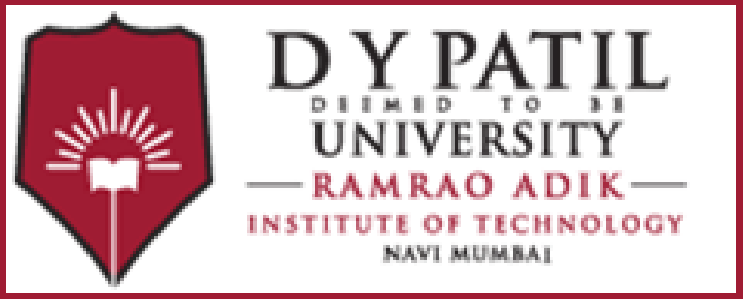


Subject Name: MACHINE LEARNING

Unit No: 3 Classification

Faculty Name : i
Ms.Rajashree Shedge

Index

Lecture No: 16

Introduction to NN

Human Brain

- Human brain composed of specific types of cells called, **Neurons**,which dosen't regenerate.
- As they aren't replaced, they have ability to remember, think & apply previous experience to everyday actions.

- **Human brain:**

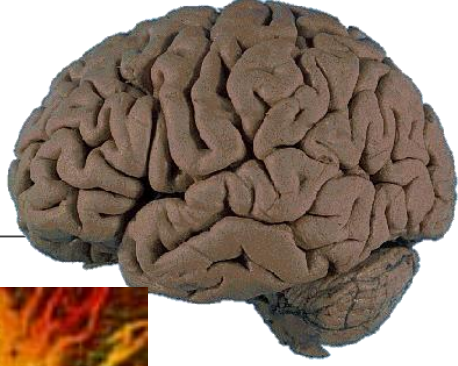
  one hundred billion (100,000,000,000) neurons

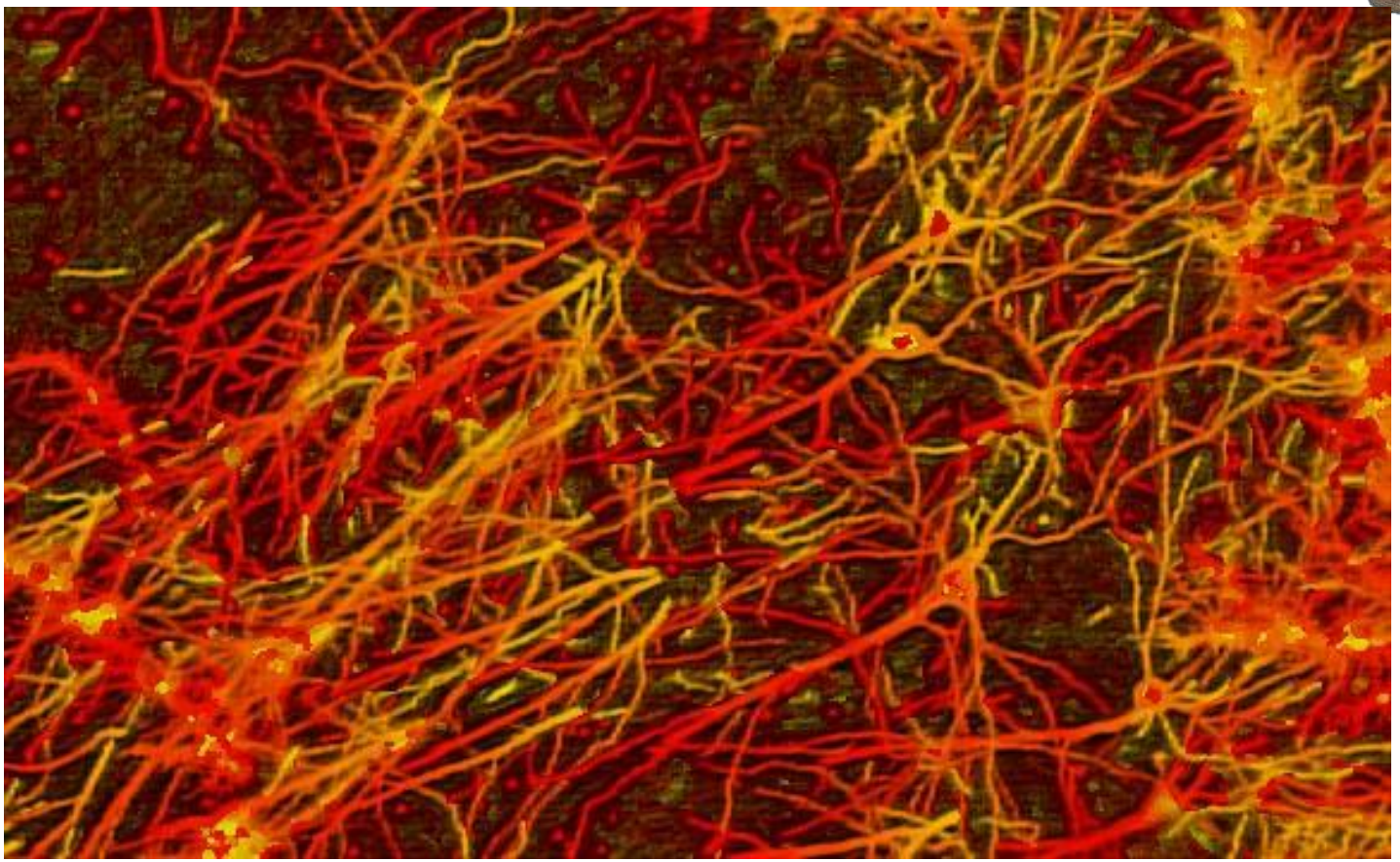
  each with about 1000 synaptic connections

- Each connected to other neurons

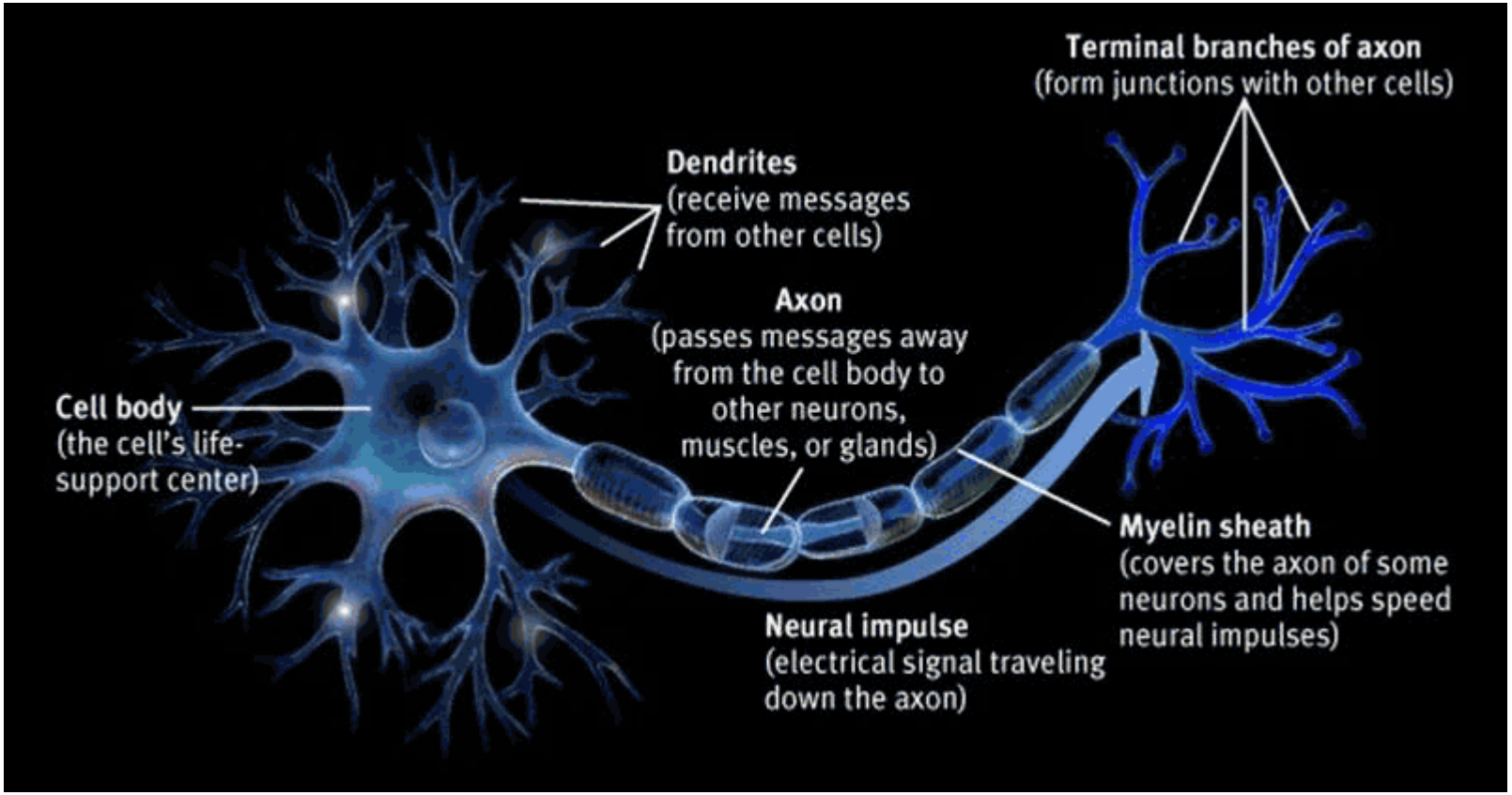
- Together these neurons & their connections form a process.
- How synapses are wired defines our brilliance
- Learning : changing effectiveness of synapses.

INTERCONNECTIONS IN BRAIN



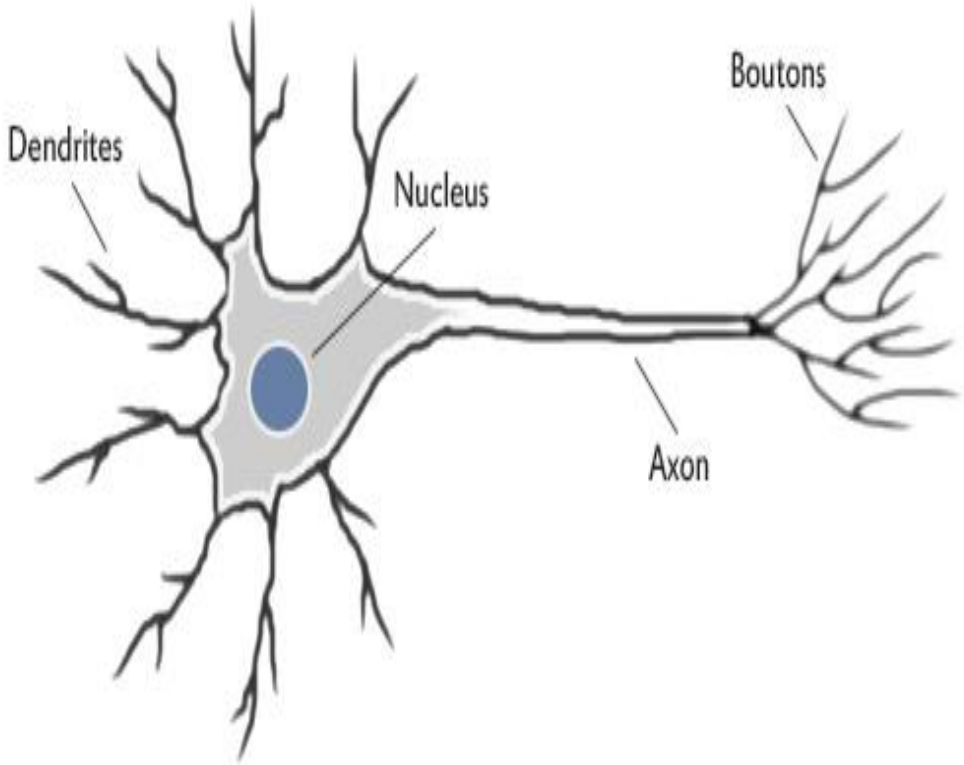


Biological Neural Network (Visualization)



Biological neuron

- collects inputs using dendrites
- sums up all inputs from dendrites
- if the resulting value is greater than its firing threshold, the neuron fires.
- Firing neuron sends an electrical impulse through the neuron's axon to its boutons.
- Boutons connect to other neurons via synapses.



Artificial Neural Network : An Introduction

- Resembles the characteristic of biological neural network.
- ***Nodes*** – interconnected processing elements (units or neurons)
- Neuron is connected to other by a ***connection link.***
- Each connection link is associated with ***weight*** which has information about the input signal.
- ANN processing elements are called as ***neurons or artificial neurons*** , since they have the capability to model networks of original neurons as found in brain.
- Internal state of neuron is called ***activation or activity level*** of neuron, which is the function of the inputs the neurons receives.
- Neuron can send only one signal at a time.

Artificial Neural Networks

- Hopes to **reproduce human brain** by artificial means.
- **Mimics** how **our nervous system** process information.
- ANN is **composed of** a large number of h**ighly interconnected processing elements (neurons)** working in unison to solve specific problems.
- ANNs, like people, **learn by example/experience**.
- It is configured for special application such as pattern recognition and data classification through a learning process.
- 85-90% accurate.

Definition of Neural Networks

- **According to the DARPA Neural Network Study (1988, AFCEA International Press, p. 60):**

  "A neural network is a system composed of many simple processing elements operating in parallel whose function is determined by network structure, connection strengths, and the processing performed at computing elements or nodes."

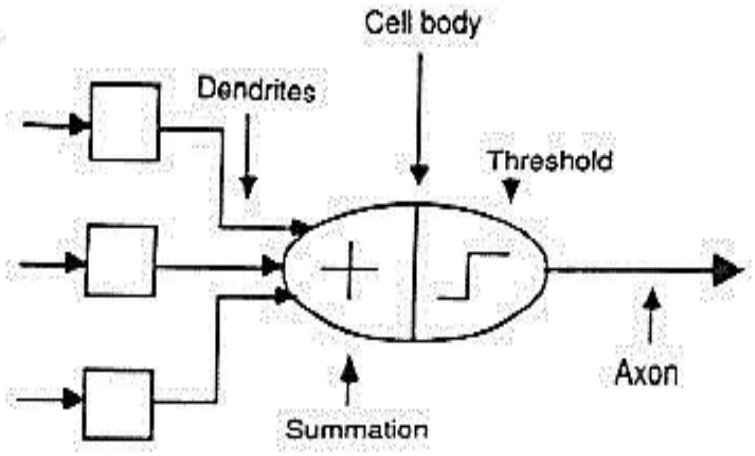
- **According to Haykin (1994), p. 2:**

  "A neural network is a massively parallel distributed processor that has a natural propensity for storing experiential knowledge and making it available for use."

  It resembles the brain in two respects:

- Knowledge is acquired by the network through a learning process.
- Interneuron connection strengths known as synaptic weights are used to store the knowledge.

From Human Neurons to Artificial Neurons

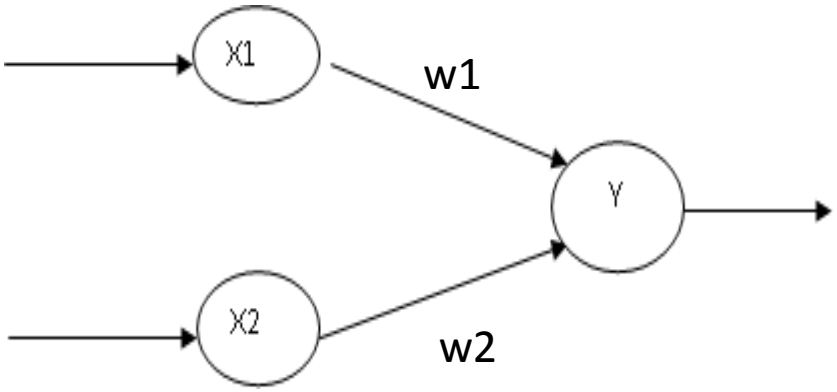


Biological Neuron	Artificial Neuron
Cell	Neuron
Dendrites	Weights or interconnections
Soma/cell body	Net input
Axon	Output

Basic Operation of a Neural Net

- X1 and X2 – input neurons.
- Y- output neuron
- Weighted interconnection links- W1 and W2.
- Net input calculation is :

$$Yin = x1w1 + x2w2$$



- Output is :

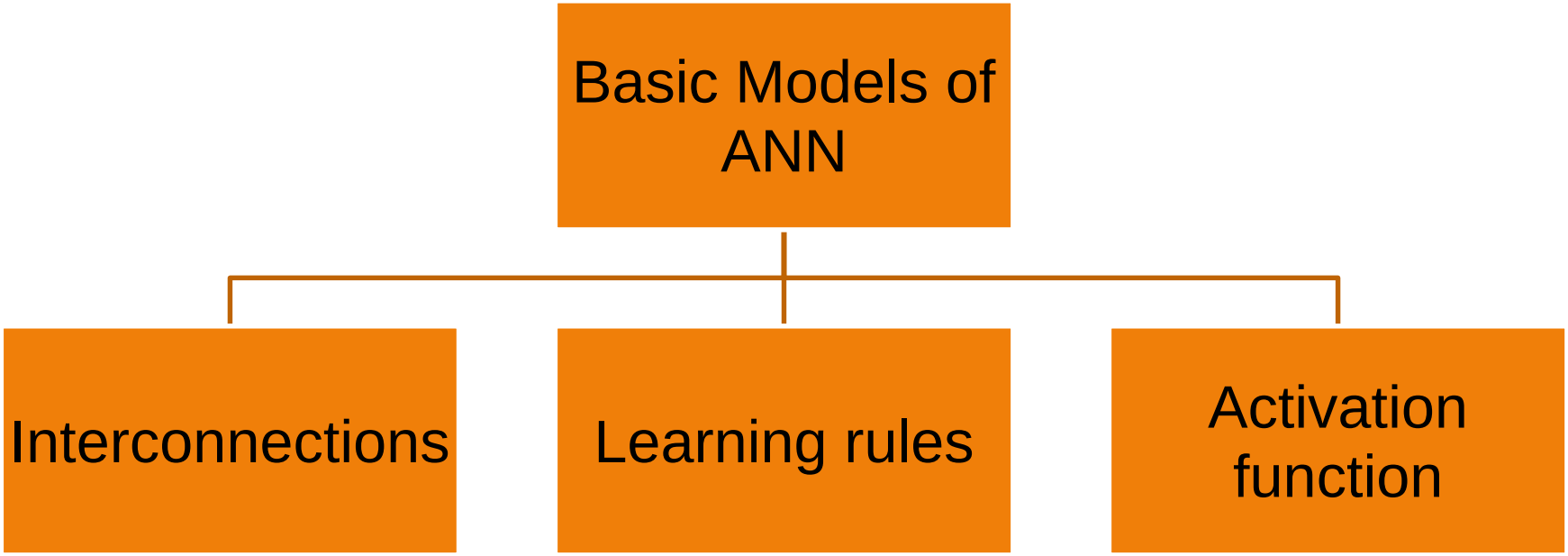
$$y = f(Yin)$$

- In general net input is calculated by:

$$Yin = x1wi + x2w2 + \cdots \ldots\ldots + xnwn$$

$$\sum_{i=1}^{n} x_i w_i$$

Components of Neural Networks

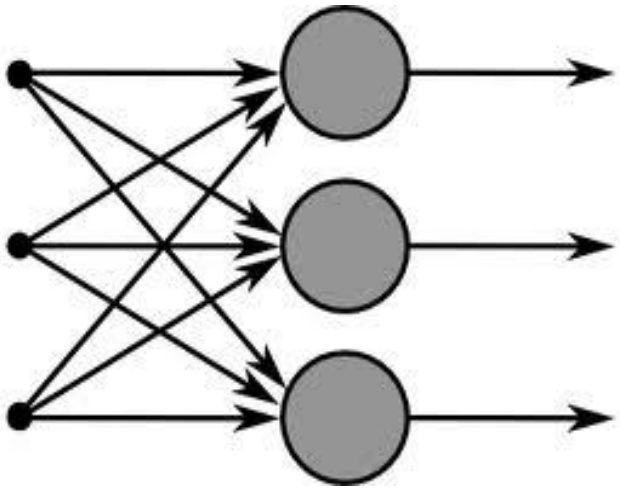


Basic models of ann

- The *arrangement of neurons to form layers* and the *connection pattern formed within and between layers* is called the ***network architecture.***
- Five types:
  - Single layer feed forward network
  - Multilayer feed-forward network
  - Single node with its own feedback
  - Single-layer recurrent network
  - Multilayer recurrent network

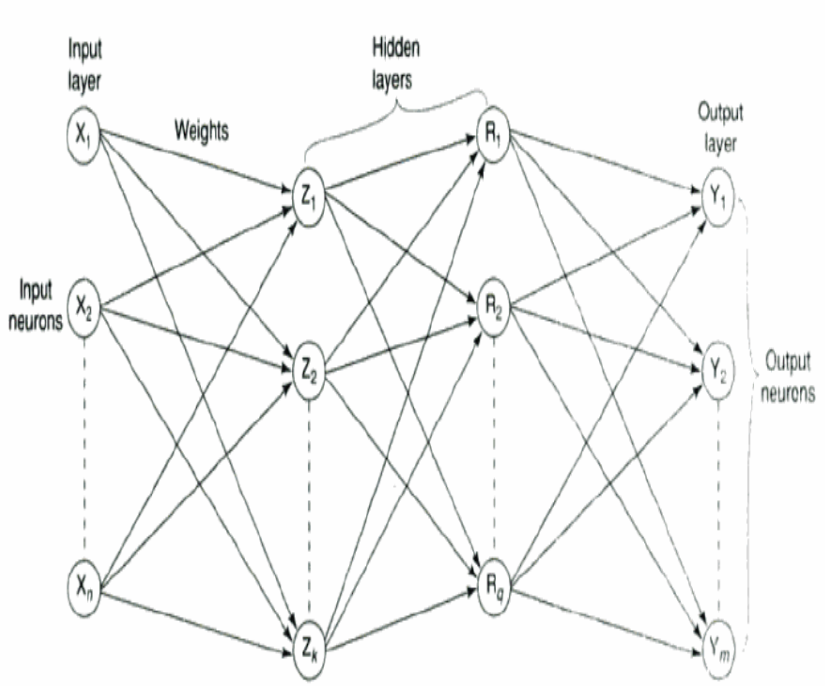
Single layer Feed- Forward Network

- Layer is formed by taking processing elements and combining it with other processing elements.
- Input and output are linked with each other
- Inputs are connected to the processing nodes with various weights, resulting in series of outputs one per node.



Multilayer feed-forward network

- Formed by the interconnection of several layers.
- Input layer receives input and buffers input signal.
- Output layer generated output.
- Layer between input and output is called *hidden layer.*
- Hidden layer is internal to the network.
- Zero to several hidden layers in a network.
- More the hidden layer, more is the complexity of network, but efficient output is produced.



Feed back network

- If no neuron in the output layer is an input to a node in the same layer / proceeding layer – ***feed forward network.***
- If outputs are directed back as input to the processing elements in the same layer/proceeding layer – ***feedback network.***
- If the output are directed back to the input of the same layer then it is ***lateral feedback.***
- ***Recurrent networks*** are networks with feedback networks with closed loop.

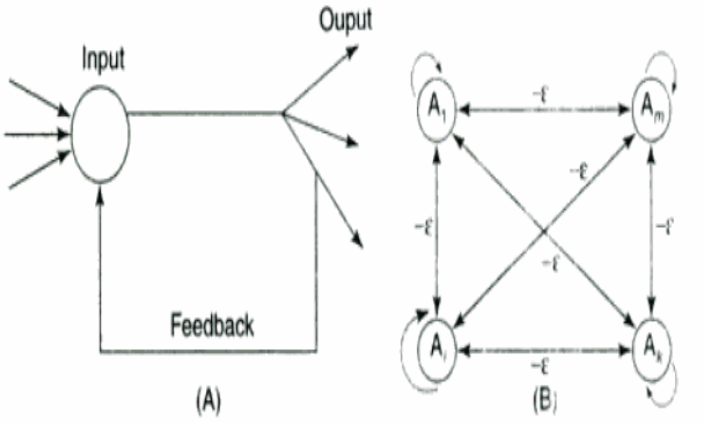


Figure 2-8 (A) Single node with own feedback. (B) Competitive nets.

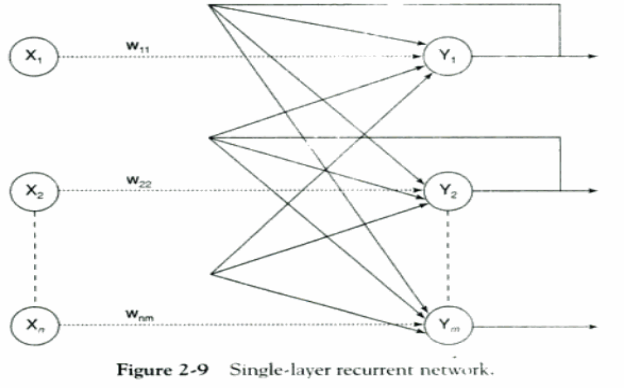
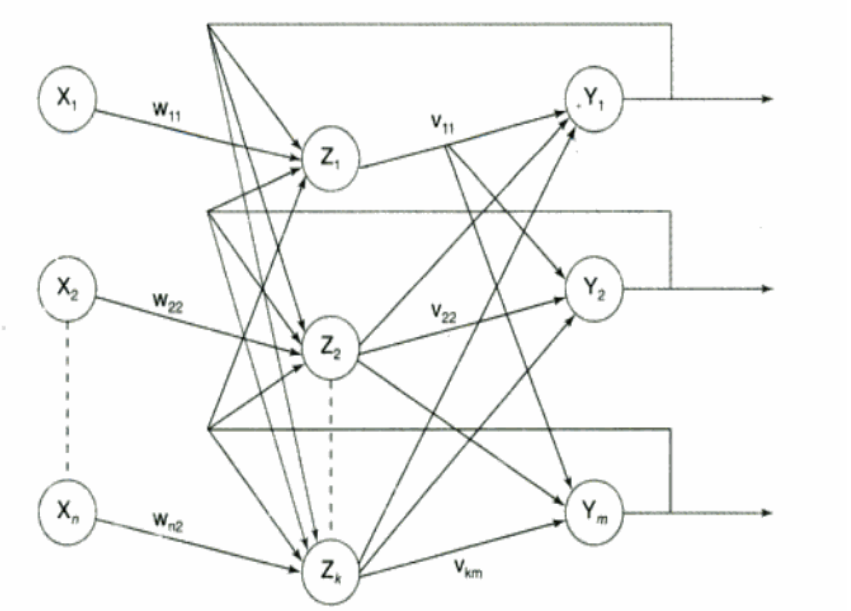


Figure 2-9 Single-layer recurrent network.

Continued….

- Processing element output can be directed back to the nodes in the preceding layer, forming a ***multilayer recurrent network.***
- Processing element output can be directed to processing element itself or to other processing element in the same layer.



Learning

- Two broad kinds of learning in ANNs is :

i) parameter learning – updates connecting weights in a neural net.

ii) Structure learning – focus on change in the network.

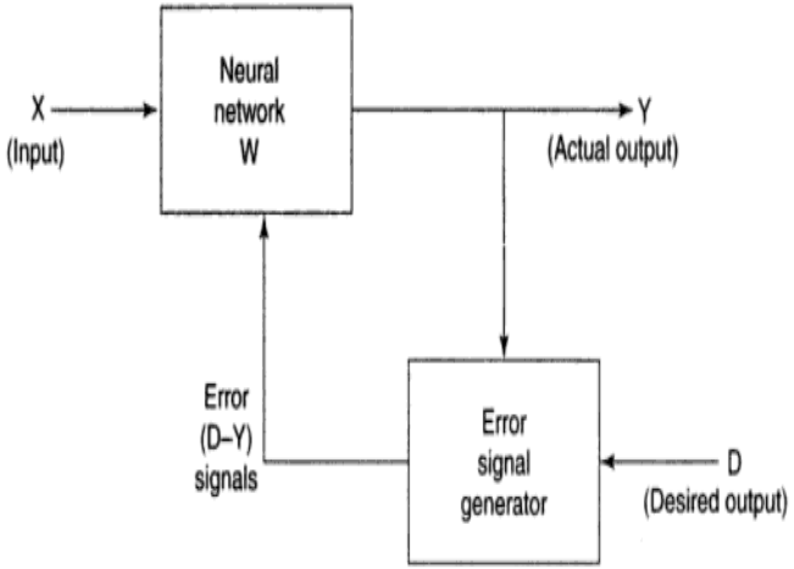
- Apart from these, learning in ANN is classified into three categories as

    i) supervised learning

    ii) unsupervised learning

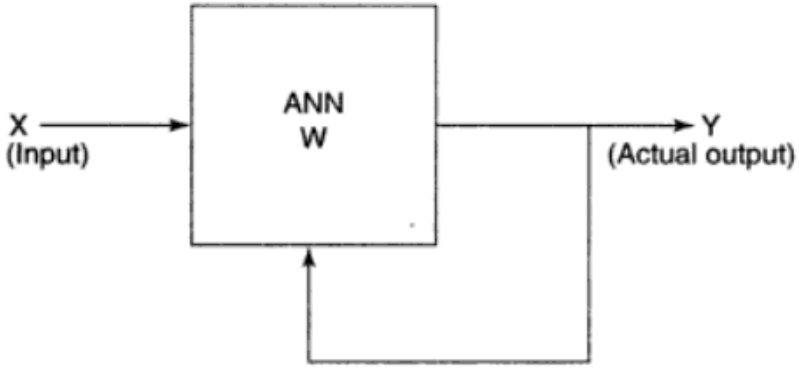
Supervised learning

- Learning with the help of a teacher.
- Example : learning process of a small child.
- Child doesn't know read/write.
- Their each & every action is supervised by a teacher
- In ANN, each input vector requires a corresponding target vector, which represents the desired output.
- The input vector along with target vector is called ***training pair.***
- The input vector results in output vector.
- The actual output vector is compared with desired output vector.
- If there is a difference means an error signal is generated by the network.It is used for adjustment of weights until actual output matches desired output.



Unsupervised learning

- Learning is performed without the help of a teacher.
- Example: tadpole – learn to swim by itself.
- In ANN, during training process, network receives input patterns and organize it to form clusters.
- From the Fig. it is observed that no feedback is applied from environment to inform what output should be or whether they are correct.
- The network itself discover patterns, regularities, features/ categories from the input data and relations for the input data over the output.
- Exact clusters are formed by discovering similarities & dissimilarities so called as *self – organizing.*



Activation functions

- To make work more efficient and for exact output, some force or activation is given.
- Like that, activation function is applied over the net input to calculate the output of an ANN.
- Information processing of processing element has two major parts: input and output.
- An integration function (*f*) is associated with input of processing element.
- Several activation functions are there.

1. Identity function:

it is a linear function which is defined as

$$f(x) = x \text{ for all } x$$

The output is same as the input.

2. Binary step function

it is defined as

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

where θ represents thresh hold value.

It is used in single layer nets to convert the net input binary (0 or 1)

Activation functions….

3. *Bipolar step function:*

It is defined as $$f(x) = \begin{cases} 1 & if\ x \geq \theta \\ -1 & if\ x < \theta \end{cases}$$

where θ represents threshold value.

used in single layer nets to convert the net input to an output that is bipolar (+1 or -1).

4. *Sigmoid function*

used in Back propagation nets.

Two types:

a) binary sigmoid function

-logistic sigmoid function or unipolar sigmoid function.

-it is defined as

where λ – steepness parameter. $$f(x) = \frac{1}{1 + e^{-\lambda x}}$$

-The derivative of this function is

f'(x) = λ f(x)[1-f(x)]. The range of sigmoid function is 0 to 1.

Activation functions….

b) *Bipolar sigmoid function*

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

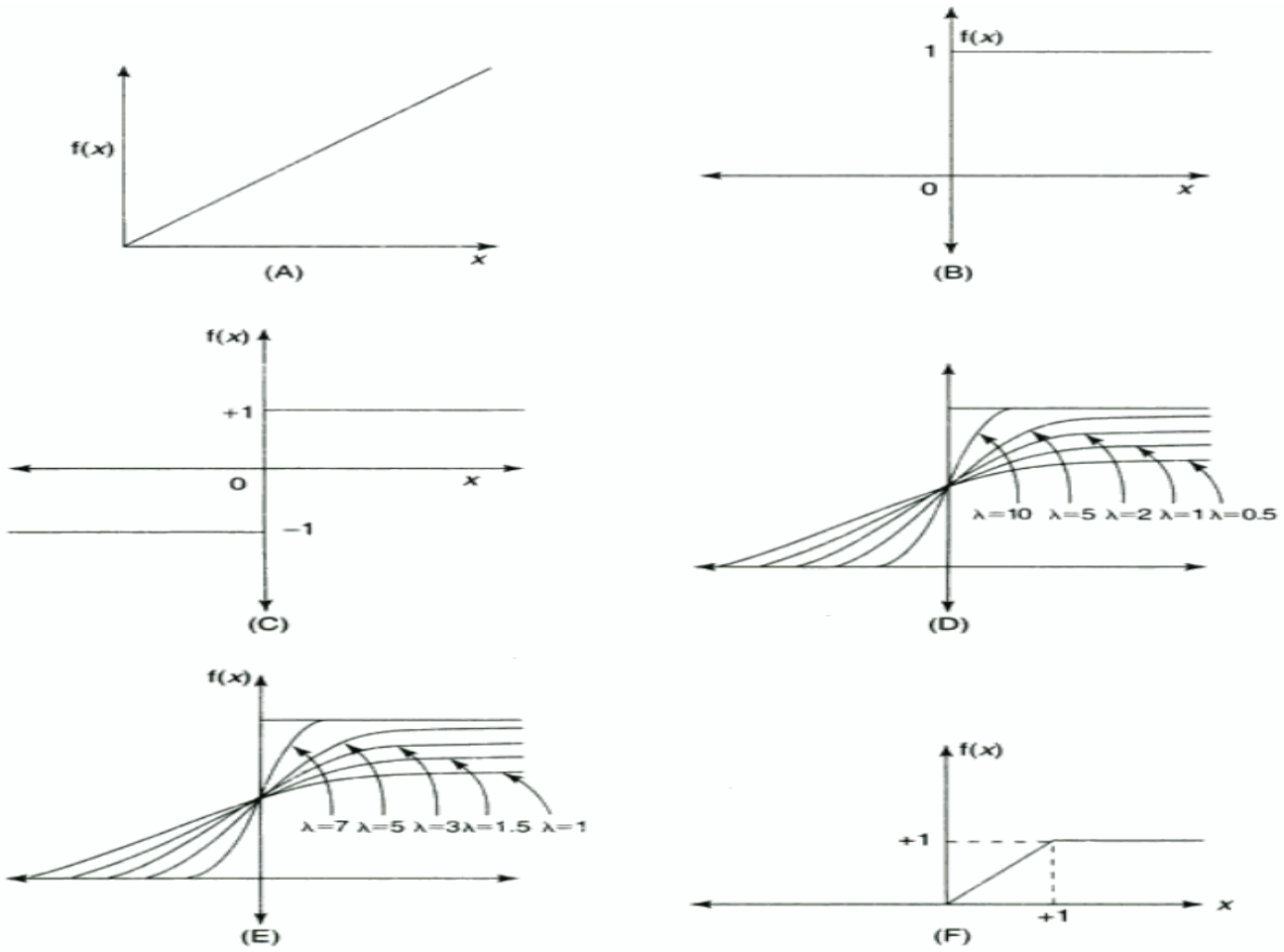
where λ- steepness parameter and the sigmoid range is between -1 and +1.

5. Ramp function

$$f(x) = \begin{cases} 1 & if\ x > 1 \\ x & if\ 0 \leq x \leq 1 \\ 0 & if\ x < 0 \end{cases}$$

The graphical representation of all these function is given in the upcoming Figure

Activation Functions....



2-15 Depiction of activation functions: (A) identity function; (B) binary step function; (C) bipolar step function; (D) binary sigmoidal function; (E) bipolar sigmoidal function; (F) ramp function.

Lecture No: 17
McCulloch-Pitt's Neuron

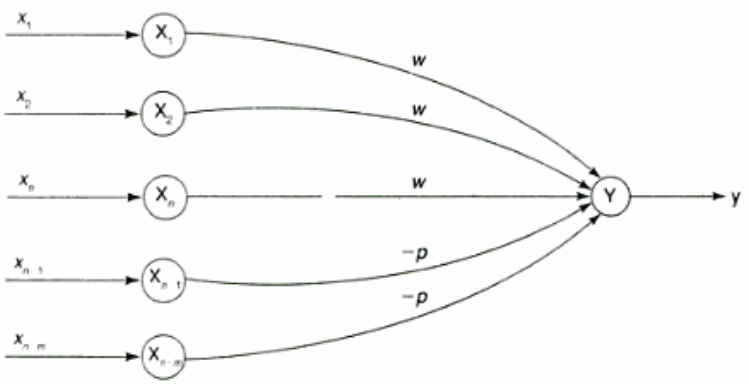
Mcculloch-Pitts neuron

- Discovered in 1943.
- Usually called as *M-P neuron.*
- M-P neurons are connected by directed weighted paths.
- Activation of M-P neurons is binary (i.e) at any time step the neuron may fire or may not fire.
- Weights associated with communication links may be excitatory(weights are positive)/inhibitory(weights are negative).
- Threshold plays major role here. There is a fixed threshold for each neuron and if the net input to the neuron is greater than the threshold then the neuron fires.
- They are widely used in logic functions.

Continued...

- A simple M-P neuron is shown in the figure.
- It is excitatory with weight (*w>0)* / inhibitory with weight *–p (p<0)*.
- In the Fig., inputs from x_1 to x_n possess excitatory weighted connection and X_{n+1} to x_{n+m} has inhibitory weighted interconnections.
- Since the firing of neuron is based on threshold, activation function is defined as

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



Continued....

- For inhibition to be absolute, the threshold with the activation function should satisfy the following condition:

$$\theta > nw - p$$

- Output will fire if it receives "*k*" or more excitatory inputs but no inhibitory inputs where

$$kw \geq \theta > (k-1)\, w$$

- **The M-P neuron has no particular training algorithm.**
- An analysis is performed to determine the weights and the threshold.
- It is used as a building block where any function or phenomenon is modeled based on a logic function.

Practice Problem

- Implement AND function using McCulloch Pitts neuron,
- Steps:
  - Provide training data(truth table of AND operation)
  - Assume weights
  - Draw NN architecture
  - Calculate Net Input

$$Yin = x1wi + x2w2 + \cdots \ldots\ldots + xnwn$$

  - ChooseThreshold to apply activation function
  - Calculate output using activation function.

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

Practice Problem

Q. Implement AND function using McCulloch-Pitts neuron (take binary data)

Soln: Consider the truth table for AND function

x1	x2	y
1	1	1
1	0	0
0	1	0
0	0	0

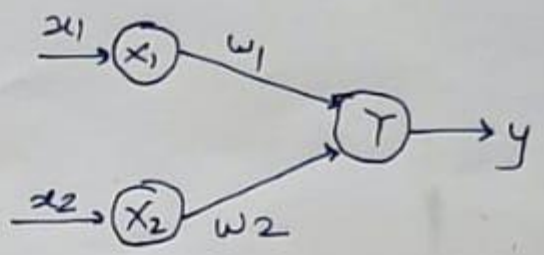
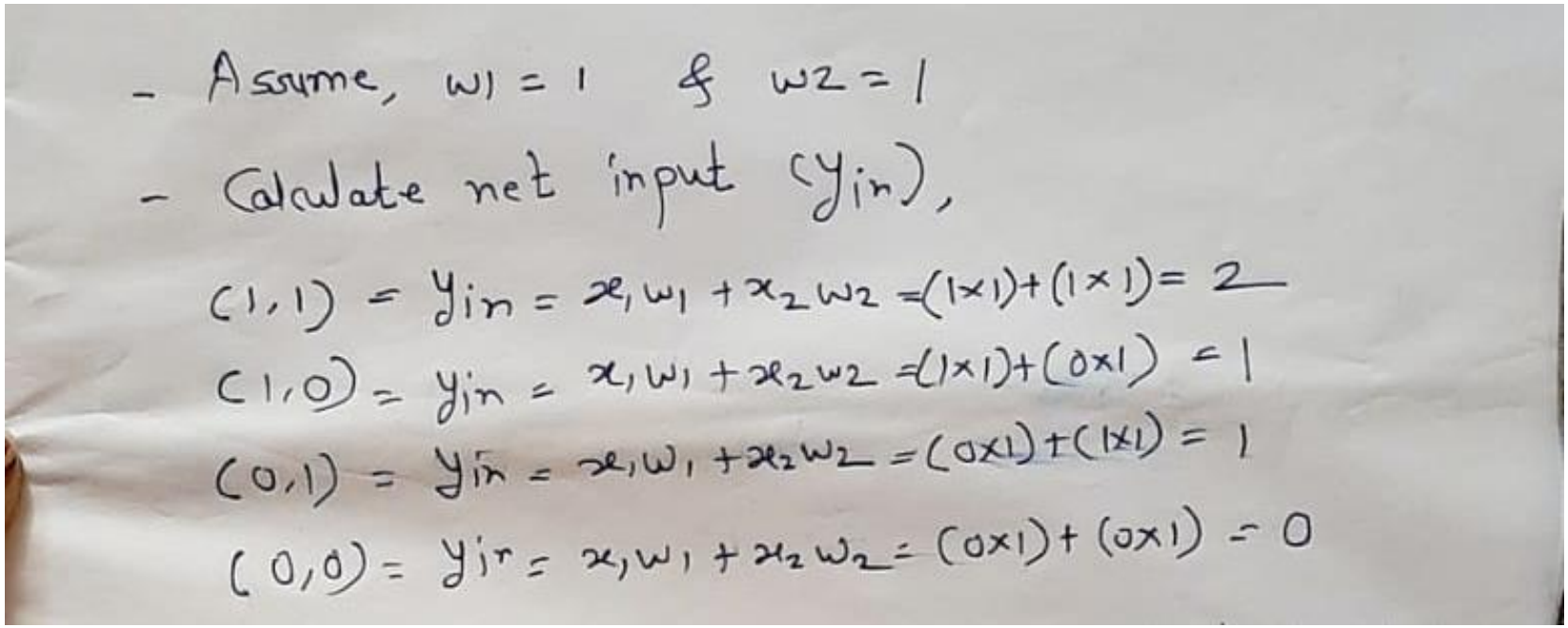
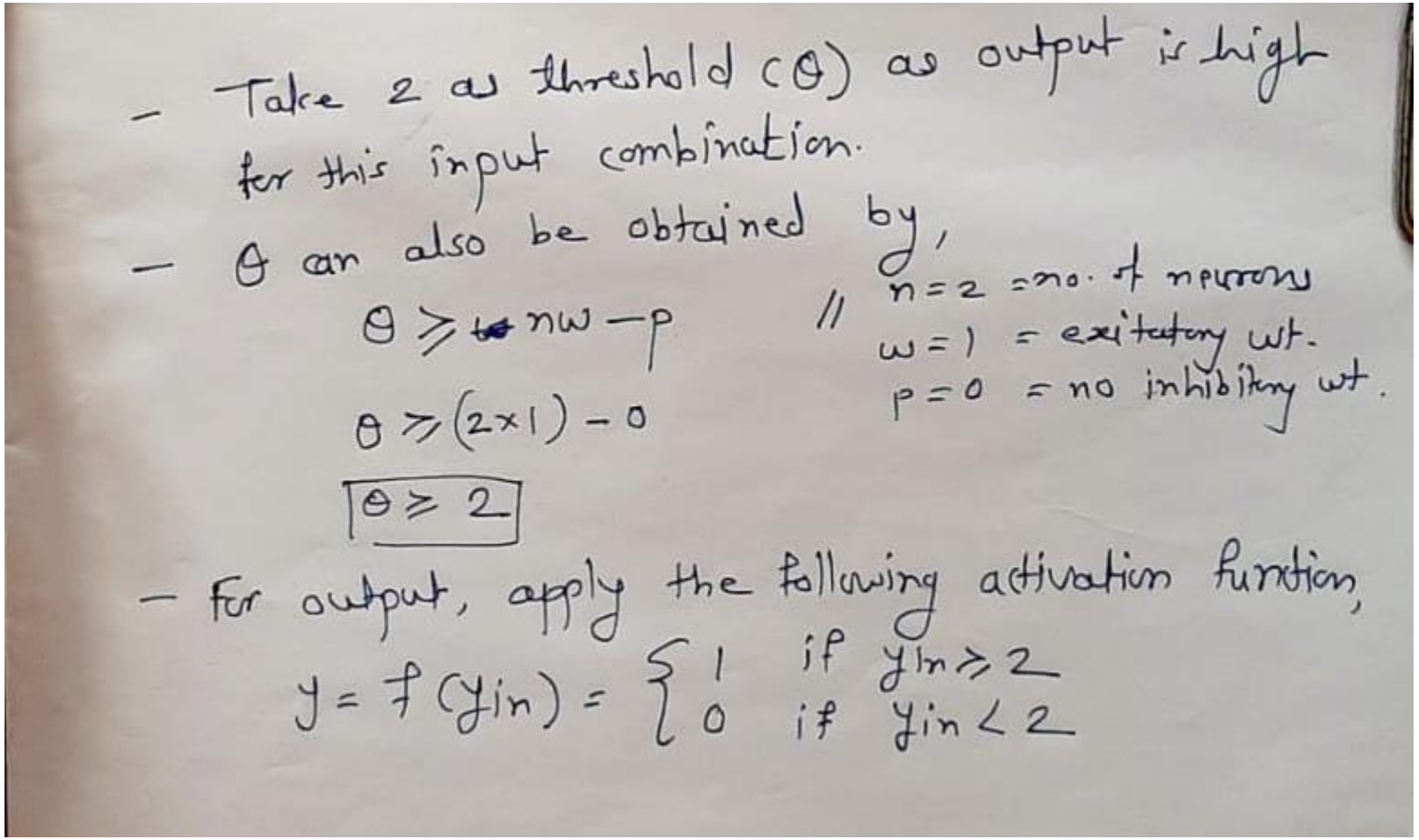


Fig. Neural net

Practice Problem



Practice Problem



Reference for problem solving

PRINCIPLES OF SOFT COMPUTING- Book by S.N. Deepa & S.N. Sivanandam

https://pg.its.edu.in/sites/default/files/MCAKCA032-PRINCIPALES%20OF%20SOFT%20COMPUTING-SN%20SIVNANDAM%20AND%20DEEPA%20SN.pdf

- McCulloch-Pitt's Model (M-P Neuron): Book Pg No. 34

Lecture No: 18
NN Case Study

NN for Regression

- The purpose of using Artificial Neural Networks for Regression over Linear Regression is that the linear regression can only learn the linear relationship between the features and target and therefore cannot learn the complex non-linear relationship.
- In order to learn the complex non-linear relationship between the features and target, we are in need of other techniques. One of those techniques is to use Artificial Neural Networks.
- Artificial Neural Networks have the ability to learn the complex relationship between the features and target due to the presence of activation function in each layer.

NN Case Study on Regression

Regression-based neural networks: Predicting Average Daily Rates for Hotels

https://towardsdatascience.com/regression-based-neural-networks-with-tensorflow-v2-0-predicting-average-daily-rates-e20fffa7ac9a

Thank You

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