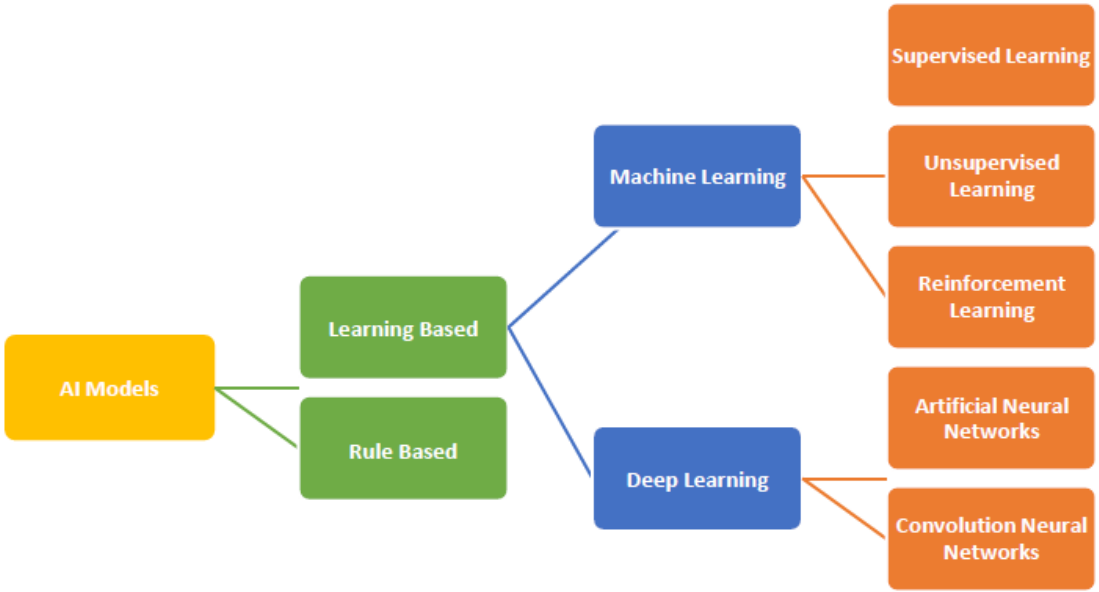
- The testing data set is used to test the accuracy of the model.
- Just like how a teacher takes a class test related to a topic to evaluate the understanding level of students.
- Test is performed without labeled data and then verify results with labels.

Modelling

AI Modelling refers to developing algorithms, also called models which can be trained to get intelligent outputs. That is, writing codes to make a machine artificially intelligent.

Types of AI Models

Generally, AI models can be classified as follows:



Rule Based Approach

Rule Based Approach refers to the AI modelling where the relationship or patterns in data are defined by the developer. The machine follows the rules or instructions mentioned by the developer, and performs its task accordingly.

Rule-based Chatbots are commonly used on websites to answer frequently asked questions (FAQs) or provide basic customer support.

A drawback/feature for this approach is that the learning is static. The machine once trained, does not take into consideration any changes made in the original training dataset. That is, if you try testing the machine on a dataset which is different from the rules and data you fed it at the training stage, the machine will fail and will not learn from its mistake.

Rule Based Approach

Scenario: A clothing website has a Chabot to answer questions about order tracking.

- **Data:** The Chabot doesn't require a massive dataset for training. It relies on a predefined set of questions and corresponding answers.
- **Rules:** The Chabot uses a decision tree approach with clearly defined rules to understand user queries and provide responses. Here's a simplified example:

Rule 1: If the user's message contains keywords like "track order," "shipment status," or "delivery," proceed to order tracking options.

- **Rule 2:** Under order tracking options: ✦ If the user asks for their order number, prompt them to enter it.
  If the user enters a valid order number, retrieve the tracking information from the database and display it.
  If the user enters an invalid order number, provide an error message and ask them to re-enter it.

- **Rule 3:** If the user's message doesn't match any defined rules, offer a message like "Sorry, I can't help you with that. Perhaps you can try searching our FAQs or contact customer support."

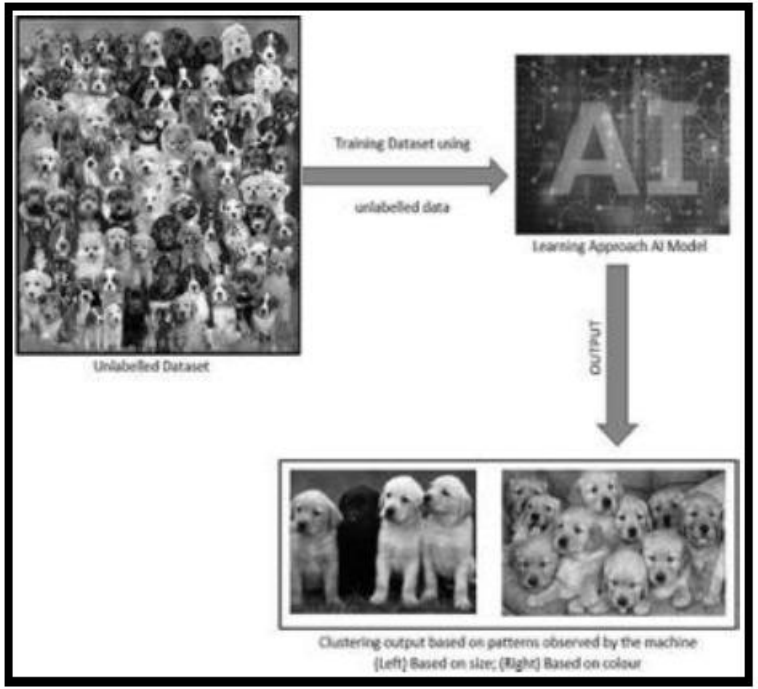
- **Interaction:** When a user chats with the bot, their message is analyzed based on the defined rules. The Chabot responds with a pre-written answer or prompts the user for additional information depending on the scenario.

Learning Based Approach

A learning-based approach is a method where a computer learns how to do something by looking at examples or getting feedback, similar to how we learn from experience. Instead of being explicitly programmed for a task, the computer learns to perform it by analyzing data and finding patterns or rules on its own.

Revisiting AI, ML, DL

For example, suppose you have a dataset of 1000 images of random stray dogs of your area. Now you do not have any clue as to what trend is being followed in this dataset as you don't know their breed, or colour or any other feature. Thus, you would put this into a learning approach-based AI machine and the machine would come up with various patterns it has observed in the features of these 1000 images. It might cluster the data on the basis of colour, size, fur style, etc. It might also come up with some very unusual clustering algorithm which you might not have even thought of!



Learning Based AI Model

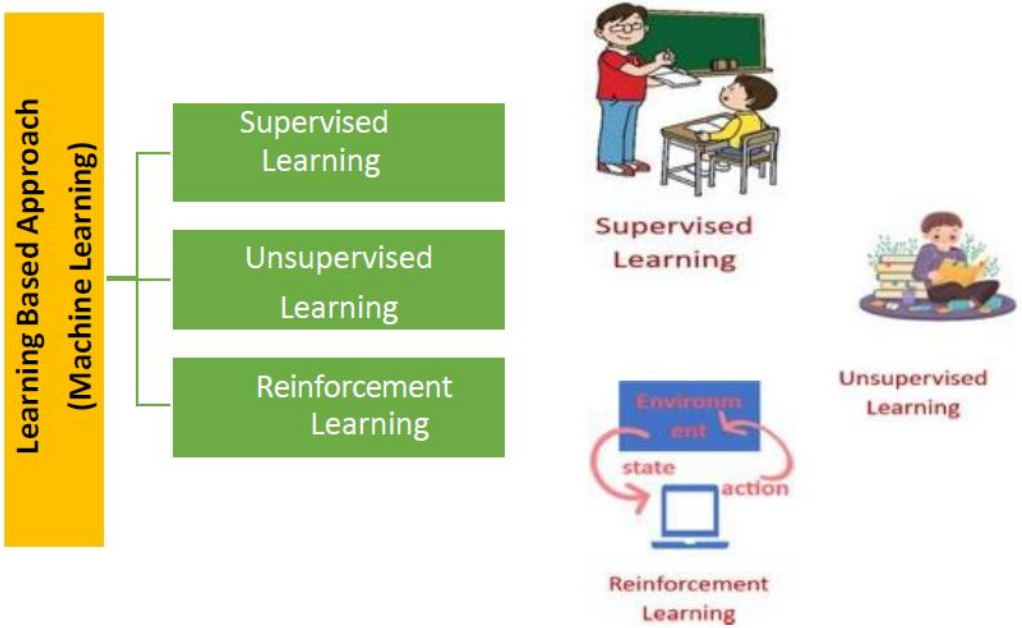
Learning Based Approach

- It refers to the AI modelling where the machine learns by itself. Under the Learning Based approach, the AI model gets trained on the data fed to it and then is able to design a model which is adaptive to the change in data.
- That is, if the model is trained with X type of data and the machine designs the algorithm around it, the model would modify itself according to the changes which occur in the data so that all the exceptions are handled in this case.
- For example, A learning-based spam email filter is a computer program that automatically identifies whether an incoming email is spam or not. Instead of being explicitly programmed with rules for identifying spam, the filter learns from examples of labeled emails during a training phase.

Learning Based Approach

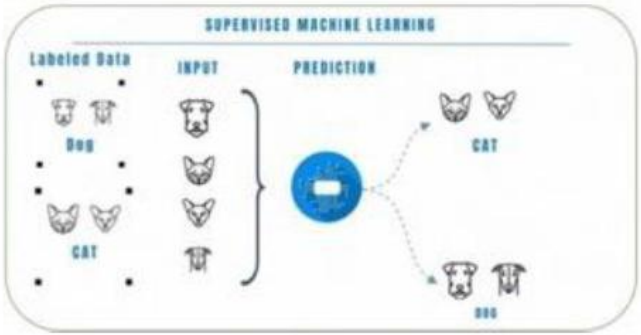
Categories of Machine learning based models

Learning-based approaches are indeed a broad category that encompass both machine learning and deep learning. Machine learning can further be divided into three parts:



Learning Based Approach

- **Supervised Learning**
- In a supervised learning model, the dataset which is fed to the machine is labelled. In other words, we can say that the dataset is known to the person who is training the machine only then he/she is able to label the data. A label is some information which can be used as a tag for data. For example, students get grades according to the marks they secure in examinations. These grades are labels which categorize the students according to their marks.



- Supervised Learning indicates having a supervisor as a teacher

For e.g. A math teacher teaches the class by making the students learn using a lot of solved examples(training) and then test the knowledge gained by giving the class, problems to solve on their own.

Learning Based Approach

- **Supervised Learning – Example**

Let's consider the example of currency coins.

Problem Statement: Build a model to predict the coin based on its weight.

Assume that we have different currency coins (dataset) having different weights.

1 Euro weighs 5 grams

1 Dirham weighs 7 grams

1 Dollar weighs 3 grams

1 Rupee weighs 4 grams and so on

Feature – Weights

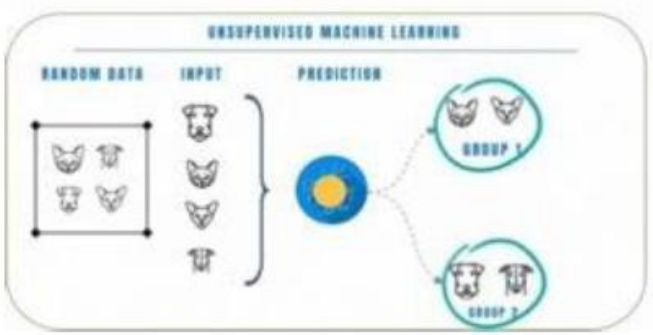
Label – Currency

So, if a model is trained in tagging the features i.e., the weights of the coin with the targets i.e., currency, the trained model can be further be used to identify a coin based on its weight (since it has already learnt).

Learning Based Approach

Unsupervised Learning

An unsupervised learning model works on unlabelled dataset. This means that the data which is fed to the machine is random and there is a possibility that the person who is training the model does not have any information regarding it. The unsupervised learning models are used to identify relationships, patterns and trends out of the data which is fed into it. It helps the user in understanding what the data is about and what are the major features identified by the machine in it.



Learning Based Approach

Unsupervised Learning

For example, you have a random data of 1000 dog images and you wish to understand some pattern out of it, you would feed this data into the unsupervised learning model and would train the machine on it. After training, the machine would come up with patterns which it was able to identify out of it. The Machine might come up with patterns which are already known to the user like colour or it might even come up with something very unusual like the size of the dogs.

- Unsupervised Learning is a type of learning without any guidance
- For e.g. A child learning to swim on his own without any supervision. Here, the child is the model trying to discover ways and techniques to swim and the swimming pool is similar to the unknown data fed to the model.
- Here, the machine is responsible to discover patterns, similarities, and differences on its own based on the unlabeled dataset.

Learning Based Approach

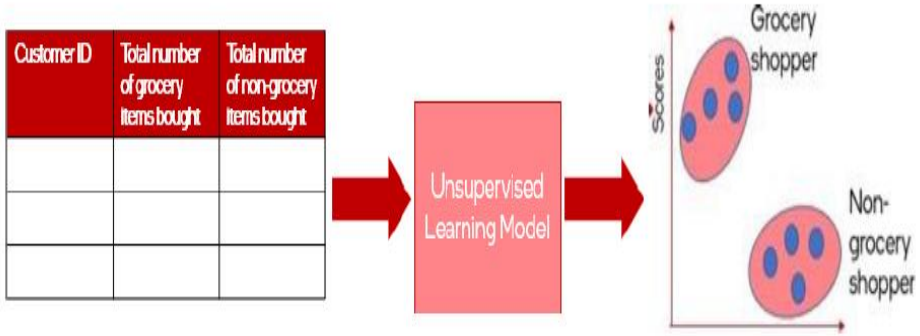
Unsupervised Learning - Example

Let’s consider the example of a supermarket

Assume that we have a customer database with records of their products bought over a period.

Now you being the marketing manager decides to send a grocery offer message to those customers who buys grocery regularly.

Note that there was no customer labeled as grocery shoppers and non-grocery shopper. Model could discover patterns on its own and could come up with these two clusters/groups.



Learning Based Approach

Identify the model: Supervised or Unsupervised?

Case 1: Social Media platforms identify your friend in a picture from an album of tagged photographs.

ANSWER: It is supervised learning. Here social media platform is using tagged photos to recognize the person. Therefore, the tagged photos become the labels of the pictures and we know that when the machine is learning from labeled data, it is supervised learning.

Case 2: OTT(over-the-top) platform Recommendations based on someone's watch history

ANSWER:It is unsupervised learning. This is what OTT platforms like Netflix, Pandora, and Spotify do all the time; they collect the songs/movies that you like already, evaluate the features based on your likes/dislikes and then recommend new movies/songs based on similar features.

Case 3: Analyze bank data for suspicious-looking transactions and flag the fraud transactions [Note that suspicious transactions are not defined in this case]

ANSWER: It is unsupervised learning. In this case, the suspicious transactions are not defined, hence there are no labels of "fraud" and "not fraud". The model tries to identify outliers by looking at anomalous transactions and flags them as 'fraud'.

Learning Based Approach

Supervised Vs. Unsupervised Learning

Supervised Learning	Unsupervised Learning
▪ Deals with labelled data	▪ Deals with unlabelled data
▪ Useful in real-world problems-like predicting the prices of an item something based on past trends.	▪ Useful in finding unknown patterns within data-like making sense of a large number of observations from an experimental device.
▪ Computing power required is simpler as clean labelled data is used as input.	▪ The computing power required is more complex as unsorted and messy data is used as input.

Learning Based Approach

Reinforcement Learning

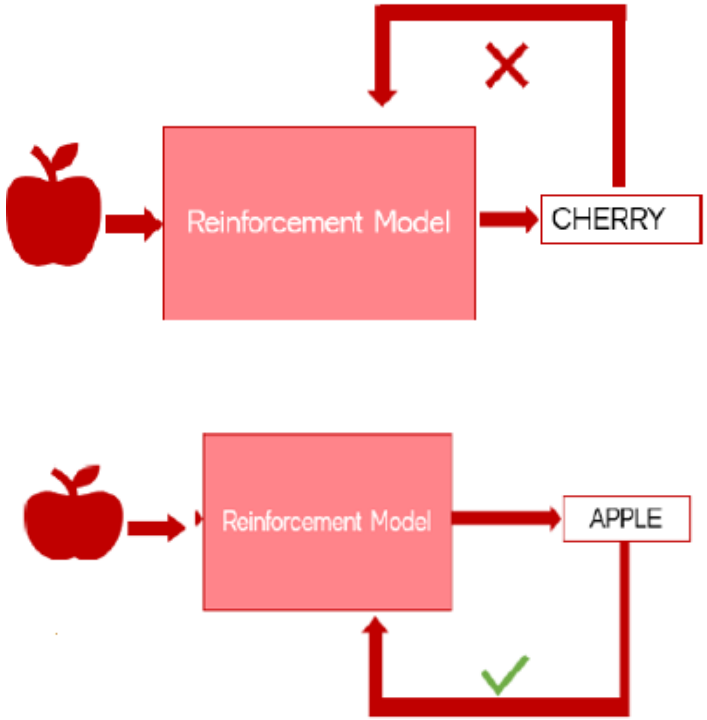
This learning approach enables the computer to make a series of decisions that maximize a reward metric for the task without human intervention and without being explicitly programmed to achieve the task.

Reinforcement Learning – Example

Reinforcement learning is a type of learning in which a machine learns to perform a task through a repeated trial-and-error method.

Let's say you provide an image of an apple to the machine and ask the machine to predict it-

The machine first predicts it as 'cherry' and you give negative feedback that it's incorrect. Now, the machine learns that it's not a cherry. Then again, you ask the machine to predict the fruit by giving an image of an apple as input; Now, it knows it is not a cherry. It predicts it as an apple and you give positive feedback that it's correct. So, now the machine learns that this is an apple.



Learning Based Approach

What makes it different?

- For supervised learning and unsupervised learning, you need to have a pretty good idea of the data that you have, what's going on, and how to solve the problem.
- However, you will frequently encounter situations where you have to deal with large complex problem spaces.
- You may need to respond to unforeseen environments, and you don't have sufficient data on those specific scenarios.
- The environment may change. Hence your system needs to be adaptive. Reinforcement Learning will be important because it doesn't require a lot of pre- existing knowledge or data to provide useful solutions.

Examples of Reinforcement Learning

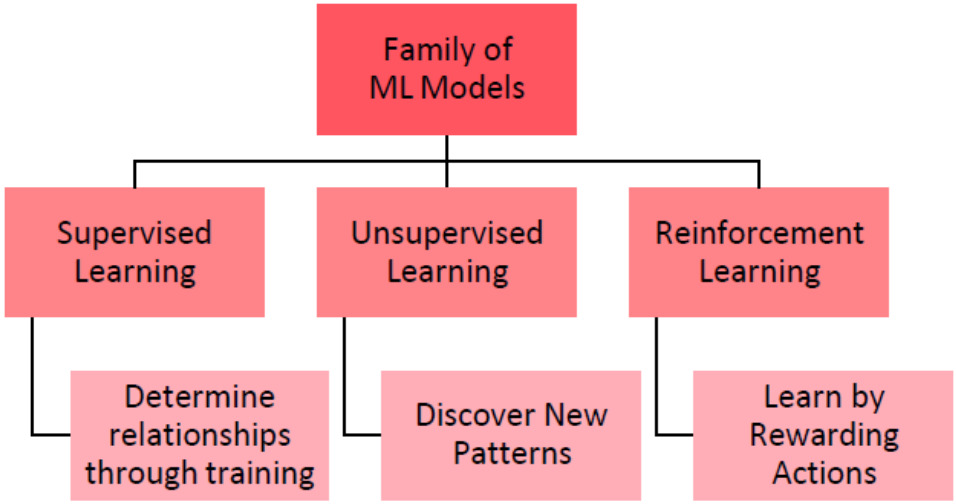
Parking a car

Humanoid walking

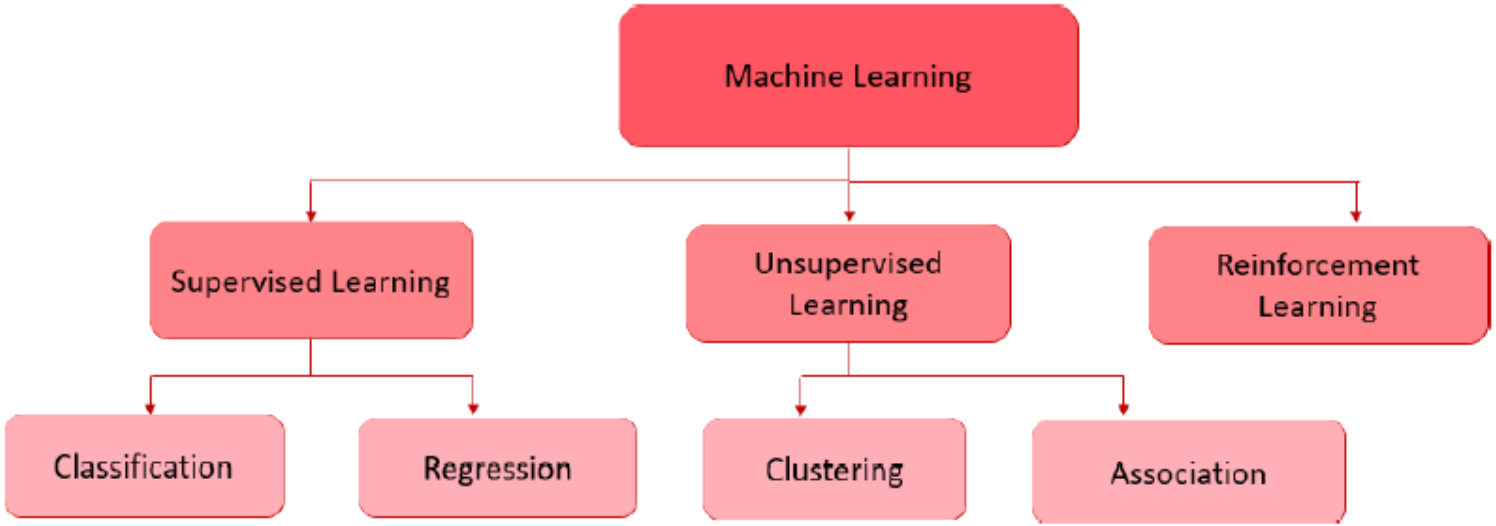
Learning Based Approach

Summary of ML Models

- Supervised learning models are used when we want to determine relationshi through training.
- Unsupervised learning models are used when we want to discover new patterns from data.
- Reinforcement learning models are used when we want to implement machine learning through a reward mechanism.



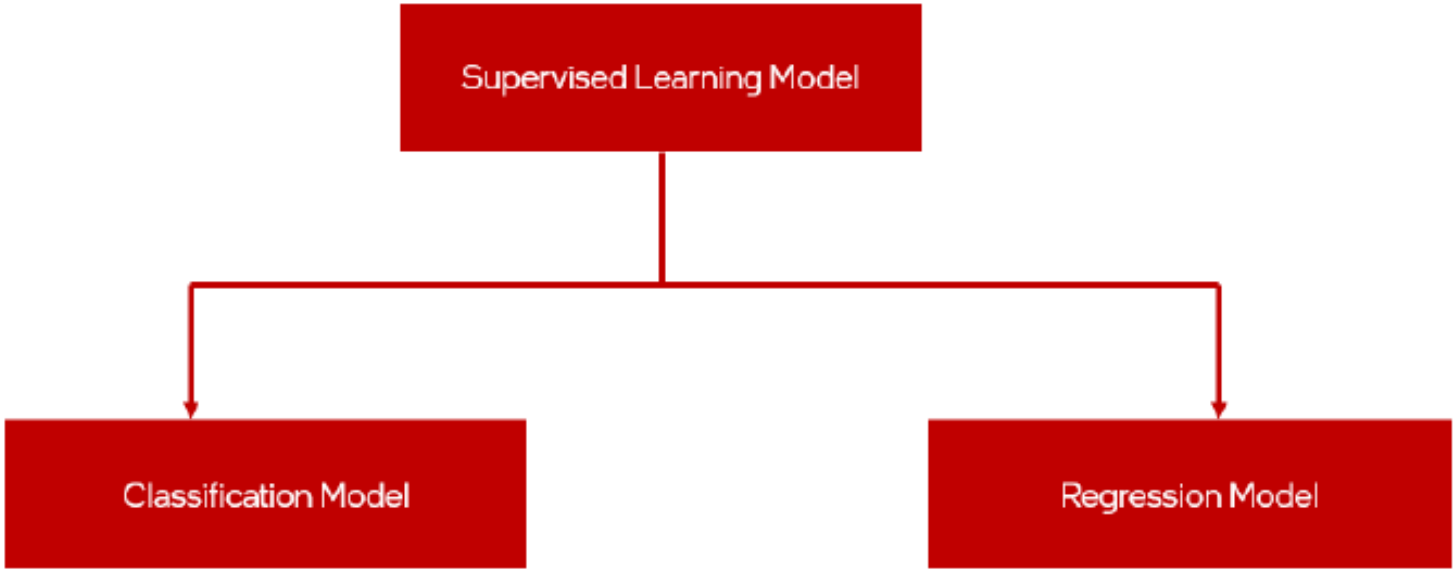
Summary of detailed classification of ML models



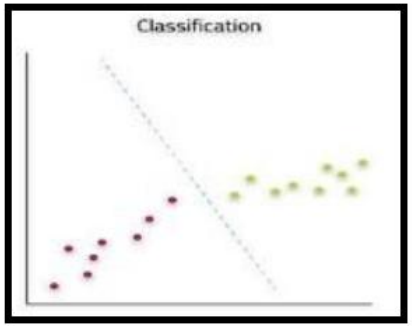
Learning Based Approach

Sub-categories of Supervised Learning Model

There are two types of Supervised Learning models: Classification model and Regression model.



Sub-categories of Supervised Learning Model

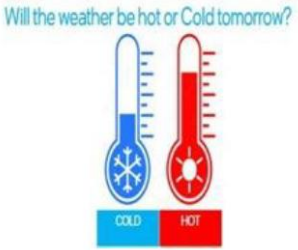


Classification Model

Here the data is classified according to the labels. For example, in the grading system, students are classified on the basis of the grades they obtain with respect to their marks in the examination. This model works on discrete dataset which means the data need not be continuous.

Examples of the Classification Model

- In this case, the model would be trained on historical weather data that includes temperature information labeled as "hot" or "cold". The model would learn the patterns that differentiate hot and cold weather based on
- factors like:
- Location (average temperatures vary geographically)
- Season (summer vs. winter)
- High and low temperatures
- Humidity

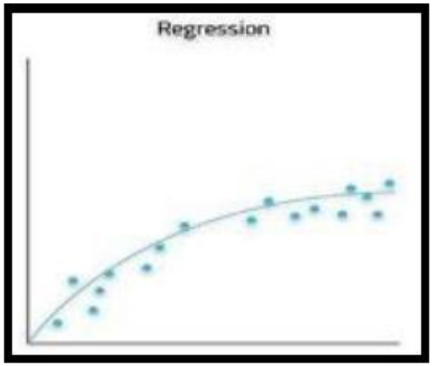


When presented with weather data for tomorrow, the trained classification model would analyse these factors and predict the most likely category - "hot" or "cold" weather tomorrow.

Examples of the Classification Model

Classifying emails as spam or not:
The model is shown tons of emails, both real ones (like from friends or colleagues) and spam. The model learns what makes an emai look like spam. Once trained, the model sees new email. It analyses the clues in the email and decides: is this spam or not? It assigns a category - "spam" or "not spam" - just like sorting your mail.

Sub-categories of Supervised Learning Model



Regression Model

Regression: Such models work on continuous data. For example, if you wish to predict your next salary, then you would put in the data of your previous salary, any increments, etc., and would train the model. Here, the data which has been fed to the machine is continuous.

Regression algorithms predict a continuous value based on the input variables.

Continuous values as Temperature, Price, Income, Age, etc.

Example 1: Predicting temperature

Temperature is a continuous variable, meaning it can take on any value within a range. Regression models are well-suited for predicting continuous outputs.

Example 2: Predicting the price of the house

Predicting the price of the house based on some parameters:

- No of bedrooms
- Carpet Size
- Garage Area
- Price

In the House Price Prediction Problem, we are trying to predict the price (dependent variable) based on certain parameters like the number of bedrooms, carpet size, and garage area (independent variables).

Example 3: Used Car Price Prediction

This model predicts the selling price of the car with the help of a few parameters like

- fuel type
- years of service,
- the number of previous owners,
- kilometres driven,
- transmission type (manual/automatic)

This type of model will be of type regression since it will predict an approximate price (continuous value) of the car based on the training dataset.

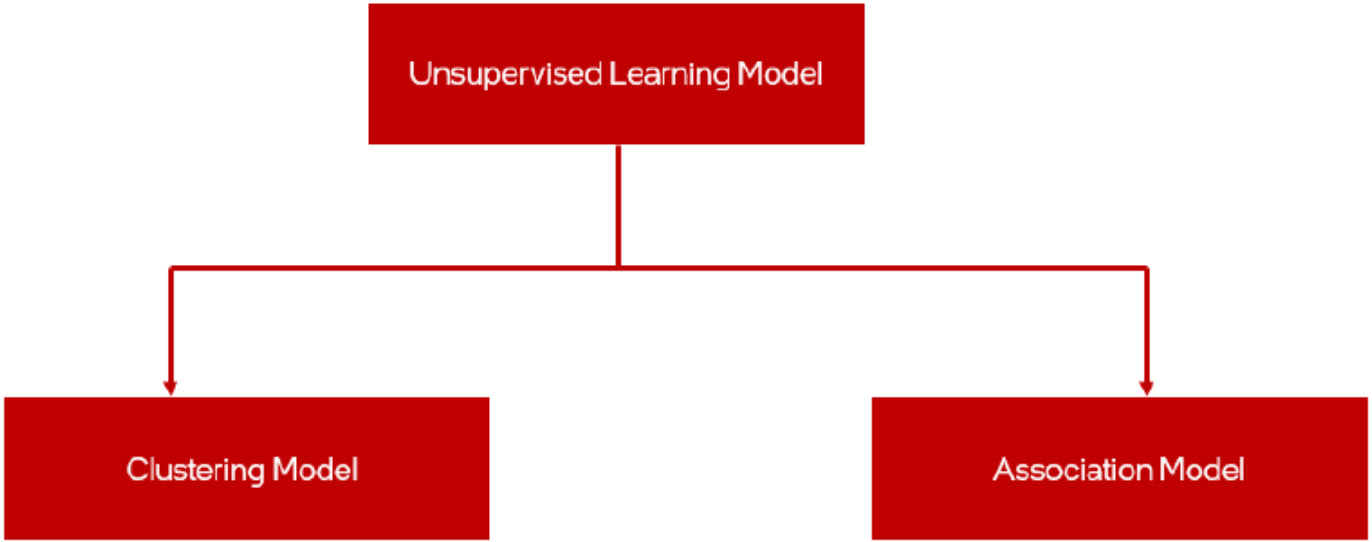
Identify the model: Classification or Regression?

Case 1: Predicting whether a customer is eligible for a bank loan or not?
It is Classification. Binary Classification; since the model is going to predict whether or not the customer is eligible for a loan- The output will be either yes or no (discrete values)

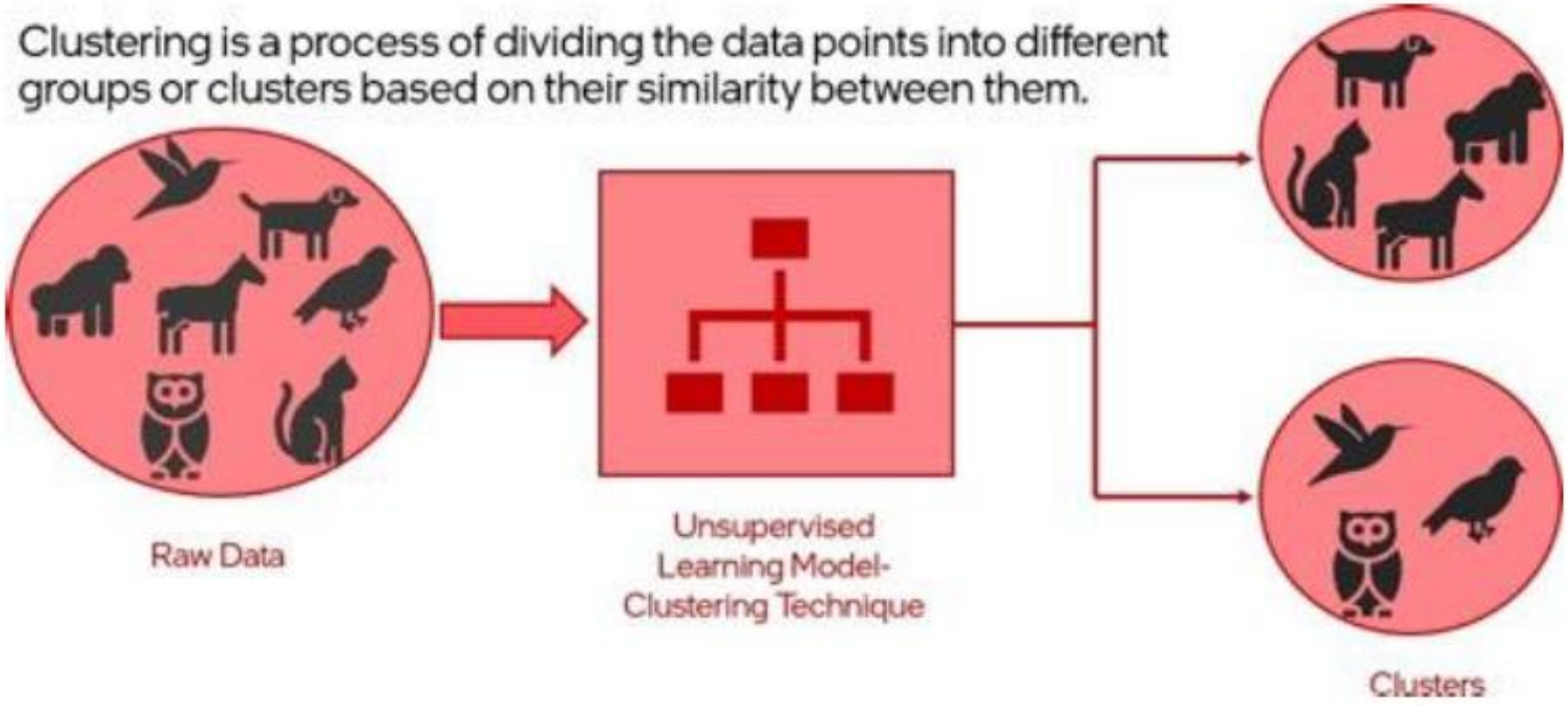
Case 2: Predicting weather for next 24 hours
It is Regression because predicting weather for next 24 hours will be a continuous range (it will keep changing over the period of 24 hours)

Sub-categories of Unsupervised Learning Model

Unsupervised learning models can be further divided into two categories: Clustering model and Association model.



What is Clustering?



Difference between Clustering and Classification

- Classification uses predefined classes in which objects are assigned.
- Clustering finds similarities between objects and places them in the same cluster and it differentiates them from objects in other clusters.

Clustering – Example

Jim enjoys listening to music. Jim likes to listen to music having slow tempo and soft intensity whereas he dislikes songs having fast tempo and high intensity.

We have grouped all the songs having slow tempo and soft intensity into 1 cluster that he likes

While, songs with a fast tempo and high intensity into another cluster

Now if he listens to a new song X with a slow tempo and soft intensity. Could you predict will he like the song X or not?

Sub-categories of Unsupervised Learning Model

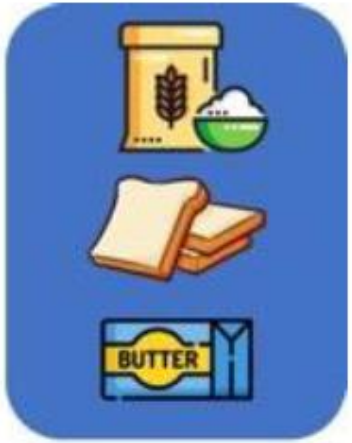
Association

Association Rule is an unsupervised learning method that is used to find interesting relationships between variables from the database.

Consider a supermarket example wherein

- Customer A buys bread, butter, and milk
- Customer B buys rice, bread, and butter

Customer A



Customer B

Sub-categories of Unsupervised Learning Model

Association

Based on the purchase pattern of customers A and B, can you predict any Customer X who buys bread will most probably buy?

Customer A

Customer B

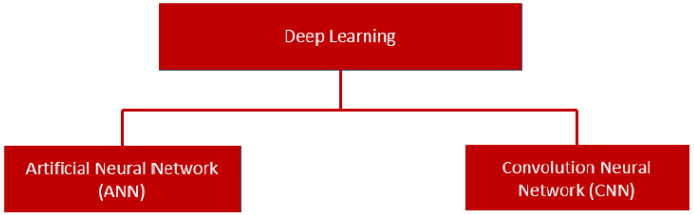
Customer X

Based on the purchase pattern of other customers, we can predict that there is high probability that any customer x who buys bread will most probably buy butter.
Therefore, such meaningful associations can be useful to recommend items to customers.
This is called Association Rule.

Sub-Categories of Deep Learning

Deep Learning enables software to train itself to perform tasks with vast amounts of data. In deep learning, the machine is trained with huge amounts of data which helps it to train itself around the data.

There are two types of Deep Learning models:
Artificial Neural Networks (ANN)
Convolution Neural Network (CNN).



Artificial Neural networks (ANN) - Artificial Neural networks are modelled on the human brain and nervous system. They are able to automatically extract features without input from the programmer. Every neural network node is essentially a machine learning algorithm. It is useful when solving problems for which the data set is very large.

Convolutional Neural Network (CNN) - Convolutional Neural Network is a Deep Learning algorithm which can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image and be able to differentiate one from the other.

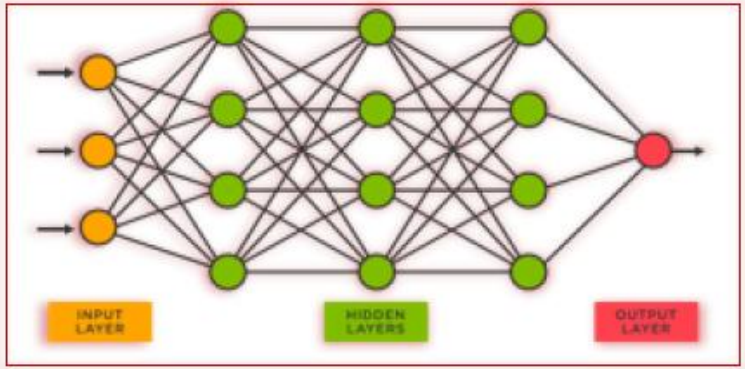
Artificial Neural Networks

What is Neural Network?

Neural networks are loosely modelled after how neurons in the human brain behave. The key advantage of neural networks is that they are able to extract data features automatically without needing the input of the programmer.

A neural network is essentially a system of organizing machine learning algorithms to perform certain tasks.

It is a fast and efficient way to solve problems for which the dataset is very large, such as in images.



Artificial Neural Networks

This is a representation of how neural networks work:

- A Neural Network is divided into multiple layers and each layer is further divided into several blocks called nodes. Each node has its own task to accomplish which is then passed to the next layer.
- Neural Network consists of an input layer, hidden layer which performs computation using weights and biases on each node and finally, information is passed through these layers to reach the output layer.
- The first layer of a Neural Network is known as the input layer. The job of an input layer is to acquire data and feed it to the Neural Network. No processing occurs at the input layer.
- Next to it, are the hidden layers. Hidden layers are the layers in which the whole processing occurs. Their name essentially means that these layers are hidden and are not visible to the user. Each node of these hidden layers has its own machine learning algorithm which it executes on the data received from the input layer.
- The hidden layer performs computation by means of weights and biases Information passes from one layer to the other after the value found from this calculation passed through a selected activation function.
- The process of finding the right output begins with trial and error until the network finally learns.
- With each try, the weights are adjusted based on the error found between the desired output and the network output.

How does AI make a Decision?

Let's say you want to go out to the park today. What would be your thought process? What would you consider?

Most of us would want to avoid getting soaked in the rain. These are possible factors that may influence your decision whether to go out. So, the first question that you may ask is, “Should I bring a rain jacket?”

Then, you may also ask, “Should I bring an umbrella?” Or you may also ask, “What is the weather now?”
And finally, “What will the weather be like, later in the day?”

Do I have a jacket?

Do I have an umbrella?

Is it raining now?

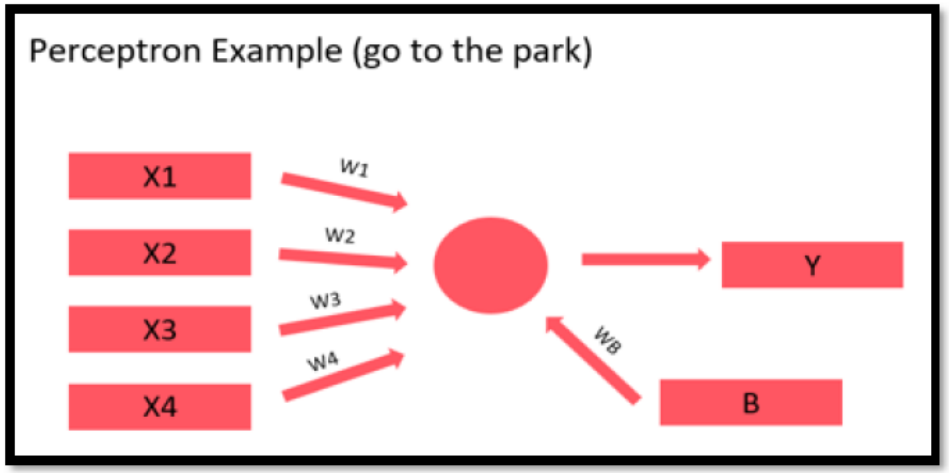
What is the weather forecast for later?

Now let us convert this to perceptron.

Going back to the earlier example, we have four inputs. So, let's draw the perceptron with four inputs (from X1 to X4).

Next, we have their weights (from W1 to W3). Then, we also have the bias B, with weight WB.

Finally, we sum them all up, compare with threshold, and we will get our output.

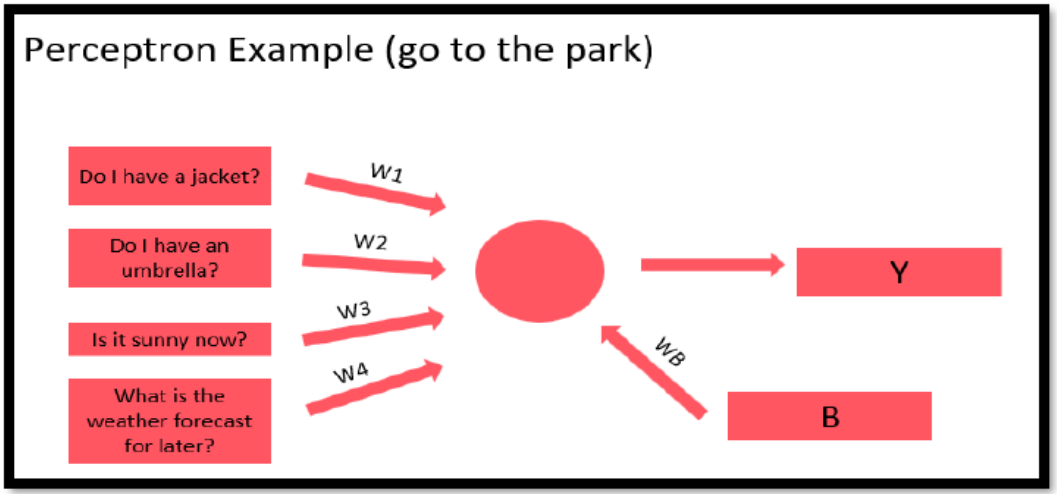


Now we will fill in the four inputs with the factors that we have listed out.

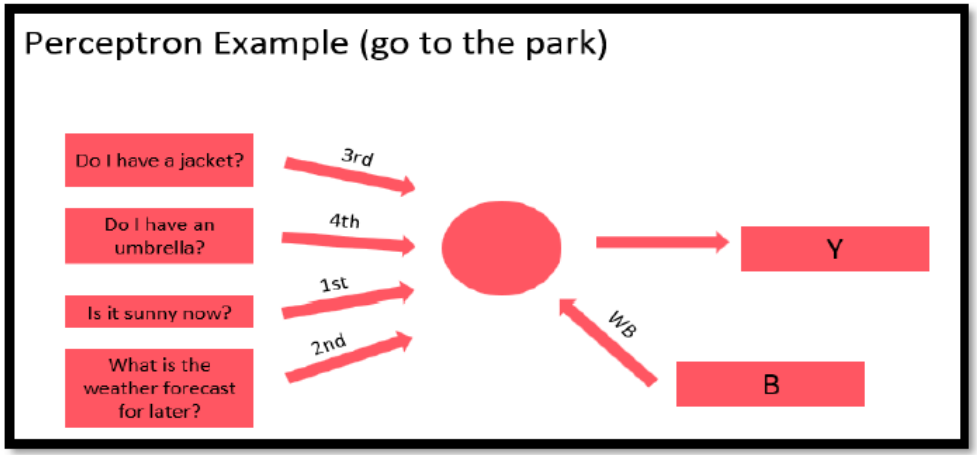
- Do I have a jacket?
- Do I have umbrella?
- Is it sunny now?
- What is the weather forecast for later?

Now we will fill in the importance. But the importance is not very useful in mathematical calculations.
Next, let us assign some numbers to them. At the same time, we will also assign a number for the bias weight (WB).

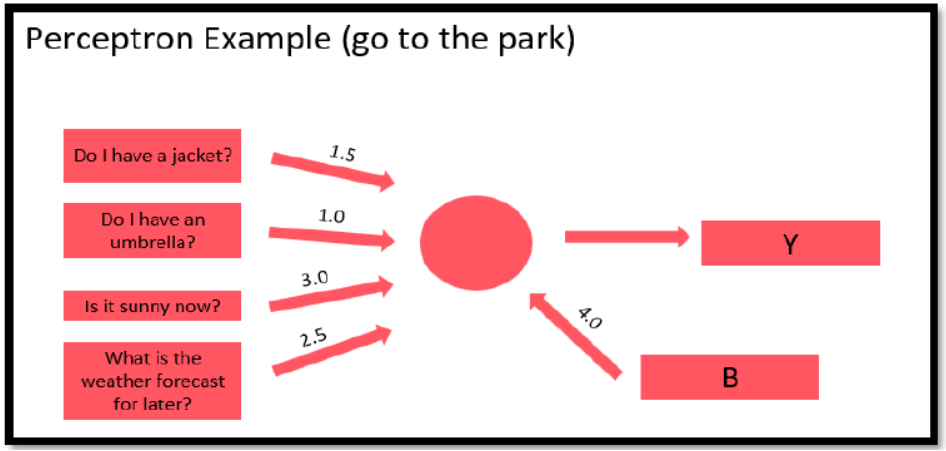
How do we know what should be the actual values for the weights? We will not know what are the actual weights. However, we can make some assumptions.



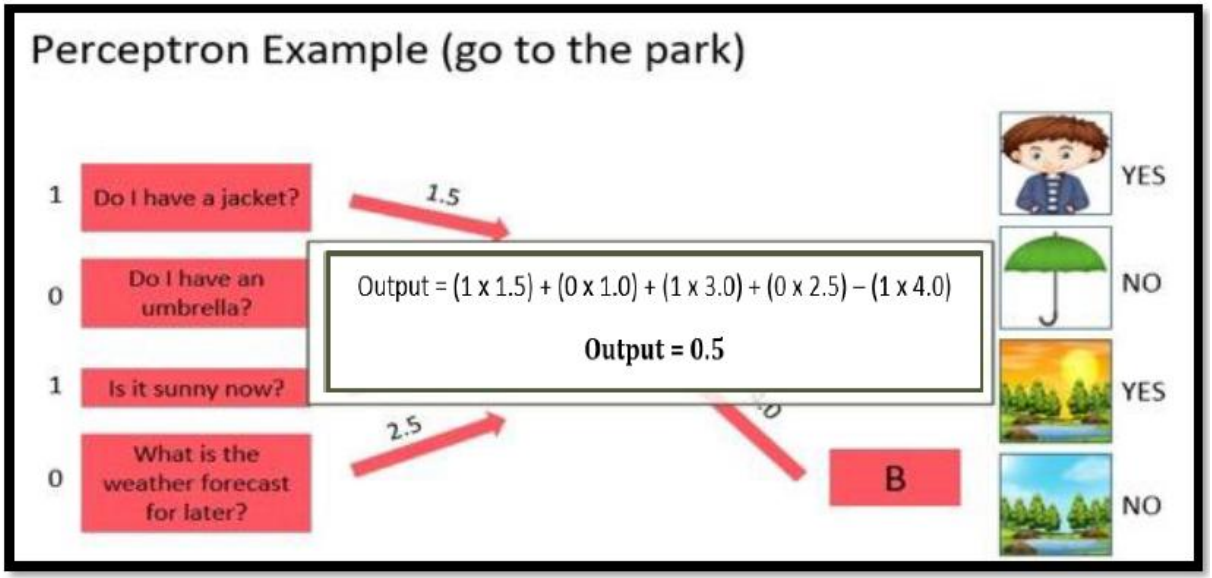
The values for the weights can come from experience. He may have an experience being sunny now would most likely mean a bright day ahead, hence the high importance there. It can also come from personal preference. A person may judge a particular factor more heavily as compared to another person. For example, she may be more concerned with the weather forecast, hence the higher importance there. The values for WB are also based on personal preference. If a person is more cautious, he may set the value for WB to be higher, hence his decision would gear towards staying indoors unless he is sure that it would not rain. On another hand, a person who is more daring will have a lower WB, hence he is more likely to go out regardless of the current situation. In this example, we choose 4 as we want to be more cautious.



Therefore, there is no right or wrong answers in coming up with the values for the weights. However, the effects of the values will determine the outcome that the person is going to take, whether to go out or not. That is the reason why everyone comes up with a different decision, even though the situation is the same for everyone.



From this calculation, the output is 0.5. Since this is higher than the threshold (which is zero), the result is I will go out to the park.



From this calculation, the output is -0.5. Since this is lower than the threshold (which is zero), the result is I will not go out to the park.