Models of Artificial Neural Network

Basic Models of Artificial Neural Network

- The model's synaptic interconnections
- The training or learning rules adopted for updating and adjusting the connection weights
- Their activation functions

A simple neuron net architecture

- Let X_1 and X_2 are input neurons, which transmit signals, and Y is the output neuron, which receives the signal.

- Input neurons X_1 and X_2 are connected to the o/p neuron Y, over a weighted interconnection links W_1 and W_2 respectively.

- The net I/P for the above model can be calculated as:

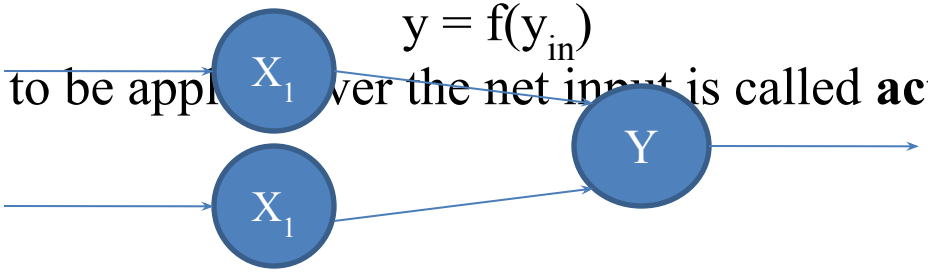
$$Y_{in} = x_1 w_1 + x_2 w_2$$

Where x_1 and x_2 are the activations of the i/p neurons X_1 and X_2.

- The output y of the output neuron Y can be obtained by applying activations over the net input, i.e. the function of the net input as:

$$y = f(y_{in})$$

The function to be appl ver the net input is called **activation function**.



Neural Network Architecture (on basis of interconnections)

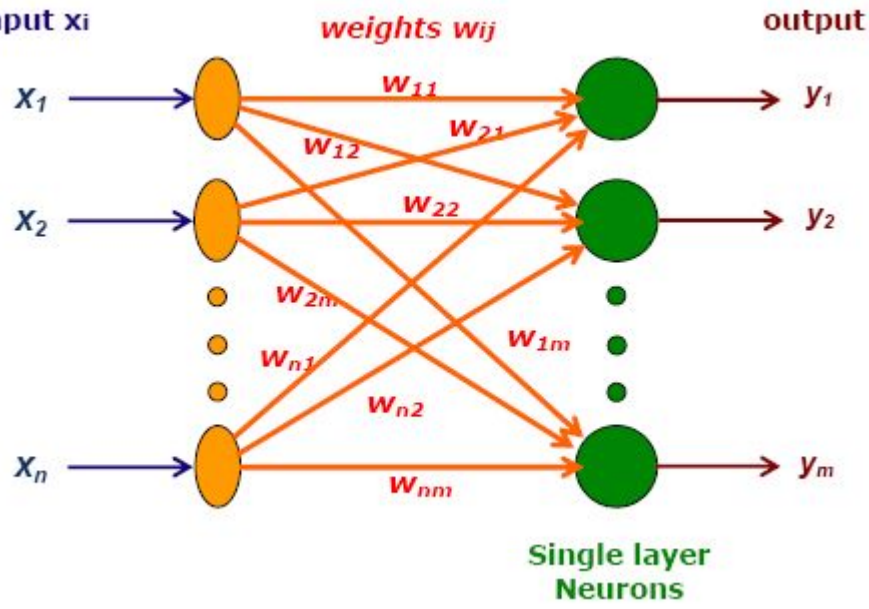
- Following are the basic types of neural architectures:
  - Single layer feed forward network
  - Multilayer feed forward network
  - Multilayer recurrent network

Single layer feed-forward Network Architecture

- The single layer feed-forward network consists of a single layer of weights, where inputs are directly connected to the outputs, via a series of weights.

- The synaptic links carrying weights connect every input to every output, but not other way.

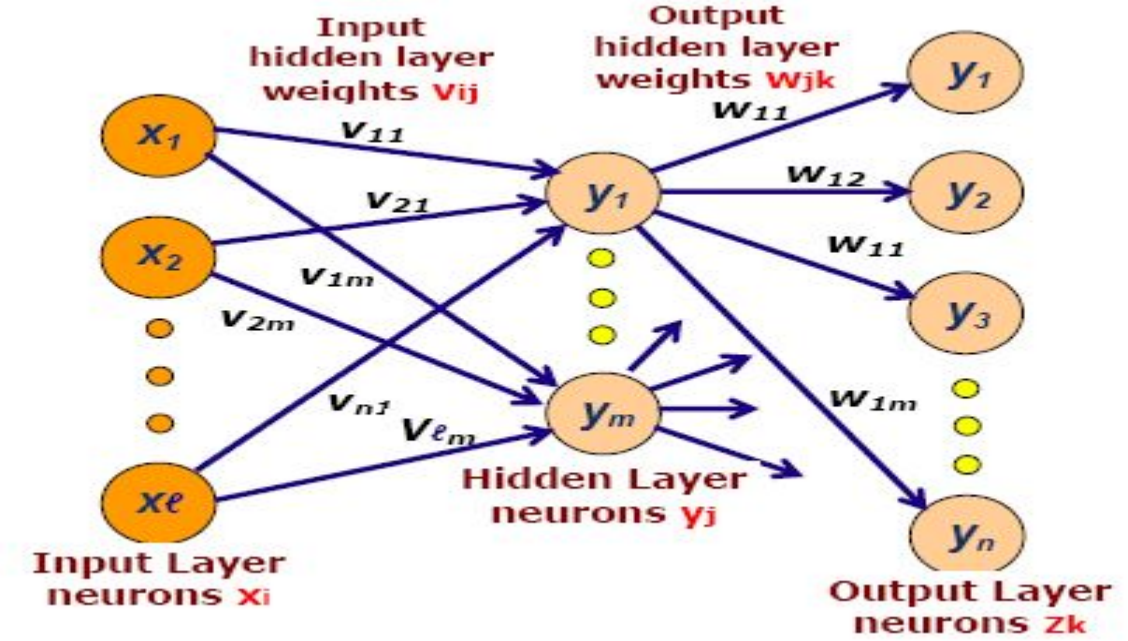
- The sum of the products of the weights and the inputs is calculated in each neuron node, and if the value is above some threshold the neuron fires and takes the activate deactivated value (typically -1)



Multi layer feed-forward Network Architecture

- The name suggests, it consists of multiple layers.

- The architecture of this class of network, besides having the input and output layers, also have one or more intermediary layers called hidden layers.

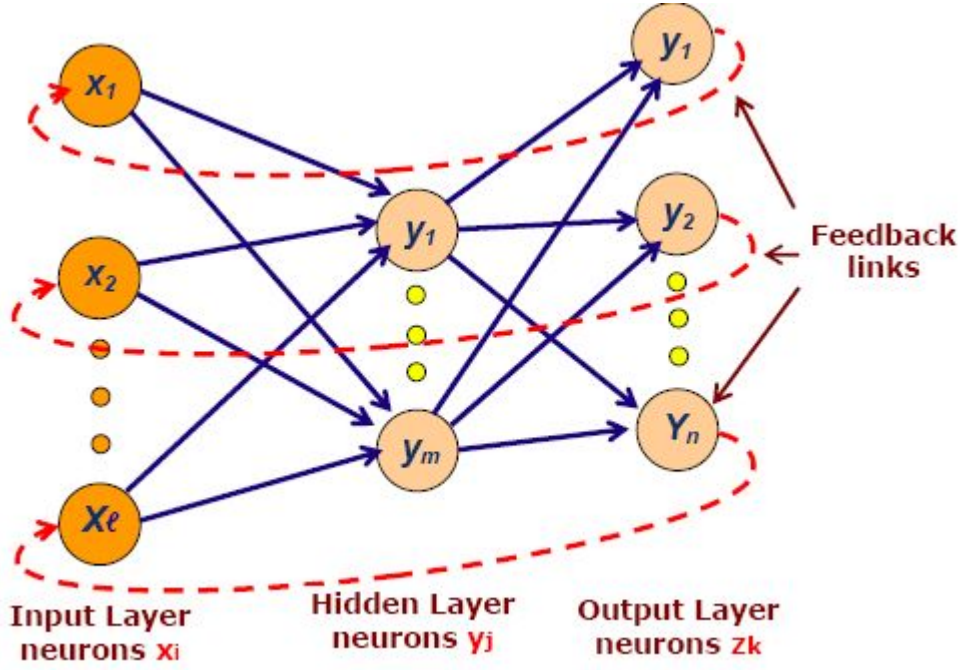


- The hidden layer does the intermediate computation before directing the input to the output layer.

Recurrent Network Architecture

- The recurrent networks differ from feed-forward architecture.

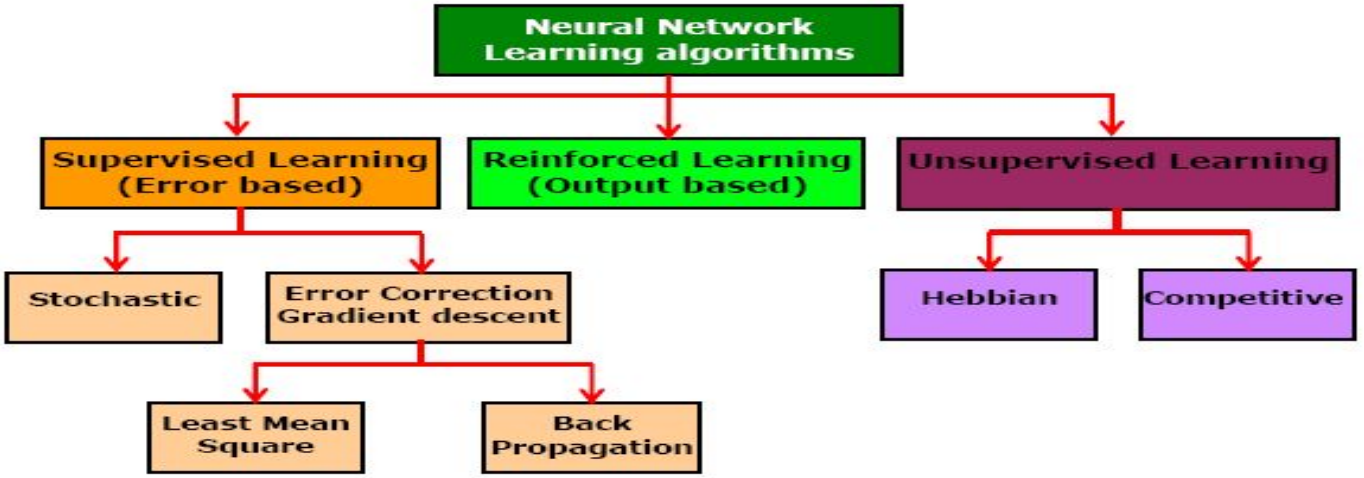
- A Recurrent network has at least one feed back loop.



- There could be neurons with self-feedback links; that is the output of a neuron is fed back into it self as input.

Learning methods in Neural Networks

- The Learning methods in Neural Networks are classified into three basic types:
  - Supervised Learning
  - Unsupervised learning, and



- The supervised and Unsupervised learning methods are most popular forms of learning compared to Reinforced learning

Supervised Learning

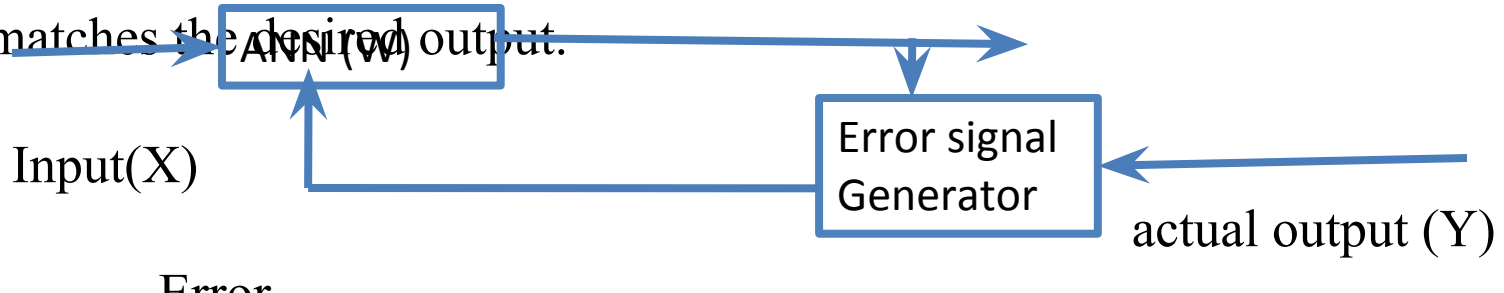
- In Supervised Learning, each input vector requires a corresponding target vector, which represents the desired output.

- During training, the input vector is presented to the network, which results in an output vector.

- This output vector is the actual output vector. Then the actual output vector is compared with the desired output vector.

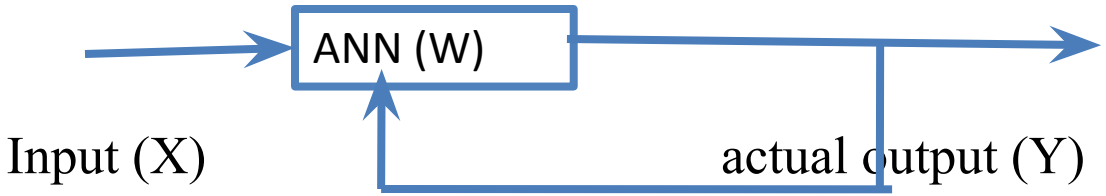
- If there exists a difference between the two output vectors then an error signal is generated by the network.

- This error signal is used for adjustment of weights until the actual output matches the desired output.



Unsupervised Learning

- The Learning, here is performed without the help of a teacher.
- In the training process, the network receives the input patterns and organizes these patterns to form clusters.
- When a new input pattern is applied, the neural network gives an output response indicating the class to which the input pattern belongs.
- If for an input, pattern class can not be found then a new class is generated.



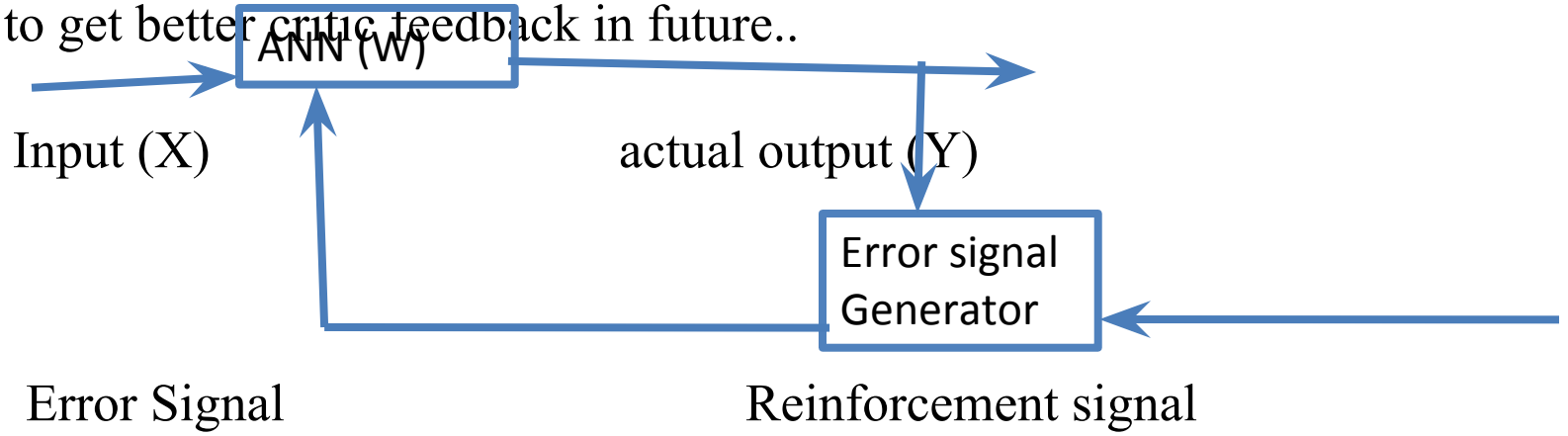
Reinforced Learning

- A teacher is present but does not present the expected or desired output, only indicates if the computed output is correct or incorrect.

- For example, the network might be told that its actual output is only 50% correct or so. Thus, here only critic information is available, not the exact information. (does not represent quantity by which the output is incorrect).

- i.e. the feed back obtained here is only evaluative not instructive.

- The critic signals are sent to the ANN for adjustment of weights properly so as to get better critic feedback in future..



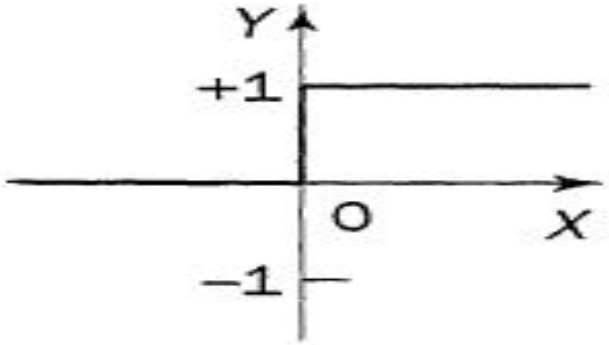
Activation Functions

- The activation function is applied over the net input to calculate the output of an ANN i.e.

- The function Y = f(x) describes a relationship, an input-output mapping, from x to y.

- **`Binary Step function:**

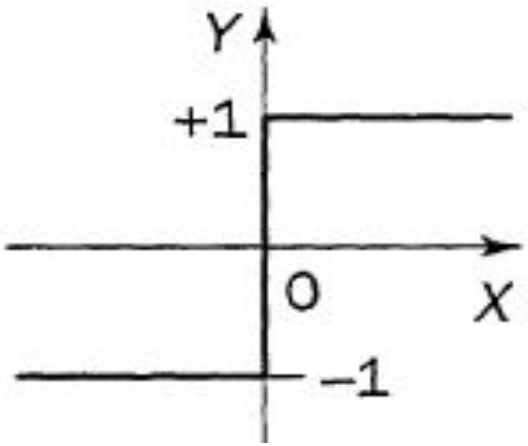
$$Y^{step} = \begin{cases} +1 & \text{if } X >= \theta \\ 0 & \text{if } X < \theta \end{cases}$$



Activation Functions

- **Sign function (bipolar step)**

$$Y^{sign} = \begin{cases} +1 & \text{if } X \geq \theta \\ -1 & \text{if } X < \theta \end{cases}$$

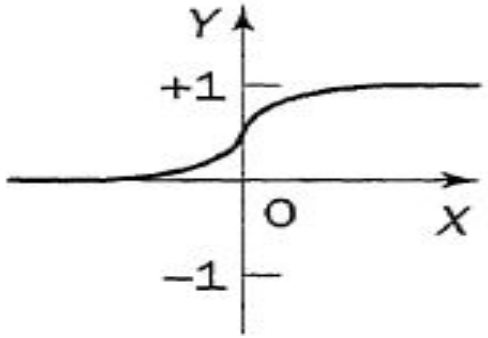


Activation Functions

Signmoidal function

- **Binary sigmoid function**

$$Y_{sigmoid} = \frac{1}{1 + e^{-x}}$$



- **Bipolar Sigmoid function**

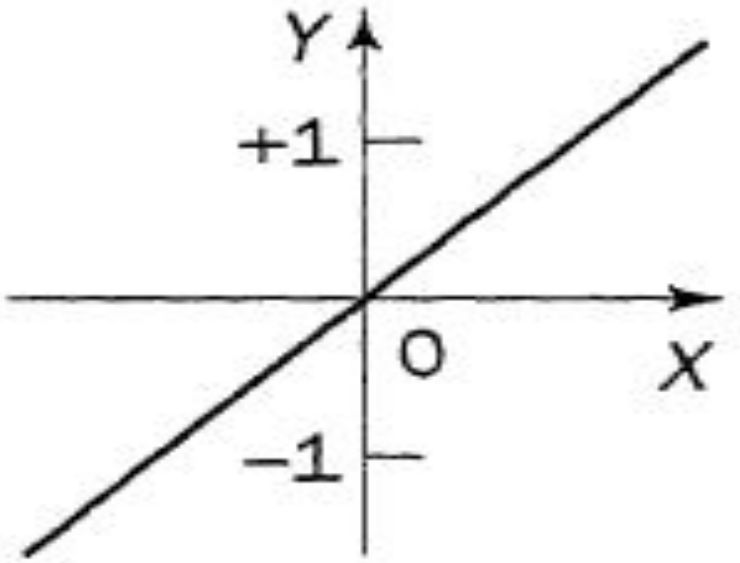
$$f(x) = 2/(1+e^{-\lambda x}) - 1$$

$$= (1-e^{-\lambda x})/(1+e^{-\lambda x})$$

Activation Functions

- **Linear function**

$$Y^{linear} = X$$



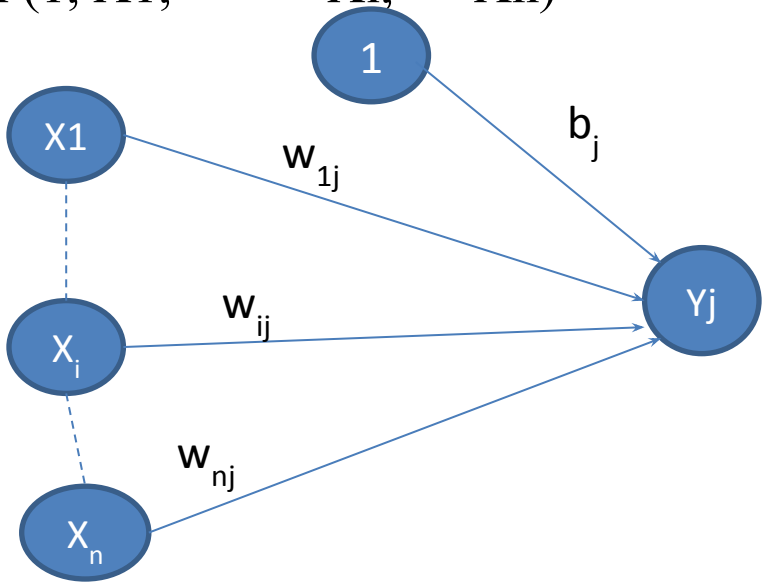
Few more important terminologies in ANN

Bias:

- The bias included in the network has its impact in calculating the net input. The bias is included by adding a component X0=1 to the input vector X.

- Thus, the input vector becomes:

X (1, X1, --------Xi, --- Xn)



- The bias is considered like another weight, that is $w_{0j} = b_j$

Few more important terminologies in ANN

Bias:

- The net input to the output neuron Y_j is calculated as:

$$Y_{inj} = \sum x_i w_{ij}$$

$$= x_0 w_{0j} + x_1 w_{1j} + x_2 w_{2j} + \text{---------} + x_n w_{nj}$$

$$= w_{0j} + \sum x_i w_{ij}$$

$$= bj + \sum_{i=1} x_i w_{ij}$$

Few more important terminologies in ANN

Learning Rate:

- The learning rate is denoted by ‘α’ .

- It is used to control the amount of weight adjustment at each step of training. The learning rate ranges from 0 to 1, determines the rate of learning at each time step