Introduction to ANN (Artificial Neural Network)

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ANN

- An artificial neural network is an information processing system that has been developed as a generalization of the mathematical model of human cognition (sense of knowing).
- A neural network is a network of interconnected neurons, inspired from the studies of the biological nervous system. In other words, neural network functions in a way similar to the human brain.
- The function of a neural network is to produce an output pattern when presented with an input pattern.
- Neural network is the study of networks consisting of nodes connected by adaptable weights, which store experimental knowledge from task examples through a process of learning.
- The nodes of the brain are adaptable; they acquire knowledge through changes in the node weights by being exposed to samples.

Neural Network: Artificial Neuron

- The artificial neuron (also called processing element or node) mimes the characteristics of the biological neuron. A processing element possesses a local memory and carries out localized information processing operations.
- The artificial neuron has a set of ‘n’ inputs x_i, each representing the output of another neuron.
- The subscript i in x_i takes values between i and n and indicates the source of the vector input signal.

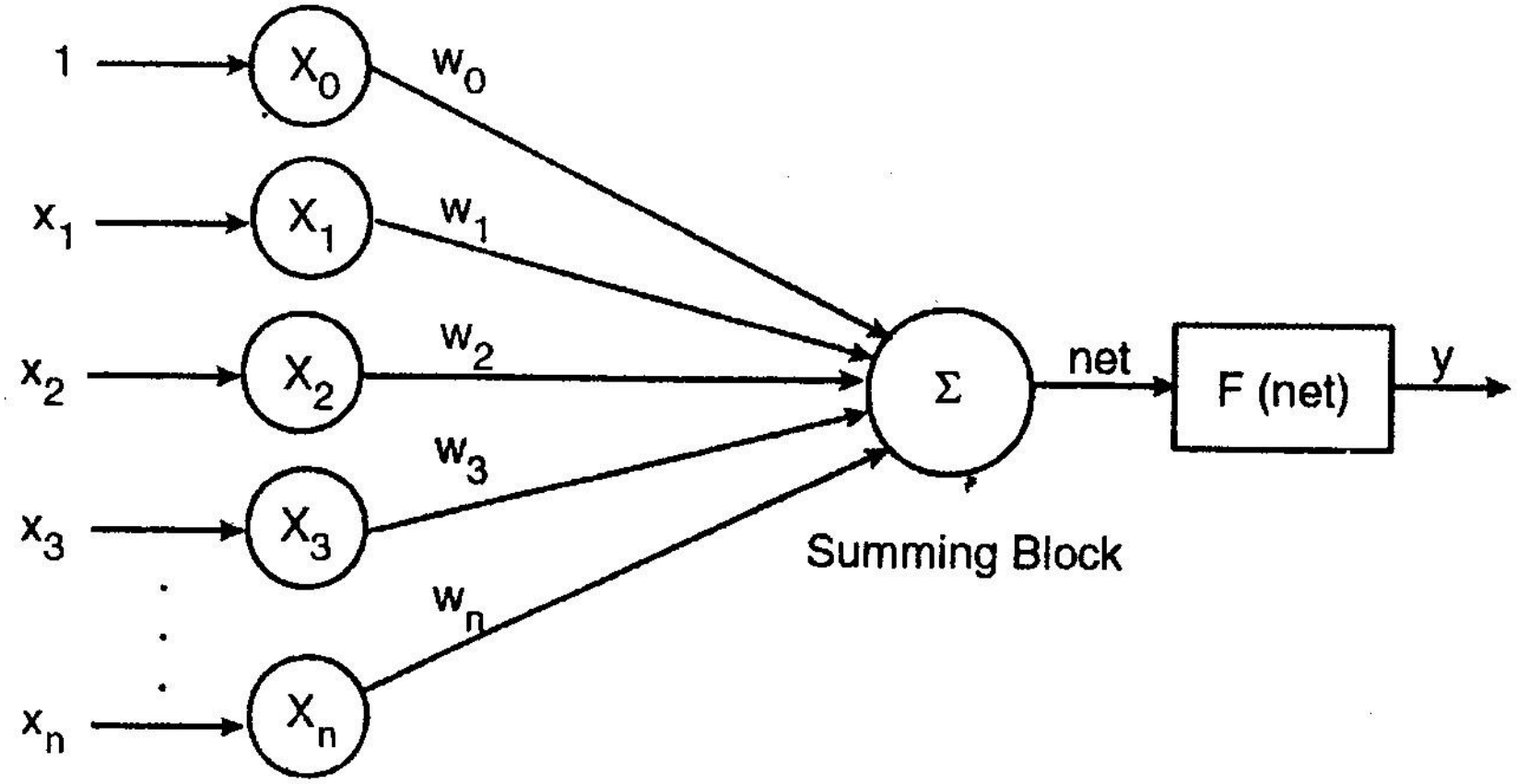
Neural Network: Artificial Neuron

- The inputs are collectively referred to as X.
- Each input is weighed before it reaches the main body of the processing element by the connection strength or the weight factor (or simply weight) analogous to the synaptic strength.
- The amount of information about the input that is required to solve a problem is stored in the form of weights. Each signal is multiplied with an associated weight w_1, w_2, w_3,...,w_n before it is applied to the summing block.

Neural Network: Artificial Neuron

- In addition, the artificial neuron has a bias term w0, a threshold value ‘θ ‘ that has to be reached or extended for the neuron to produce a signal, a nonlinear function 'F' that acts on the produced signal 'net' and an output 'y' after the nonlinearity function.

Neural Network: Artificial Neuron



Basic Neuron Model

Neural Network: Artificial Neuron

- The following relation describes the transfer function of the basic neuron model.
- y = F (net), Where net = $w_0 + x_1w_1 + x_2w_2 + x_3w_3 + \ldots\ldots + x_nw_n$ or

$$net = w_0 + \sum_{i=0}^{n} x_i w_i$$

- and the neuron firing condition is: $\sum_{i=0} x_i w_i \geq \theta$

[for linear activation function], $x_0=1$

- Or $F(net) \geq \theta$

[for nonlinear activation function]

Neural Network: Classification

Artificial neural networks can be classified on the basis of

- 1. Pattern of connection between neurons, (architecture of the network)
- 2. Activation function applied to the neurons
- 3. Method of determining weights on the connection (training method)

Neural Network: ARCHITECTURE

- The neurons are assumed to be arranged in layers, and the neurons in the same layer behave in the same manner.
- All the neurons in a layer usually have the same activation function. Within each layer, the neurons are either fully interconnected or not connected at all.
- The neurons in one layer can be connected to neurons in another layer.
- The arrangement of neurons into layers and the connection pattern within and between layers is known as network architecture.

Neural Network: ARCHITECTURE

- **Input layer:** The neurons in this layer receive the external input signals and perform no computation, but simply transfer the input signals to the neurons in another layer.
- **Output layer:** The neurons in this layer receive signals from neurons either input layer or in the hidden layer.
- **Hidden layer:** The layer of neurons that are connected in between the input layer and the output layer is known as hidden layer.

Neural Network: ARCHITECTURE

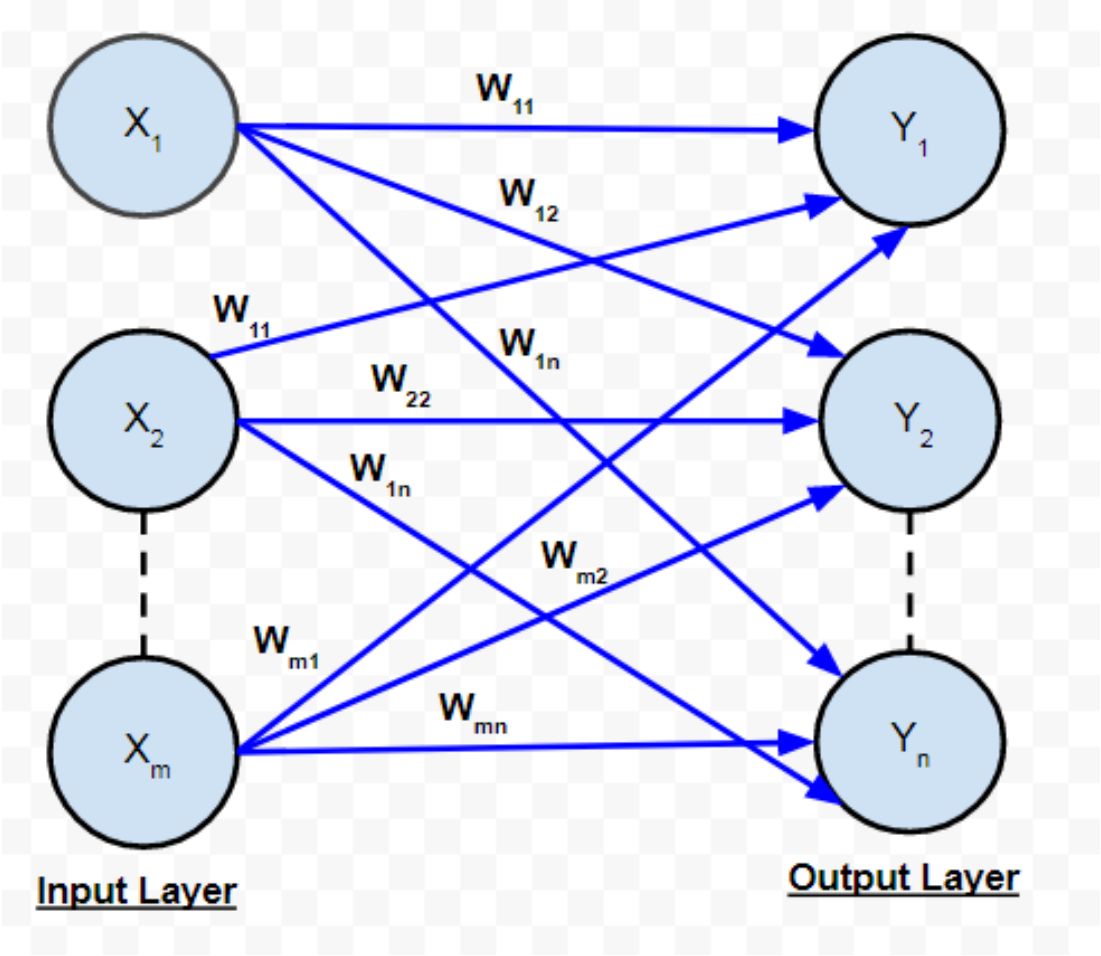
- Neural nets are often classified as single layer networks or multilayer networks.
- The number of layers in a net can be defined as the number of layers of weighted interconnection links between various layers.
- While determining the number of layers, the input layer is not counted as a layer, because it does not perform any computation.
- The architecture of a single layer and a multilayer neural network is shown in the following figures.

Neural Network: ARCHITECTURE

Single Layer Network:

- A single layer network consists of one layer of connection weights. The net consists of a layer of units called input layer, which receive signals from the outside world and a layer of units called output layer from which the response of the net can be obtained.
- This type of network can be used for pattern classification problems

Neural Network: ARCHITECTURE

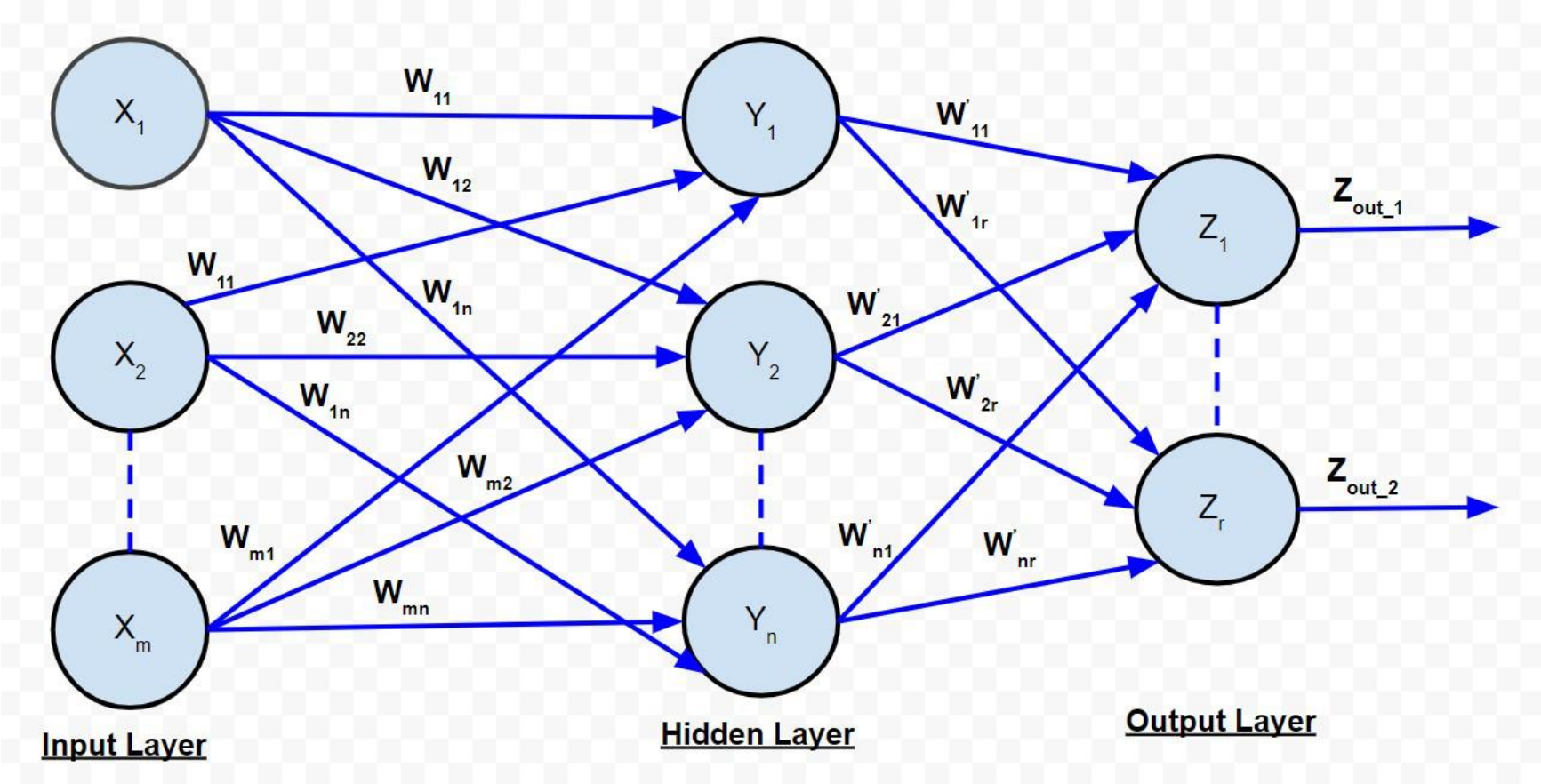


Neural Network: ARCHITECTURE

Multilayer Network:

- A multilayer network consists of one or more layers of units (called hidden layers) between the input and output layers. Multilayer networks may be formed by simply cascading a group of layers; the output of one layer provides the input to the subsequent layer.
- A multilayer net with nonlinear activation function can solve any type of problem.
- However training a multilayer neural network is very difficult.

Neural Network: ARCHITECTURE(Multi Layer)



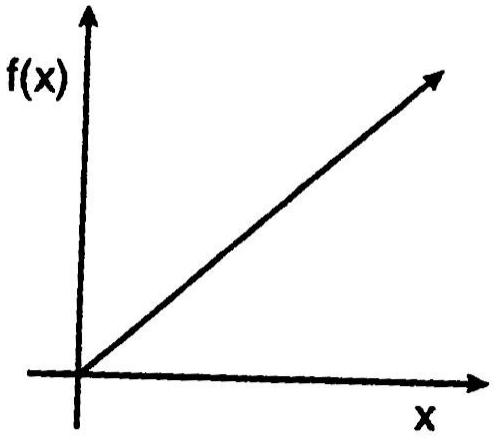
Neural Network: ACTIVATION FUNCTIONS

- The purpose of non-linear activation function is to ensure that the neuron's response is bounded - that is, the actual response of the neuron is conditioned or damped, as a result of large or small activating stimuli and thus controllable.
- Further, in order to achieve the advantages of multilayer nets compared with the limited capabilities of single-layer networks, nonlinear functions are required.
- Different nonlinear functions are used, depending upon the paradigm and the algorithm used for training the network.

Neural Network: ACTIVATION FUNCTIONS

The various activation functions are:

- **Identity function (Linear function).**
- Identity function can be expressed: f(x) = x for all x.
- **Binary step function: Binary step function is defined as:**



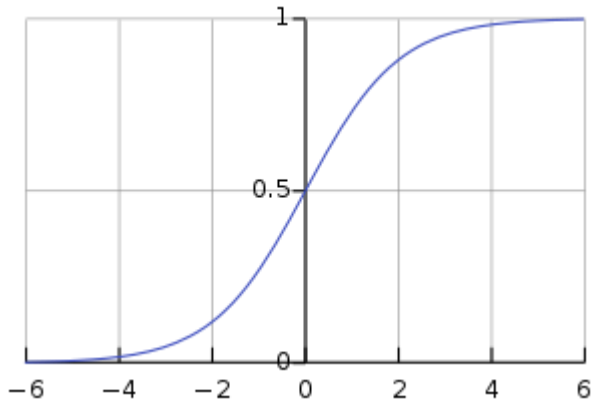
$$f(x) = \begin{cases} 1 & \text{if } x \geq \theta \\ 0 & \text{if } x < \theta \end{cases}$$

where θ is the threshold value.

Neural Network: ACTIVATION FUNCTIONS

Sigmoidal Function:

- A sigmoid function is a mathematical function having a characteristic "S"-shaped curve or sigmoid curve.
- A common example of a sigmoidal function is the logistic function shown in the figure and defined by the formula:



$$f(x) = \frac{1}{1 + e^{-x}}$$

Neural Network: ACTIVATION FUNCTIONS

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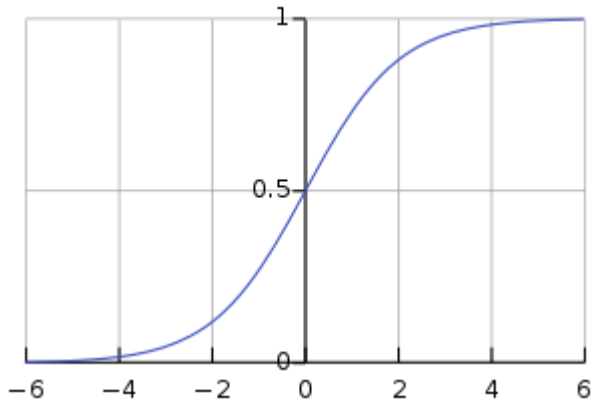

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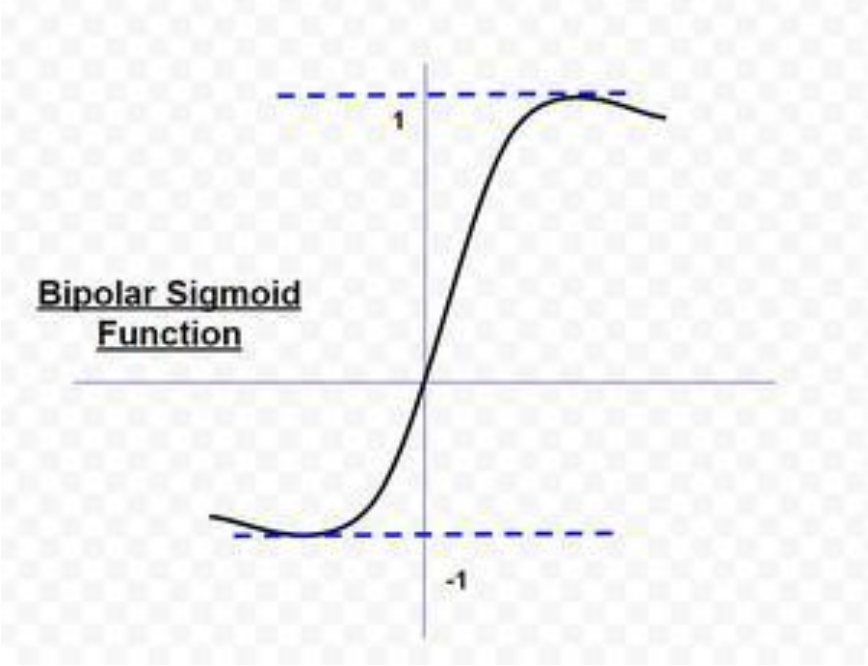
Neural Network: ACTIVATION FUNCTIONS

Bipolar Sigmoidal Function:

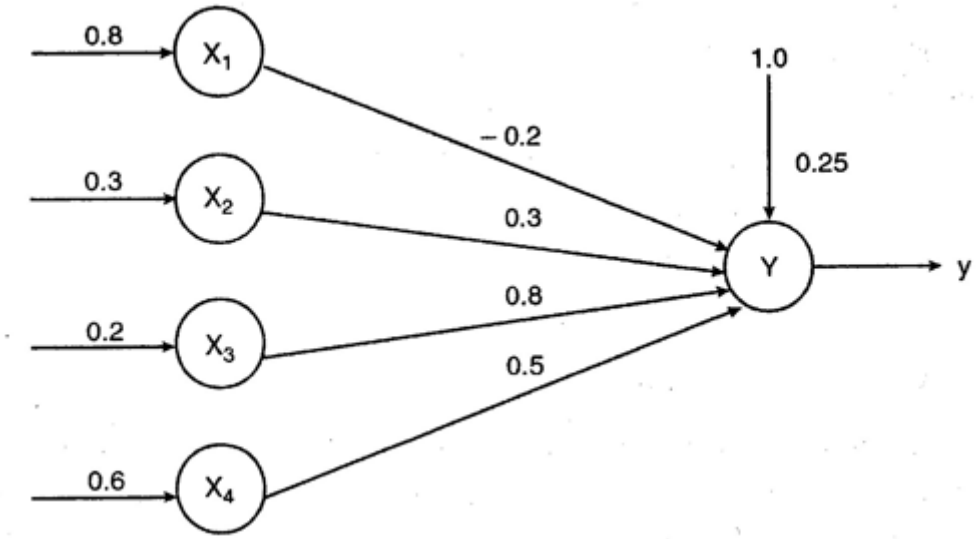
- Bipolar sigmoid function is used as an activation function when the desired range of output value is between -1 and 1.

$$f(x) = \frac{2}{1+e^{-x}} - 1$$



Neural Network: ACTIVATION FUNCTIONS

- For the network shown in the figure find the output of the neuron Y when the activation function is:
  - ✓ A) Binary Sigmoidal
  - ✓ B) Bipolar Sigmoidal



Answer of the previous Question

Net input to neuron Y is:

$$y_{in} = (0.8 \times [-0.2]) + (0.3 \times 0.3) + (0.2 \times 0.8) + (0.6 \times 0.5) + 0.25$$
$$= 0.64$$

(a) For binary sigmoidal activation function,

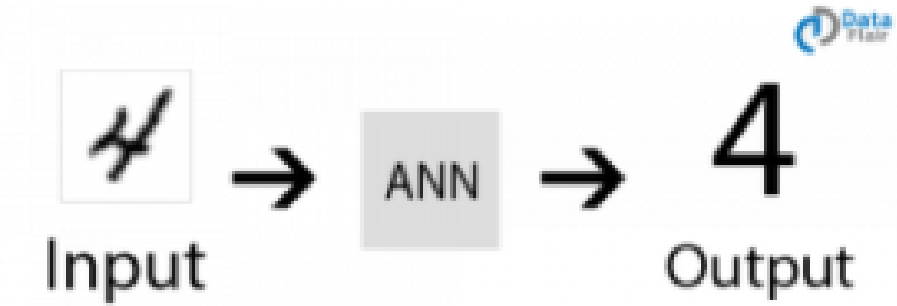
$$y = f(y_{in}) = \frac{1}{1 + e^{-0.64}} = 0.6548$$

(b) For bipolar sigmoidal activation function,

$$y = f(y_{in}) = \frac{2}{1 + e^{-0.64}} - 1 = 0.3095$$

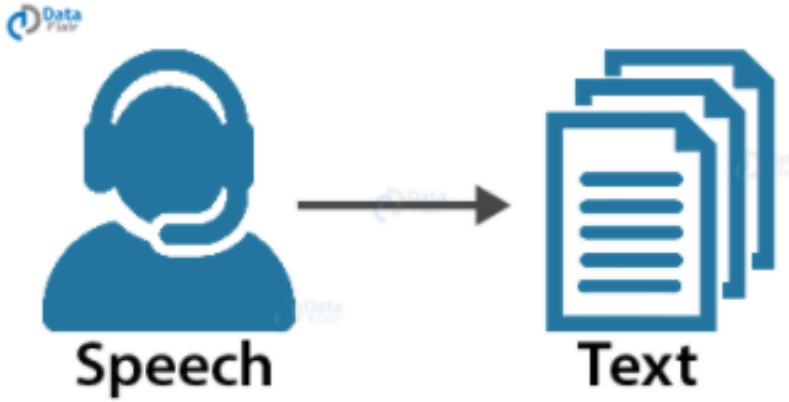
Applications of ANN

- **Handwritten Character Recognition:** ANNs are used for handwritten character recognition. Neural Networks are trained to recognize the handwritten characters which can be in the form of letters or digits.



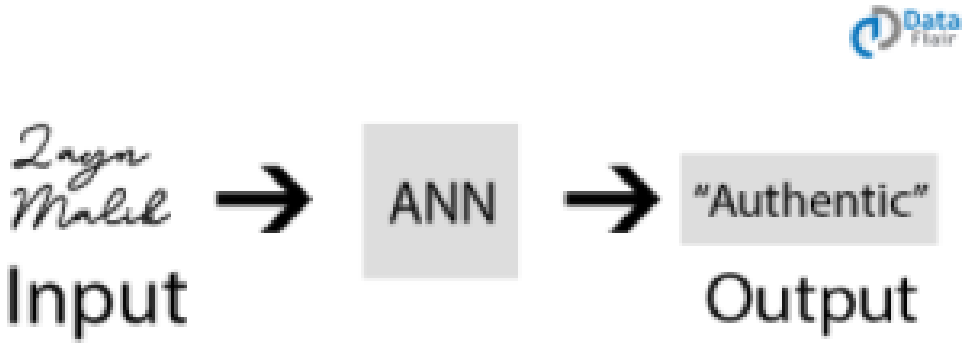
Applications of ANN

- **Speech Recognition:** ANNs play an important role in speech recognition. The earlier models of Speech Recognition were based on statistical models like Hidden Markov Models. With the advent of deep learning, various types of neural networks are the absolute choice for obtaining an accurate classification.



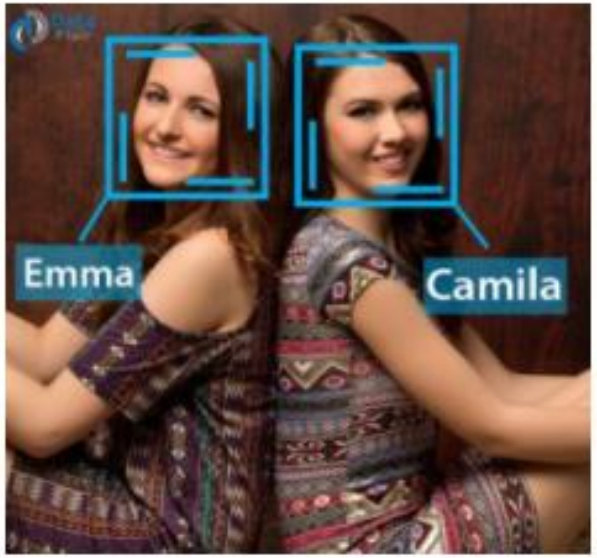
Applications of ANN

- **Signature Classification:** For recognizing signatures and categorizing them to the person's class, we use artificial neural networks for building these systems for authentication. Furthermore, neural networks can also classify if the signature is fake or not.



Applications of ANN

- **Facial Recognition:** In order to recognize the faces based on the identity of the person, we make use of neural networks. They are most commonly used in areas where the users require security access. Convolutional Neural Networks are the most popular type of ANN used in this field.



Thank You