A3CET302 - Artificial Intelligence Tools, Techniques and Applications

Unit-4

DEEP LEARNING MODEL

Department of Civil Engineering
MVGR College of Engineering(A)

Contents

- Introduction to Neural Networks.
- Training Neural Networks.
- Multilayer Perceptron and Back Propagation.
- Support Vector Machines.

Introduction to Neural Networks

- Machine Learning and Deep Learning are the two main concepts of Data Science and the subsets of Artificial Intelligence.
- Most of the people think the machine learning, deep learning, and as well as artificial intelligence as the same. But in actuality, all these terms are different but related to each other.

Introduction to Neural Networks

What is Machine Learning?

- Machine learning is a part of artificial intelligence and growing technology that enables machines to learn from past data and perform a given task automatically.
- The popular applications of ML are Email spam filtering, product recommendations, online fraud detection, etc.

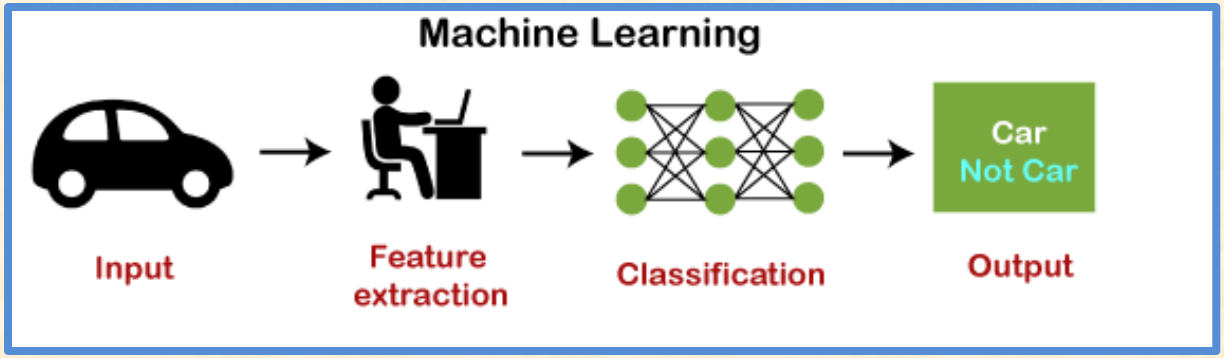
Some useful ML algorithms are:

- Decision Tree algorithm
- Naïve Bayes
- Random Forest
- K-means clustering
- KNN algorithm
- Apriori Algorithm, etc.

Introduction to Neural Networks

How does Machine Learning work?

- The working of machine learning models can be understood by the example of identifying the image of a cat or dog.
- To identify this, the ML model takes images of both cat and dog as input, **extracts** the **different features** of images such as **shape, height, nose, eyes, etc.,** applies the classification algorithm, and **predict** the **output.**
- Consider the below image:



Introduction to Neural Networks

What is Deep Learning?

- Deep Learning is the subset of machine learning or can be said as a special kind of machine learning.
- It works technically in the same way as machine learning does, but with different capabilities and approaches.
- It is inspired by the **functionality** of **human brain cells**, which are called **neurons**, and leads to the concept of artificial neural networks.
- It is also called a **deep neural network** or **deep neural learning.**
- In deep learning, models use different layers to learn and discover insights from the data.

Introduction to Neural Networks

What is Deep Learning?

- Some popular applications of deep learning are self-driving cars, language translation, natural language processing, etc.

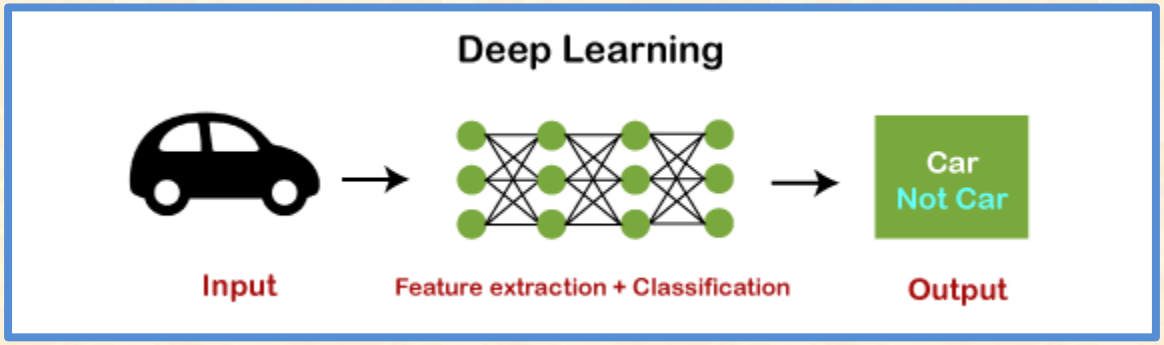
Some popular deep learning algorithms are:

- Convolutional Neural Network
- Recurrent Neural Network
- Autoencoders
- Classic Neural Networks, etc.

Introduction to Neural Networks

How Deep Learning Works?

- We can understand the working of deep learning with the same example of identifying cat vs. dog.
- The deep learning model takes the images as the input and feed it directly to the algorithms without requiring any manual feature extraction step.
- The images pass to the different layers of the artificial neural network and predict the final output.
- Consider the below image:



Introduction to Neural Networks

How Deep Learning Works?

- Deep learning is based on the branch of machine learning, which is a subset of artificial intelligence.
- Since neural networks imitate the human brain and so deep learning will do.
- In deep learning, nothing is programmed explicitly.
- Basically, it is a machine learning class that makes use of numerous nonlinear processing units so as to perform feature extraction as well as transformation.
- The output from each preceding layer is taken as input by each one of the successive layers.

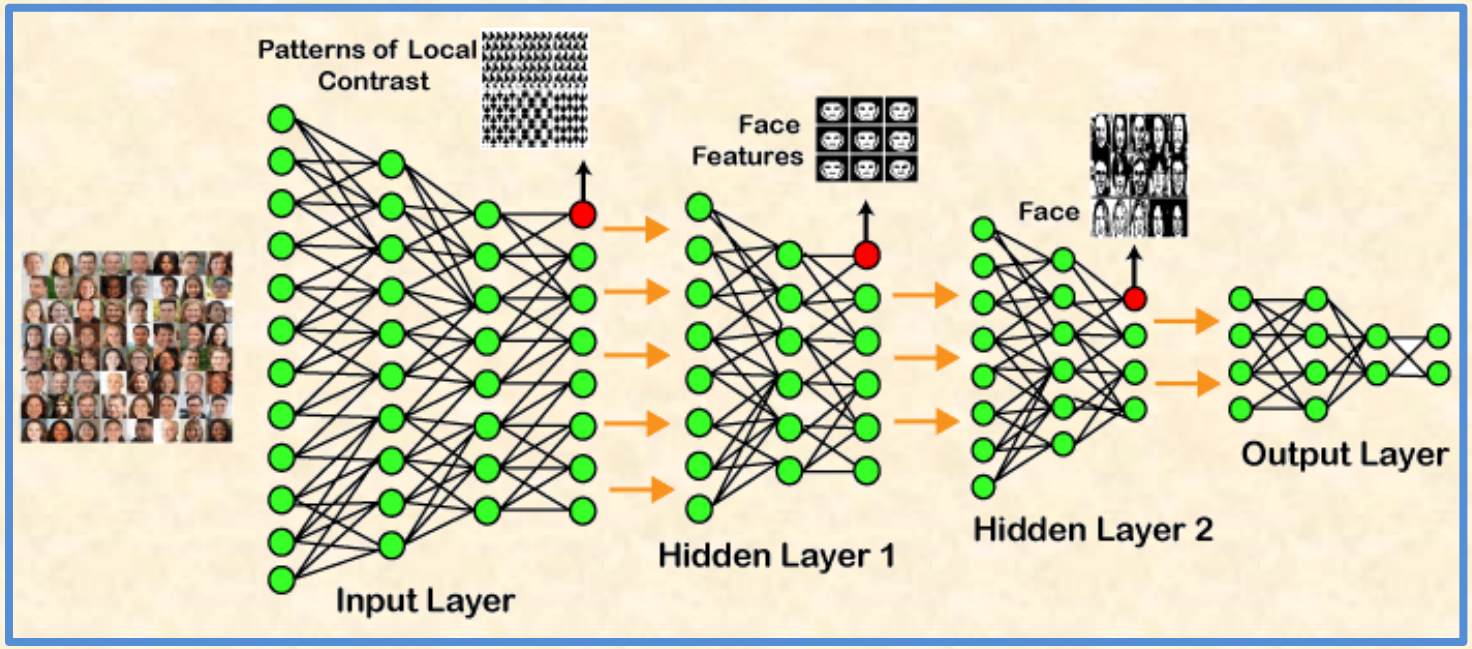
Introduction to Neural Networks

How Deep Learning Works?

- Deep learning models are capable enough to focus on the accurate features themselves by requiring a little guidance from the programmer and are very helpful in solving out the problem of dimensionality.
- Deep learning algorithms are used, especially when we have a huge no of inputs and outputs.
- Since deep learning has been evolved by the machine learning, which itself is a subset of artificial intelligence and as the idea behind the artificial intelligence is to mimic the human behavior, so same is ***"the idea of deep learning to build such algorithm that can mimic the brain"***.

Introduction to Neural Networks

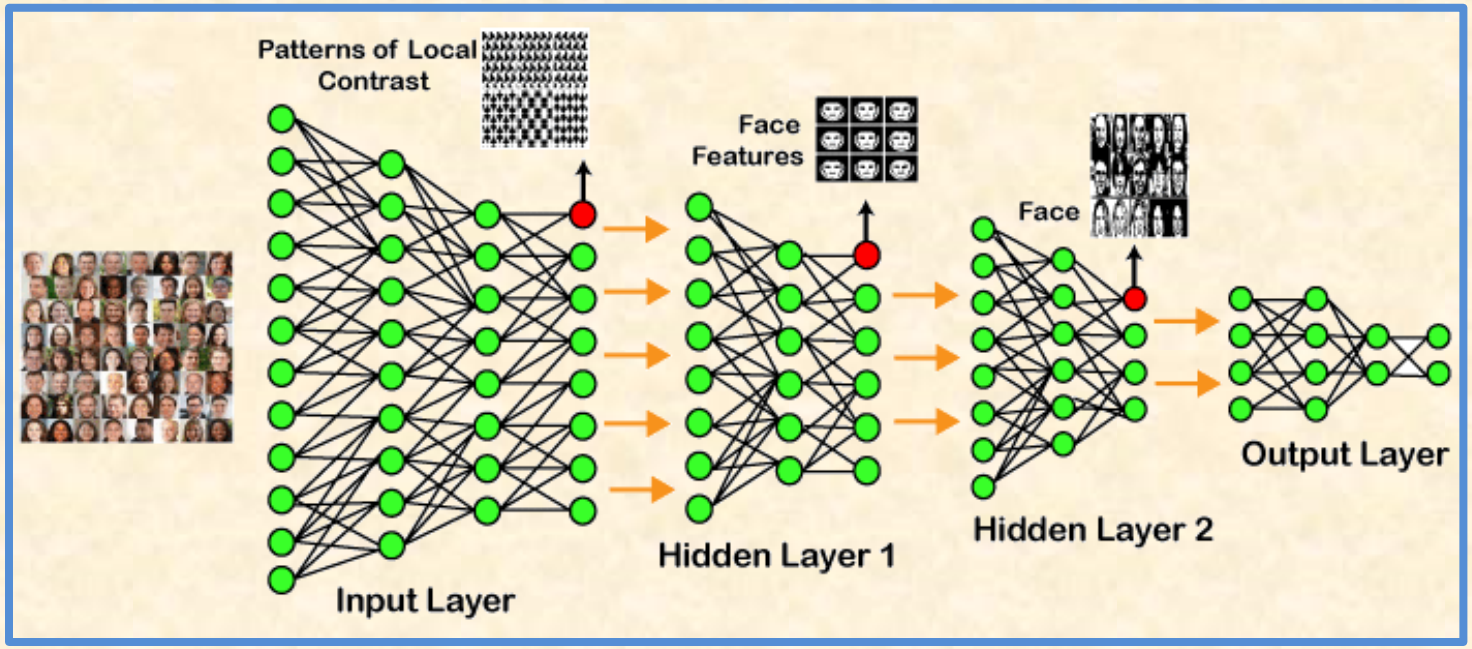
How Deep Learning Works?



- In the example given above, we provide the raw data of images to the first layer of the input layer.
- After then, these input layer will determine the patterns of local contrast that means it will differentiate on the basis of colors, luminosity, etc.
- Then the 1st hidden layer will determine the face feature, i.e., it will fixate on eyes, nose, and lips, etc.
- And then, it will fixate those face features on the correct face template.

Introduction to Neural Networks

How Deep Learning Works?



- So, in the 2nd hidden layer, it will actually determine the correct face here as it can be seen in the above image, after which it will be sent to the output layer.
- Likewise, more hidden layers can be added to solve more complex problems, for example, if you want to find out a particular kind of face having large or light complexions.
- So, as and when the hidden layers increase, we are able to solve complex problems.

Introduction to Neural Networks

Types of Deep Learning Networks

Introduction to Neural Networks

Deep learning applications

- **Self-Driving Cars**

In self-driven cars, it is able to capture the images around it by processing a huge amount of data, and then it will decide which actions should be incorporated to take a left or right or should it stop. So, accordingly, it will decide what actions it should take, which will further reduce the accidents that happen every year.

- **Voice Controlled Assistance**

When we talk about voice control assistance, then Siri is the one thing that comes into our mind. So, you can tell Siri whatever you want it to do it for you, and it will search it for you and display it for you.

Introduction to Neural Networks

Deep learning applications

- **Automatic Image Caption Generation**

Whatever image that you upload, the algorithm will work in such a way that it will generate caption accordingly. If you say blue colored eye, it will display a blue-colored eye with a caption at the bottom of the image.

- **Automatic Machine Translation**

With the help of automatic machine translation, we are able to convert one language into another with the help of deep learning.

Introduction to Neural Networks

Limitations

- It only learns through the observations.
- It comprises of biases issues.

Advantages

- It lessens the need for feature engineering.
- It eradicates all those costs that are needless.
- It easily identifies difficult defects.
- It results in the best-in-class performance on problems.

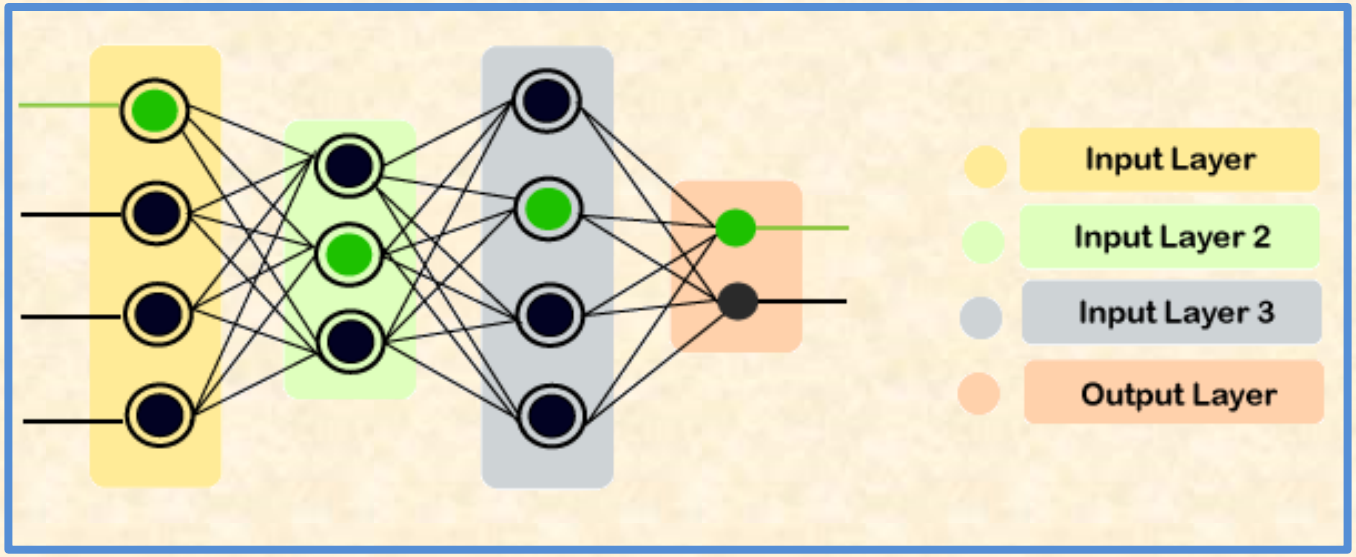
Disadvantages

- It requires an ample amount of data.
- It is quite expensive to train.
- It does not have strong theoretical groundwork.

Introduction to Neural Networks

"Artificial Neural Network is biologically inspired by the neural network, which constitutes after the human brain."

- Neural networks are modeled in accordance with the human brain so as to imitate their functionality.
- The human brain can be defined as a neural network that is made up of several neurons, so is the Artificial Neural Network is made of numerous perceptron.



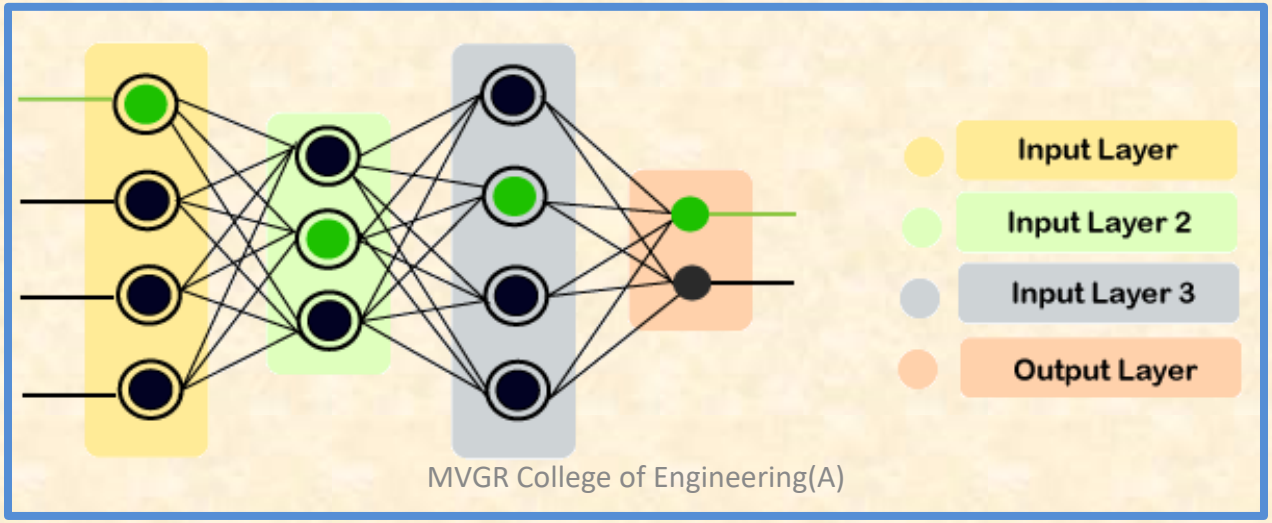
Introduction to Neural Networks

A neural network comprises of three main layers, which are as follows;

Input layer: The input layer accepts all the inputs that are provided by the programmer.

Hidden layer: In between the input and output layer, there is a set of hidden layers on which computations are performed that further results in the output.

Output layer: After the input layer undergoes a series of transformations while passing through the hidden layer, it results in output that is delivered by the output layer.



What are Artificial Neural Networks?

- Artificial Neural Networks are the computing system that is designed to simulate the way the human brain analyzes and processes the information.
- Artificial Neural Networks have **self-learning capabilities** that enable it to produce a **better result** as **more data** become available.
- So, if the network is **trained** on **more data**, it will be **more accurate** because these **neural networks** learn from the examples.
- The neural network can be configured for specific applications like **data classification, pattern recognition**, etc.
- With the help of the neural network, we can actually see that a lot of technology has been evolved **from translating webpages** to other languages to having a **virtual assistant** to order groceries online.
- All of these things are possible because of neural networks. So, an artificial neural network is nothing but a network of various artificial neurons.

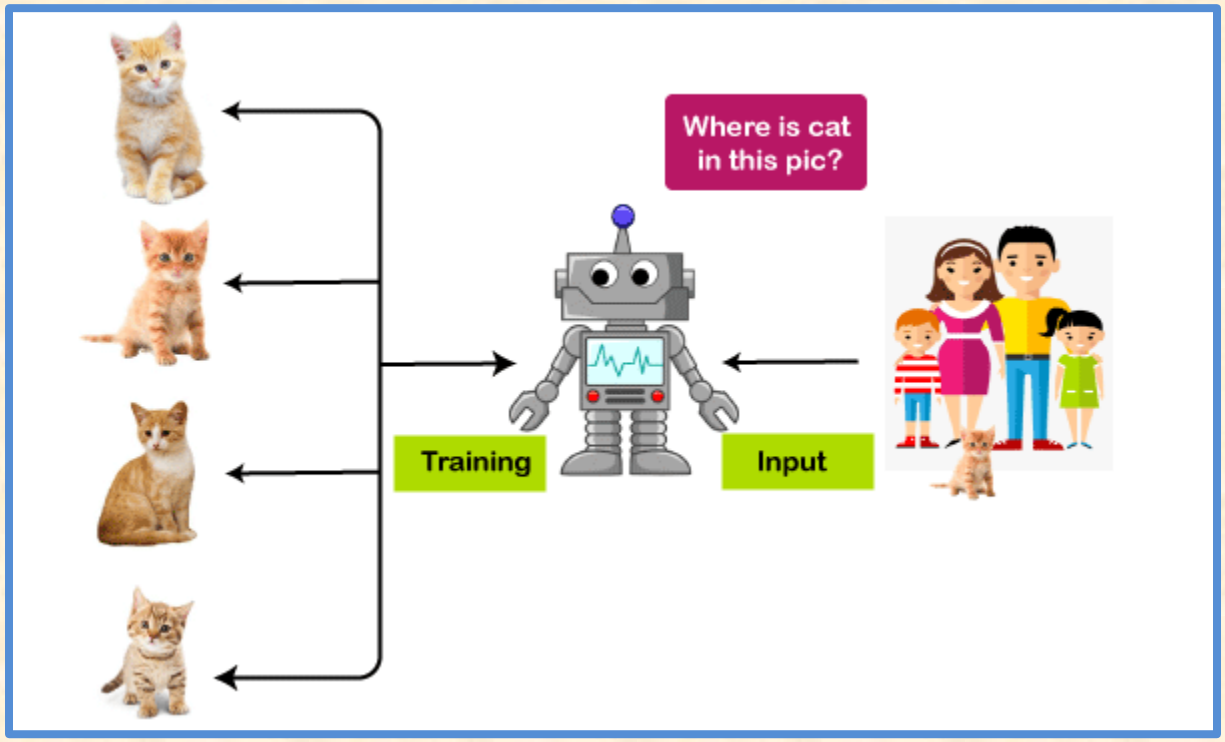
Importance of Neural Network:

Without Neural Network:

- Let's have a look at the example given below.
- Here we have a machine, such that we have trained it with four types of cats, as you can see in the image below.
- And once we are done with the training, we will provide a random image to that particular machine that has a cat.
- Since this cat is not similar to the cats through which we have trained our system, so without the neural network, our machine would not identify the cat in the picture.
- Basically, the machine will get confused in figuring out where the cat is.

Importance of Neural Network:

Without Neural Network:



Importance of Neural Network:

With Neural Network:

- However, when we talk about the case with a neural network, even if we have not trained our machine with that particular cat.
- But still, it can identify certain features of a cat that we have trained on, and it can match those features with the cat that is there in that particular image and can also identify the cat.
- So, with the help of this example, you can clearly see the importance of the concept of a neural network.

Working of Artificial Neural Networks

- Instead of directly getting into the working of Artificial Neural Networks, lets breakdown and try to understand Neural Network's basic unit, which is called a **Perceptron**.
- So, a perceptron can be defined as a neural network with a single layer that classifies the linear data.
- It further constitutes four major components, which are as follows;

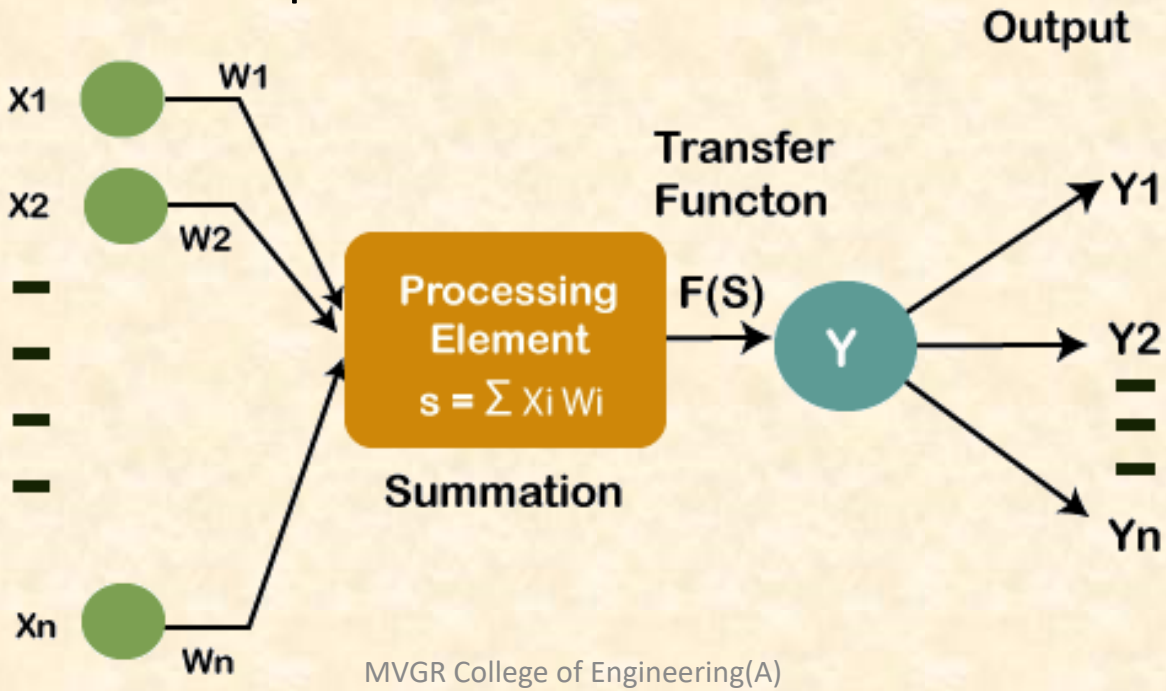
1) **Inputs**
2) **Weights and Bias**
3) **Summation Functions**
4) **Activation or transformation function**

Working of Artificial Neural Networks

The main logic behind the concept of Perceptron is as follows:

1. Inputs

- The inputs (x) are fed into the input layer, which undergoes multiplication with the allotted weights (w) followed by experiencing addition in order to form weighted sums.
- Then these inputs weighted sums with their corresponding weights are executed on the pertinent activation function.



Working of Artificial Neural Networks

2. Weights and Bias

- As and when the input variable is fed into the network, a random value is given as a **weight** of that particular input, such that each individual weight represents the importance of that input in order to make correct predictions of the result.
- However, **bias** helps in the adjustment of the curve of activation function so as to accomplish a precise output.

3. Summation Function

- After the **weights** are **assigned** to the **input**, it then computes the product of each input and weights.
- Then the **weighted sum** is calculated by the **summation function** in which all of the products are added.

Working of Artificial Neural Networks

4. Activation Function

- The main objective of the activation function is to perform a **mapping** of a **weighted sum** upon the **output.**
- The transformation function comprises of activation functions such as tanh, ReLU, sigmoid, etc.

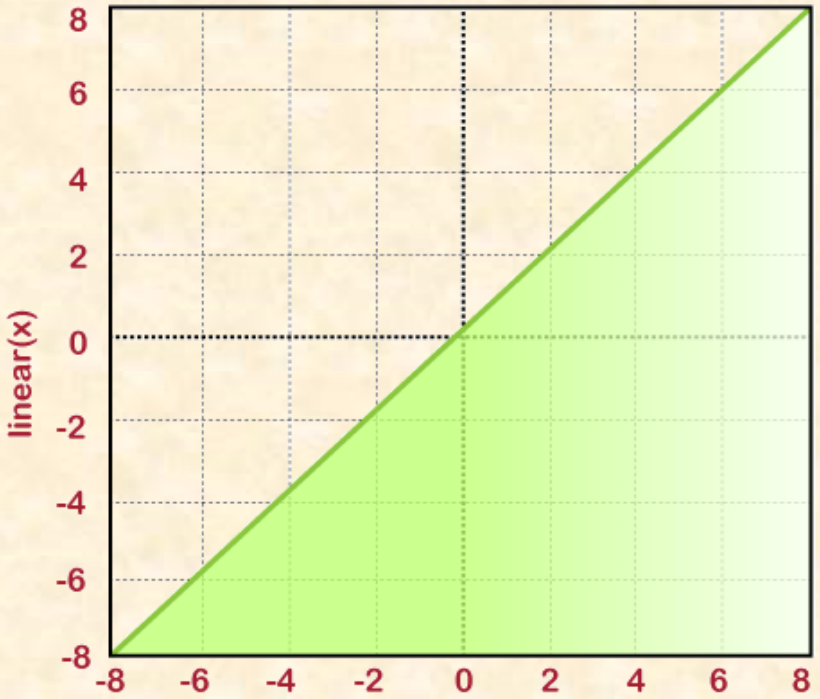
The activation function is categorized into two main parts:

- **Linear Activation Function**
- **Non-Linear Activation Function**

Working of Artificial Neural Networks

Linear Activation Function

- In the linear activation function, the **output** of functions is **not restricted** in between any **range.**
- Its range is specified from **-infinity to infinity.**
- For each individual neuron, the inputs get multiplied with the weight of each respective neuron, which in turn leads to the creation of output signal proportional to the input.

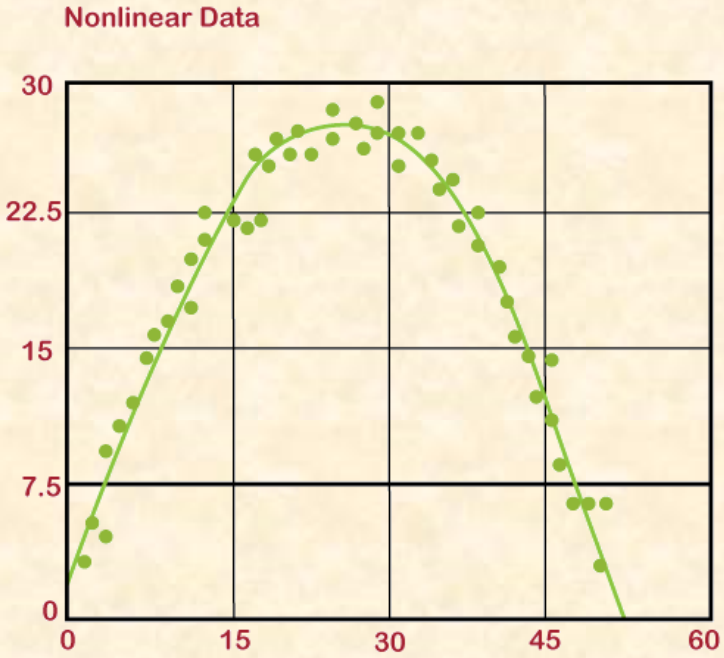


- If all the input layers are linear in nature, then the final activation of the last layer will actually be the linear function of the initial layer's input.

Working of Artificial Neural Networks

Non- linear function

- These are one of the most widely used activation function.
- It helps the model in generalizing and adapting any sort of data in order to perform correct differentiation among the output.
- It solves the following problems faced by linear activation functions:



- Since the non-linear function comes up with derivative functions, so the problems related to backpropagation has been successfully solved.
- For the creation of deep neural networks, it permits the stacking up of several layers of the neurons.

Backpropagation

- The backpropagation consists of an input layer of neurons, an output layer, and at least one hidden layer.
- The neurons perform a weighted sum upon the input layer, which is then used by the activation function as an input, especially by the sigmoid activation function.
- It also makes use of supervised learning to teach the network.
- It constantly updates the weights of the network until the desired output is met by the network.

Backpropagation

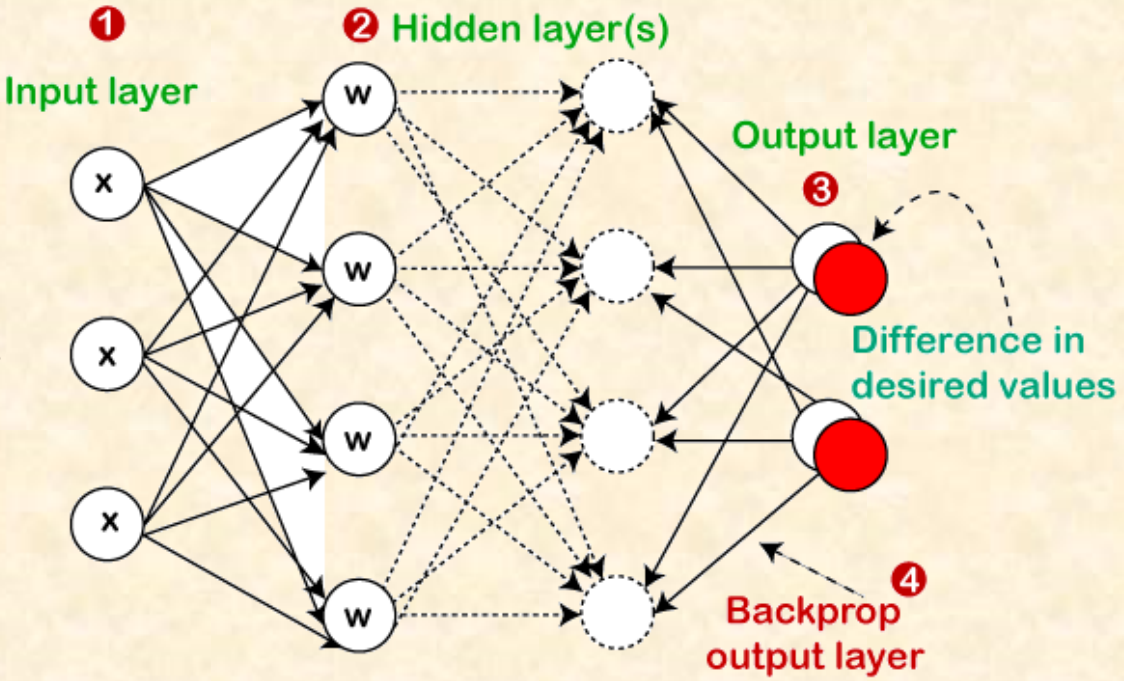
It includes the following factors that are responsible for the training and performance of the network:

- Random (initial) values of weights.
- A number of training cycles.
- A number of hidden neurons.
- The training set.
- Teaching parameter values such as learning rate and momentum.

Working of Backpropagation

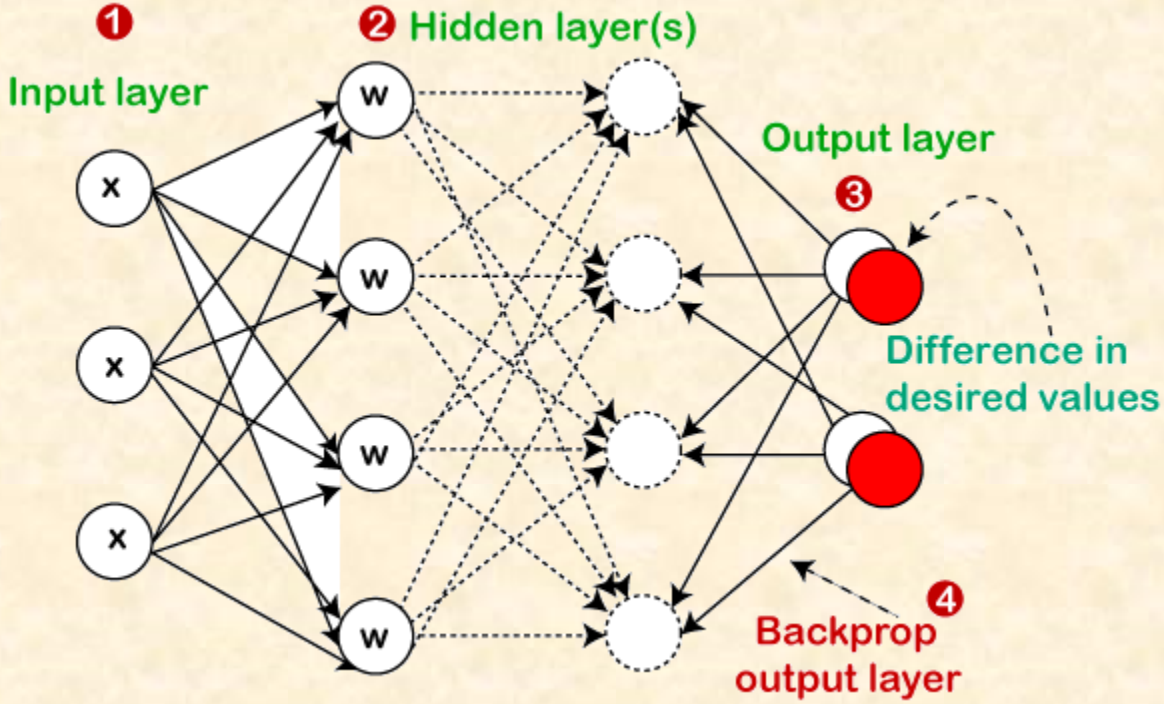
Consider the diagram given below.

1. The preconnected paths transfer the inputs **X**.
2. Then the weights **W** are randomly selected, which are used to model the input.



3. After then, the output is calculated for every individual neuron that passes from the input layer to the hidden layer and then to the output layer.

Working of Backpropagation



4. Lastly, the errors are evaluated in the outputs. **$Error_B$= Actual Output - Desired Output**
5. The errors are sent back to the hidden layer from the output layer for adjusting the weights to lessen the error.
6. Until the desired result is achieved, keep iterating all of the processes.

Need for Backpropagation

- Since it is fast as well as simple, it is very easy to implement.
- Apart from no of inputs, it does not encompass of any other parameter to perform tuning.
- As it does not necessitate any kind of prior knowledge, so it tends out to be more flexible.
- It is a standard method that results well.