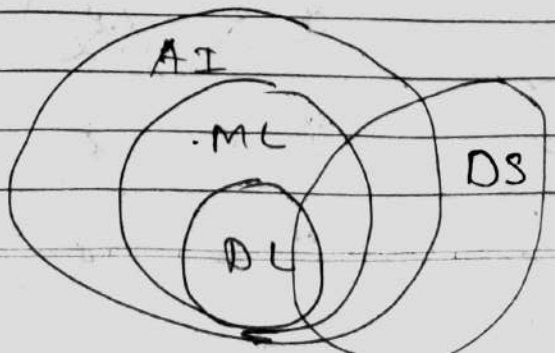
Deep Learning

- module : (1) - Information Flow in neural network, basic structure of ANN.
- module : (2) - Training a Neural Network, how to determine hidden layers, recurrent Neural Network.
- module : (3) - Convolutional Neural Networks, image classification & CNN.
- module : (4) - RNN & LSTMs LSTMs. Application of RNN in real world.

Q. (1) What is deep learning ?

- Deep learning is the branch of M.L which is based on artificial neural Network architecture.

- An Artificial neural Network or ANN uses layers of interconnected nodes called neurons that work together to process and learn from the input data.



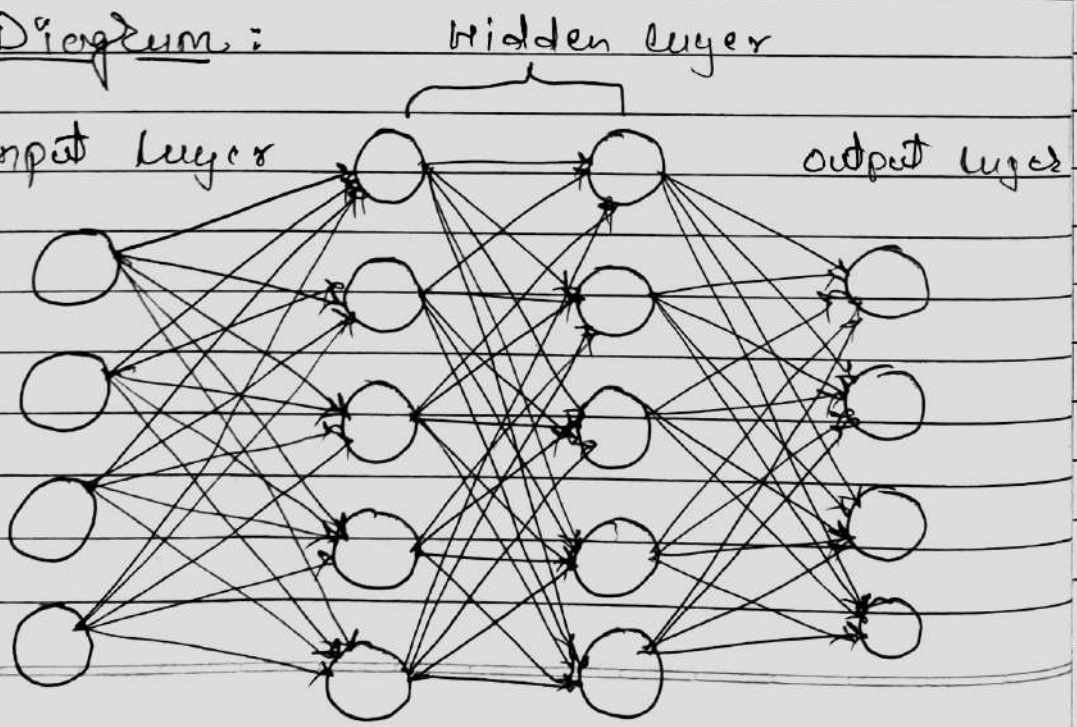
- Deep Learning can be used for Supervised, Unsupervised and Reinforcement machine learning.

Q. (2) What is Artificial Neural Networks?

- Artificial Neural Networks are built on the principles of the structure and operation of human neurons. It is a also known as Neural Network's or Neural nets.

- An artificial neural network's input layer, which is the first layer, receives input from external sources and passes it on the hidden layer, which is the second layer.

(2) Diagram:



Fully Connected ANN.

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- Artificial neurons, also known as units, are found in artificial networks. The whole Neural Network is composed of these artificial neurons, which are arranged in a series of layers.

② Explain Types of Neural Networks.

Deep learning models are able to ~~auto~~ automatically learn features from the data, which makes them well-suited for tasks such as image recognition, speech recognition, and natural language processing.

The most widely used architectures in DL are Feed Forward Neural Networks (FNN), convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs).

[1] Feed Forward Neural Network (FNN):

- FNN are the simplest type of ANN, with a linear flow of information through the network.

- FNNs have been widely used for tasks such as image classification, speech recognition, and natural language processing.

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(CNNs):

[2] Convolutional Neural Networks

- CNN are specially for image and video recognition tasks.

- CNNs are able to automatically learn features from the images, which makes them well-suited for tasks ~~such as image classifica spe.~~ such as image classification, object detection, and image Segementation

[3] Recurrent Neural Networks (RNNs):

- RNNs are a type of neural network that is able to process sequential data such as time series & natural language.

- RNNs are able to maintain an internal state that captures information about the previous inputs, which makes them well-suited for tasks such as speech recognition, natural language processing and language translation.

Q. (a) Explain Applications of DL.

- The main applications of DL can be divided into computer vision, natural

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language processing (NLP) and reinforcement learning.

(*) Computer Vision:

(ans) → In computer vision, Deep learning models can enable machines to identify and understand visual data

- Some of main application of DL in CV:

(1) object detection and recognition
(2) Image classification
(3) Image Segmentation.

(*) Natural language processing (NLPs):

- In NLP, the Deep Learning model can enable machines to understand and generate human language.

- Some of main application of DL in NLP:

(1) Automatic Text Generation
(2) language translation
(3) sentiment analysis
(4) speech recognition

(*) Reinforcement Learning:

- In Reinforcement learning, deep learning works as training agents to take

action in an environment to maximize a reward.

- Some of the main applications of deep learning in reinforcement learning:

(1) Game playing
(2) Robotics
(3) Control systems

Q.③ Explain ANN / Structure of ANN.

- Artificial Neural Networks contain artificial neurons which are called units.

- This units are arranged in a series of ~~s~~ layers that together constitute the whole Artificial Neural Network in a system.

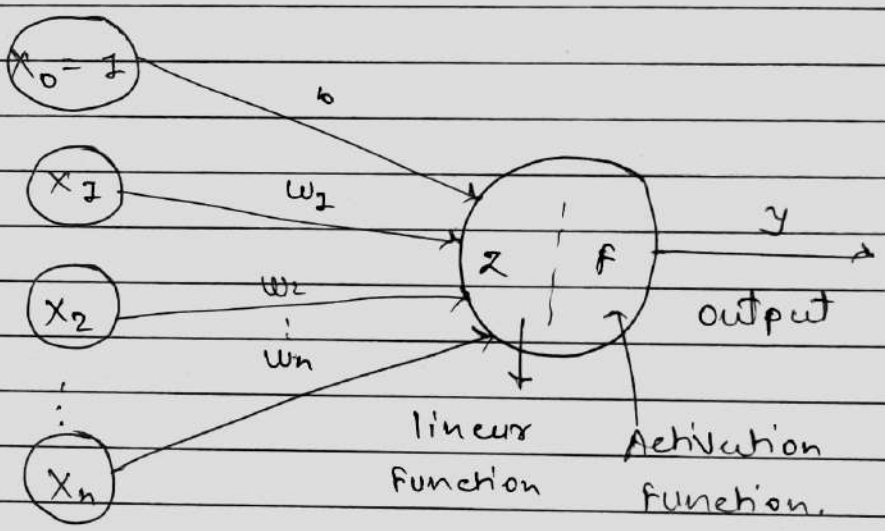
- Commonly, Artificial Neural Network has an input layer, an output layer as well as hidden layers.

- In the majority of neural Networks, units are interconnected from one layer to another. Each of these connections has weights that determine the influence of one unit on another unit.

- As the data transfers from one unit to another, the neural network learns ~~from one unit to another, the neural~~ more about the data which eventually results in an output from the output layer.

Same ANN previous one. Diagram.

⊛ Structure :-



- The structure of ann is inspired by biological neurons.
- A biological neuron has a cell body or soma to process the impulses, dendrites to receive them, and an axon that trans-fer them to other ~~en~~ neurons.

- The input node of ann receive input signals, and the output layer nodes compute the final output by processing the hidden layer's results using activation function.

Biological Neuron	Artificial Neuron
Dendrite	Inputs
Soma	Nodes
Synapses	Weights
Axon	Output.

Q. ⑥ How to train a Neural Network?

- Seven steps to train a N. Network.

[1]- **pick up a neural network architecture:** This implies that you shall be pondering primarily upon the connectivity patterns of the neural network including some of the following aspects:

(1) Number of input nodes:
(2) Number of hidden layers
(3) Number of nodes in each hidden layers
(4) Number of output nodes

(2) **Random Initialization of weights:**

- The weights are randomly initialized to value in between 0 and 1, or rather very close to zero.

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[3] **Implementation of forward propagation** algorithm to calculate hypothesis function for a set on input vector for any of the hidden layer.

[4] **Implementation of cost function** for optimizing parameter values. One may recall that cost function would help determine how well the neural network fits the training data.

[5] **Implementation of back propagation** algo to compute the error vector related with each of the nodes.

[6] **Use gradient checking method** to compare the gradient calculated using partial derivatives of cost function using back propagation and using numerical estimate of cost function gradient.

- The gradient checking method is used to validate if the implementation of back-propagation method is correct.

[7] Use gradient descent or advanced optimization technique with back propagation to try and minimize the cost function as a function of parameters or weights.

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Q.④ How to determine Hidden layers.

- In neural networks, a hidden layer is located between the input and output of the algorithm, in which the function applies weights to the inputs & directs them through an activation function as the output.

- In short, the hidden layers perform nonlinear transformations of the inputs entered into the network.

⊛ Working of Hidden layers :-

- Hidden layers, simply put, are layers of mathematical functions each designed to produce an output specific to an intended result.

Draw ANN Hidden layer diagram.

- Hidden layers allow for the function of a neural network to be broken down into specific transformations of the data.

- Each hidden layer function is specialized to produce a defined output.

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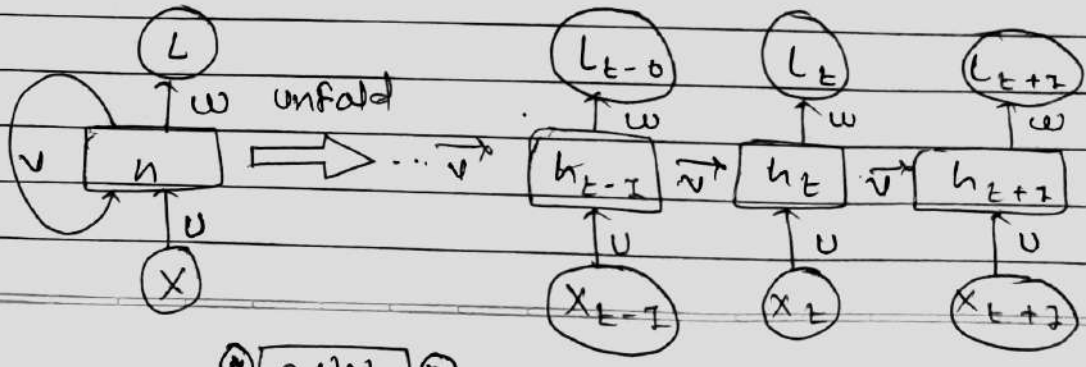
Q.⑧ Recurrent Neural Network.

- RNN is a type of Neural Network where the output from the previous step is fed as input to the current step.

- In traditional Neural Networks, all the inputs and outputs are independent of each other, but in cases when it is required to predict the next word of a sentence, the previous ~~are~~ words are required and hence there is a need to remember the previous words.

- Thus, RNN came into existence, which solved this issue with the help of a Hidden layer. The main & most important feature of RNN is its Hidden State, which remembers the previous input ~~to the~~ some information about a sequence.

- The state is also refered to as memory state since it remembers the previous input to the network.



⑧ RNN ⑧

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⊛ Architecture of RNN :-

- RNNs have the same input & output architecture as any other deep neural architecture. differences arise in the way information flows from input to output.

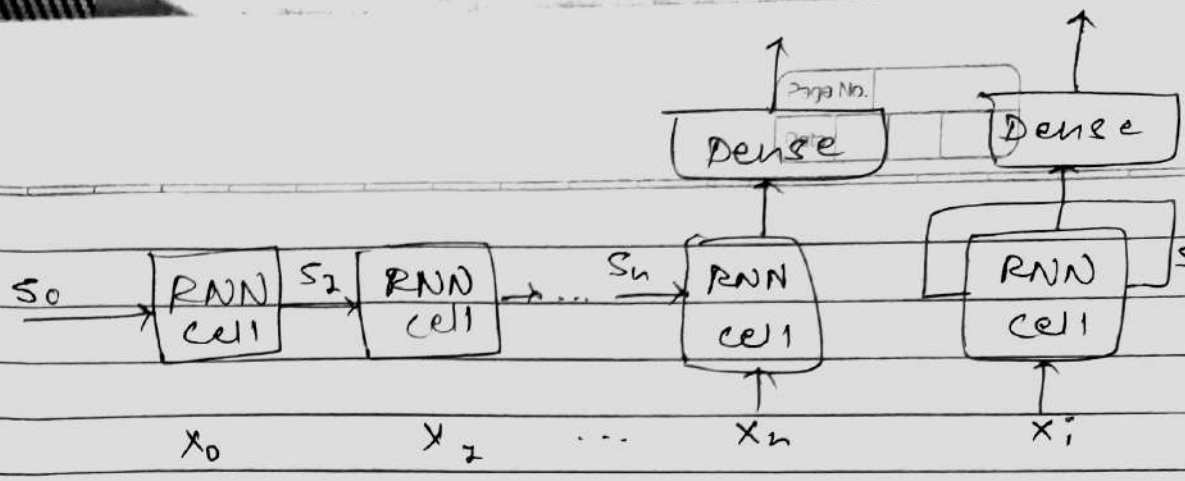
- Unlike deep neural Networks where we have different weight metrices for each Dense network in RNN, the weight across the network remains the same. It calculates state hidden state Hi for every input Xi. By using the following Formulas:

$$h = \sigma(UX + Wh_{-1} + B)$$

$$Y = O(Vh + C) \text{ Hence}$$

$$Y = f(X, h, W, U, V, B, C)$$

Here, S is the State matrix which has element Si as the State of the network at time-step i the parameters in the network are W, U, V, c, b which are shared across time step.



ⓐ Working of RNN :-

- The RNN consists of multiple fixed activation function units, one for each time step.

- Each unit has an internal state which is called the hidden state of unit.

- The hidden state signifies the past knowledge that the network currently holds at a given time step.

- This hidden state is updated at every time step to signify the change in the knowledge of the network about the past.

ⓑ The hidden state is updating using following recurrence relation:

$$h_t = F(h_{t-1}, X_t)$$

where, h_t → current state
h_{t-1} → previous state
X_t → input state

⊛ Formula for Applying Activation function (tanh):

$$h_t = \tanh\left(W_{hh} h_{t-1} + W_{xh} x_t\right)$$

where,

W_{hh} → weight at recurrent neuron
W_{xh} → weight at input neuron.

⊛ The formula for calculating for calculating output:

$$Y_t = W_{hy} h_t$$

where,

Y_t → output
W_{hy} → weight at output layer.

- These parameters are updated using Backpropegation.
- However since RNN works on sequential data here we use an updated backpropegation which is known as Backpropagation through time.

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Q. (9) Convolutional Neural Network.

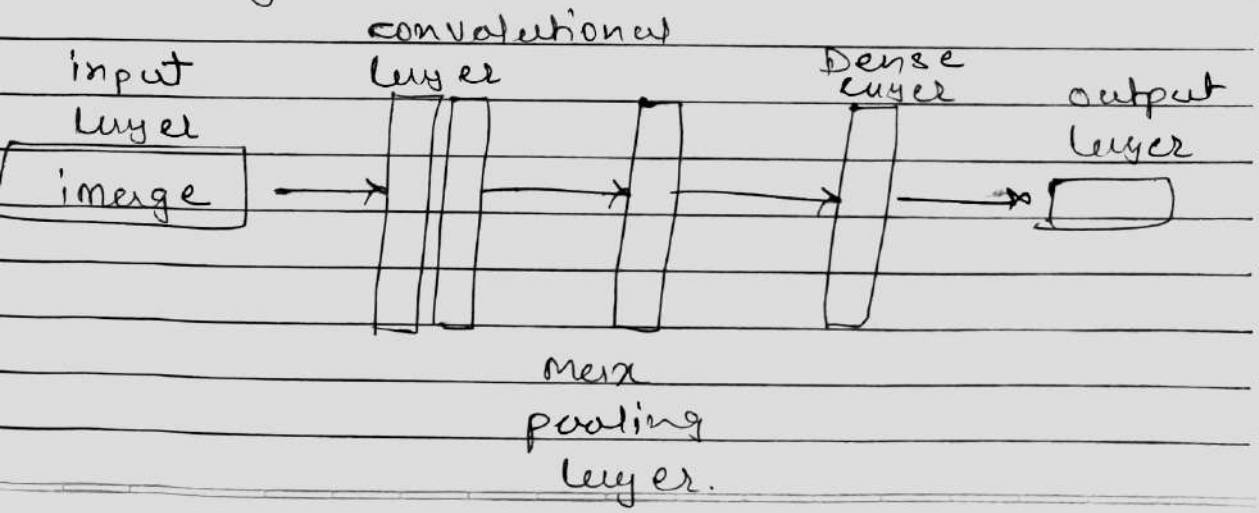
- A CNN is a type of Deep learning neural network architecture commonly used in computer vision.

- Computer vision is a field of Artificial Intelligence that enables a computer to understand and interpret the image or visual data.

(*) CNN Architecture :-

- CNN is the extented version of ANN. which is predominantly used to extract the feature from the grid like matrix dataset.

- CNN consists of multiple layers like the input layer, convolutional layer, pooling layer, and fully connected layers.



(*) CNN Architecture (*)

- The convolutional layer applies filters to the input image to extract fi features, the pooling layer downsamples the image to reduce computation, and the fully connected layer make the final prediction.

- The network learns the optimal filters through back propagation & gradient descent.

Q. (10) Image Classification using CNN.

(*) Steps (*) detail in website

↓

Step: (1) choose a dataset
Step: (2) prepare data set for Training
Step: (3) create Training Data
Step: (4) Shuffle the Dataset
Step: (5) Assigning labels & features
Step: (6) Normalising X and converting labels to categorical Data
Step: (7) Split X & Y for use in CNN
Step: (8) Define, compile & Train the CNN model.
Step: (9) Accuracy & Score of model.

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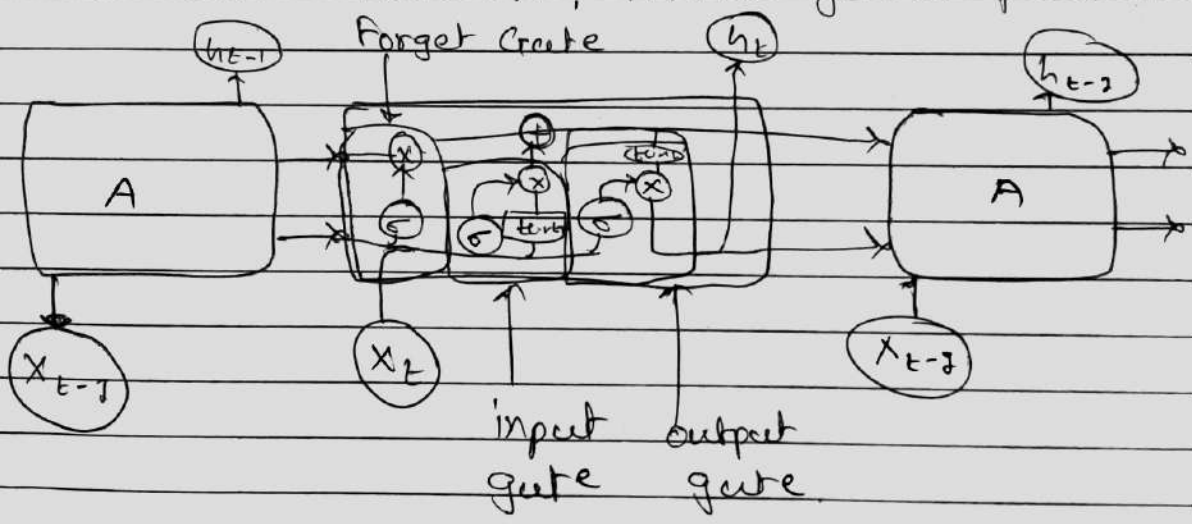
Q. (11) RNN & LSTMs.

(*) Long Short Term Memory :-

- LSTM networks are a modified version of recurrent neural networks, which makes it easier to remember past data in memory.

- The vanishing gradient problem of RNN is resolved here. LSTM is well suited to classify, process & predict time series given time lags of unknown duration. It trains model by using back-propagation.

- In LSTM network, three gates present:



(1) Input Gate
(2) Forget Gate
(3) Output Gate

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Real World

Q.(12) Applications of RNN.

(1) Machin Translation
(2) Text Creation
(3) Captioning of Images
(4) Recognition of Speech
(5) Forecasting of Time Series.

[1] Machine Translation :-

- RNN can be used to build a deep learning model that can translate text from one language to another without the need for human intervention. You can translate a text from your native language to English.

[2] Text Creation :-

- RNN can also be used to build a deep learning model for text generation.

- Based on the previous sequence of words / characters used in the text, a trained model the likelihood of the occurrence of a word / character.

- A model can be trained at the character, n-gram, sentence, or paragraph level.

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[3] Captioning of Images :-

- The process of creating text that describes the content of an image is known as image captioning.
- The image's content can depict the object as well as the action of the object on the image.

[4] Recognition of Speech :-

- This is also known as Automatic Speech Recognition (ASR), and it is capable of converting human speech into written or text format.
- Don't mix up speech recognition and voice recognition.
- Speech recognition ~~primarily~~ primarily focuses on converting voice data into text, whereas voice recognition identifies the user's voice.

[5] Forecasting of Time Series :-

- After being trained on historical time-stamped data, an RNN can be used to create a time series prediction model that predicts the future outcome. the stock market is good example.

- You can ~~build~~ use stock market data to build a ML model that can forecast stock price based on what the model learn from historical data.

Q. (5) What is backpropagation?

- Backpropagation, or backward propagation of errors, is an algorithm that is designed to test for errors working back from output nodes to input nodes.

- It is an important mathematical tool for improving the accuracy of predictions in data mining & machine learning.

- Essentially, backpropagation is an algorithm used to calculate derivatives quickly.

(*) There are two leading types of backpropagation networks.

[1] Static Backpropagation.
[2] Recurrent Backpropagation.

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(*) ~~Diagram~~ :-

[1] Static Backpropagation :-

- Static backpropagation is a network developed to map static inputs for static outputs.

- S.b. networks can solve static classification problems, such as optical character recognition (OCR).

[2] Recurrent Backpropagation :-

- The Recurrent backpropagation network is used for fixed-point learning.

- Recurrent backpropagation activation feeds forward until it reaches a fixed value.

- The key difference between S.b & R.b is that S.b offers instant maping & R.b does not.

* * *

Q.(14) What is a backpropagation algorithm in neural network ?

- Artificial neural networks use back propagation as a learning algorithm to compute a gradient descent with respect to weight values for the various inputs.

- By comparing desired outputs to achieved system outputs, the systems are tuned by adjusting connection weights to narrow the difference between the two as much as possible.

Q.(15) What is Tensorflow ? How does it works ?

- ~~Tensorflow is an open-source software library. Tensorflow was originally developed by researchers~~

- Tensorflow is an open-source end-to-end platform for creating machine learning applications.

- It is a symbolic math library and uses dataflows & differentiable programming to perform various tasks focused on training and inference of deep neural networks

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- It allows developers to create machine learning applications using various tools, libraries, and community resources.

- Tensorflow is a library developed by the google Brain Team to accelerate machine learning & deep neural network research.

- It was built to run on multiple CPUs and GPUs and even mobile operating systems, and it has several wrappers in several languages like python, C++ or Java.

- Currently, the most famous deep learning library in the world is Google's Tensorflow.

- Google product uses machine learning in all of its products to improve the search engine, translation, image captioning or recommendations.

(*) Working of Tensorflow :-

- Tensorflow enables you to build data flow graphs and structures to define how data moves through a graph by taking inputs as a multi-dimensional array called Tensor.

- It allows you to construct a flowchart of operations that can be perfored on these inputs which goes at once end and comes at the other end as output

Q.16 Explain Tensorflow architecture.

- Tensorflow architecture works in three parts:

(1) preprocessing the data
(2) Build the model
(3) Train and estimate the model

- It is called Tensorflow because it takes input as a multi-dimensional array, also known as tensors

- You can construct a sort of flowchart of operations (called a Graph) that you want to perform on that input.

- The input goes in at one end, and then it flows through this system of multiple operations and comes out the ~~order~~ other end as output

- This is why it is called Tensorflow because the tensor goes in it flows through a list of operations, & then it comes out the other side.

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Q. (17) explain Components of Tensorflow.

(*) there are two main Components of Tensorflow :-

(1) Tensors (2) Graph.

[1] Tensor :-

- In Tensorflow, all the computations involve tensors.
- A tensor is a vector or matrix of n-dimensions that represents all types of data.
- All values in a tensor hold identical data type with a known (or partially known) shape.
  - the shape of the data is the dimensionality of the matrix or array.
- A tensor can be originated from the input data or the result of a computation.
- In Tensorflow, all the operations are conducted inside a graph.
- the graph is a set of computation that take place successively. Each operation is called an op node & are connected to each other.

- The graph outlines the ops and connections between the nodes. However, it does not display the values.

- The edge of the nodes is the tensor, i.e. a way to populate the operation with data.

[2] Graphs :-

- Tensorflow makes use of a graph framework.

- The graph gathers and describes all the series computations done during the Training.

- The graph has lots of advantages:

- it was done to run on multiple CPUs & GPUs and even mobile OS.

- All the computations in the graph are done by connecting tensors together.

- A tensor has a node and an edge. The node carries the mathematical operation and produces an endpoints outputs.

- The edges The edges explain the input

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Q.(18) Explain Following Terms :
(1) Tensor, (2) Rank, (3) Shape, (4) Type & (5) Flow (graph) :

[1] Tensor :-

- A tensor is a mathematical object which is a standard way of representing data in deep learning.

- Tensors are defined as a multidimensional array or as a list.

- Tensors are identified by the following parameters.

[2] Rank :-

- The Rank of a tensor is defined by the number of directions required to describe a tensor.

Ex. A zero rank tensor is a scalar, a first rank tensor is a vector, a second rank tensor is typically a square matrix, etc.

output relationship between nodes.

[3] Shape :-

- Number of rows & columns a tensor.

[4] Type :-

- Data type assigned to the tensor's elements.

Ex. String or Boolean.

[5] Flow (Graph) :-

- Flow is the graphical representation of mathematical operations.

- TensorFlow performs computations with the help of dataflow graphs.

- It has nodes the represent the operations in your model.

- We then write code to build the graph, create a session and execute that graph.

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Q. (19) Why Tensorflow is popular?

- Tensorflow is the best library ~~for~~ of all because it is built to be accessible for everyone.

- Tensorflow library incorporates different API ~~at~~ to built at scale deep learning architecture like CNN or RNN.

- Tensorflow is based on graph computation; it allows the developer to visualize the construction of the neural network with Tensorboard. This tool is helpful to debug the program.

- Finally, Tensorflow is built to be deployed at ~~scale~~ scale. It runs on CPU and GPU.

(*) Diagram practical :-

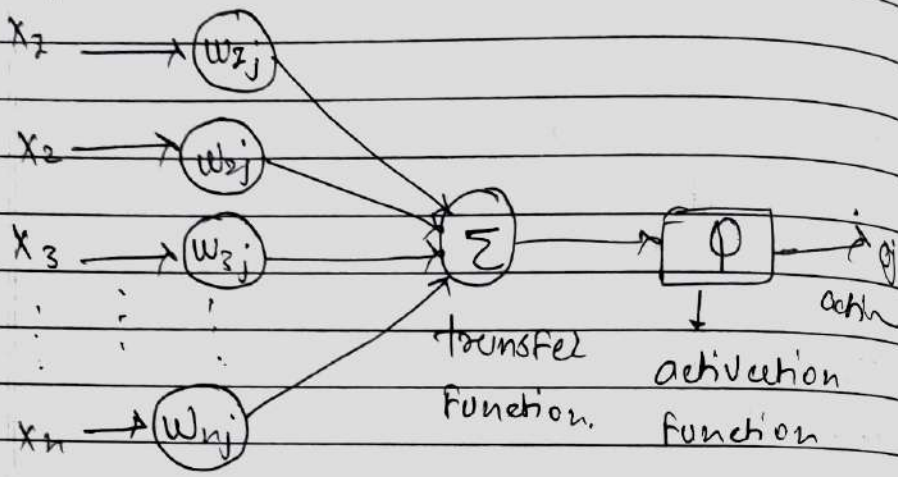
popup wal : Cancel Auto Shut

Msg : OK

Q. (20) What is activation functions?

- To put in simple terms, an artificial neuron calculates the 'weighted sum' of its input and adds a bias, as shown

in the figure below by the input.



Mathematically.

net input = Σ (weight * input) + bias

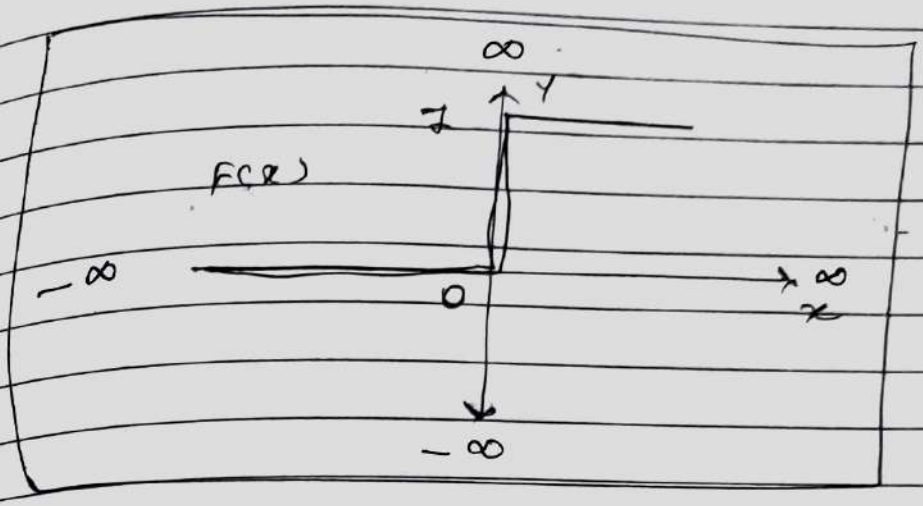
(*) Types of activation functions.

(1) Step function
(2) Sigmoid function
(3) ReLU
(4) Leaky ReLU :

(1) Step function :-

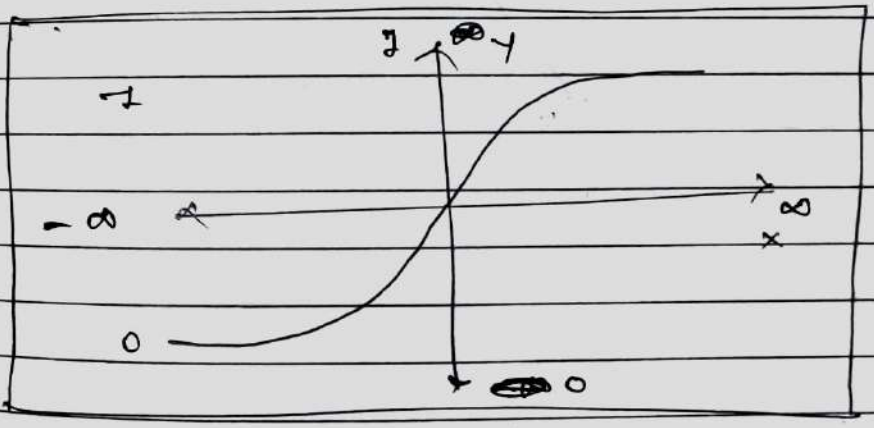
→ $f(x) = 1$ if $x \geq 0$

→ $f(x) = 0$ if $x < 0$



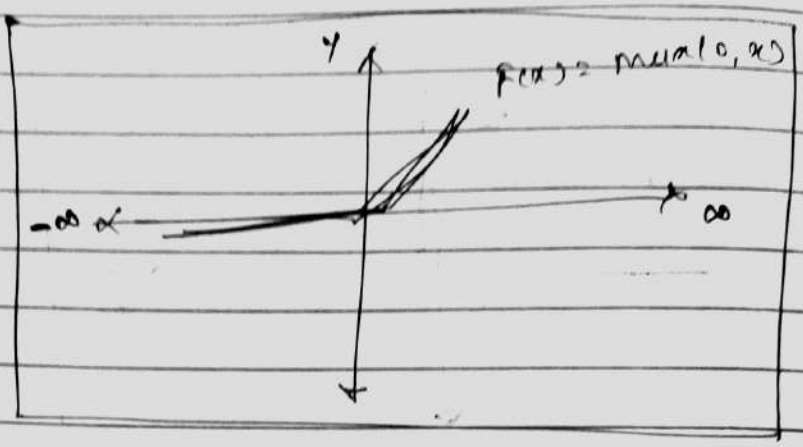
[2] sigmoid Function :-

$$z = \frac{1}{1 + e^{-z}}$$



[3] ReLU : Reflected linear unit.

$$F(x) = \max(0, x)$$



[4] Leaky ReLU:

$f(x) = (ax, x), \quad x < 0$

$f(x) = x, \quad \text{otherwise}$