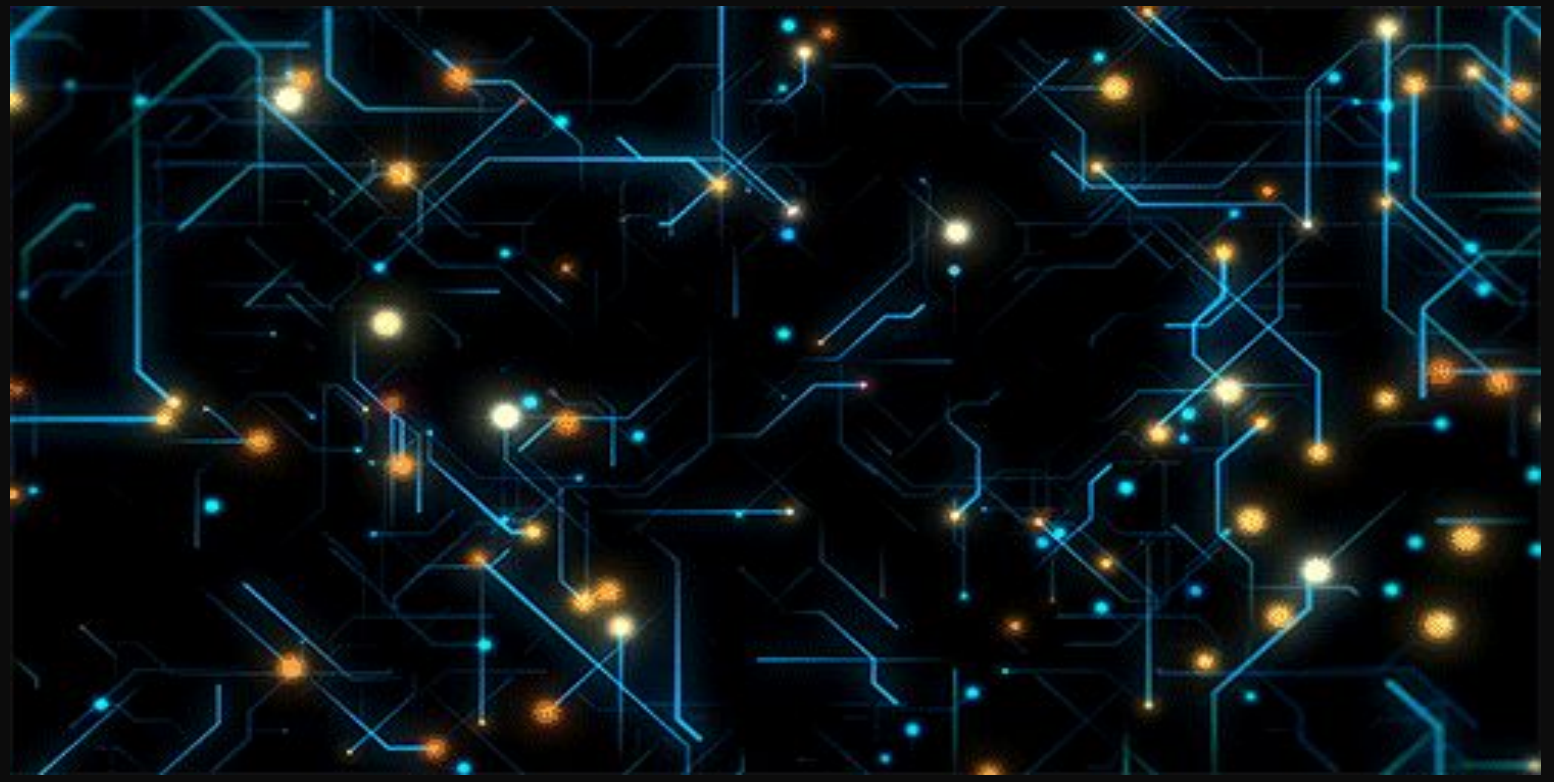


Artificial Neural Network

UNIT 1 – Introduction to ANN

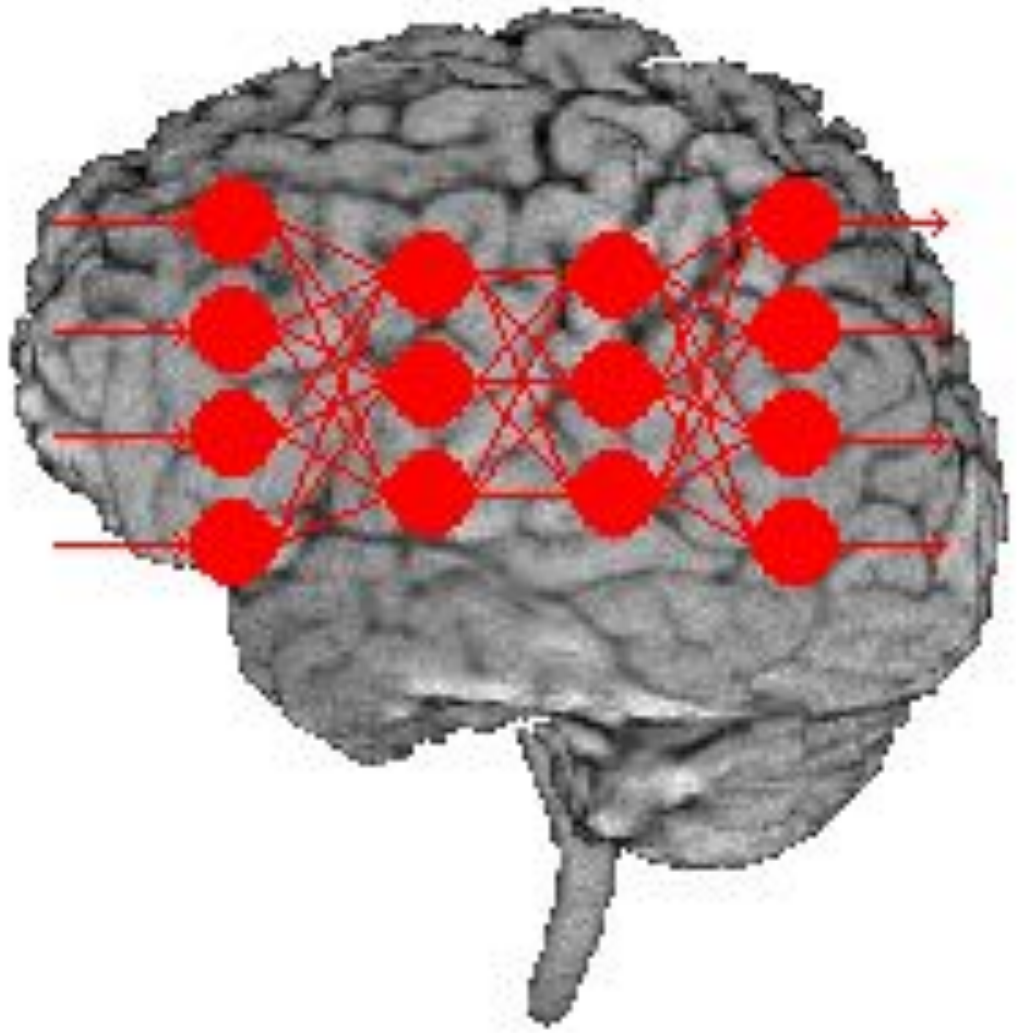
Made by: - Pranjali Bahalkar & Vaidehi Sharma

Teaching Scheme-

Teaching Scheme	Credit	Examination Scheme
TH: 04 Hours/Week	03	**Mid_Semester(TH): 30 Marks**
		End_Semester(TH): 70 Marks

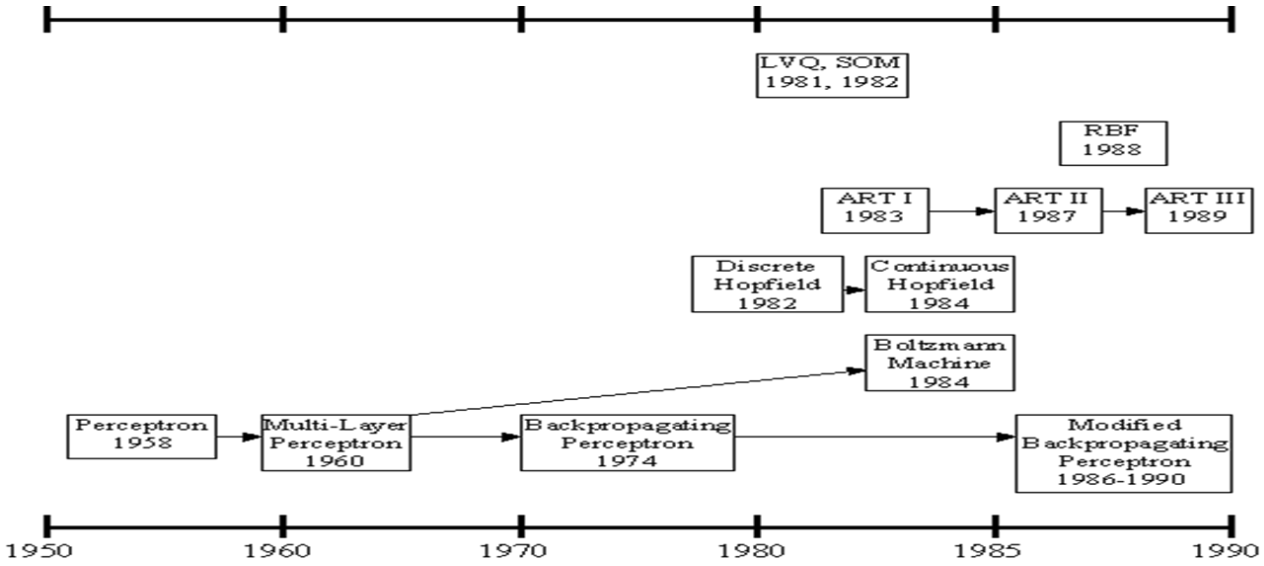
Syllabus-

Unit I	**Introduction to ANN**	**(07 Hours)**
Unit II	**Learning Algorithms**	**(07 Hours)**
Unit III	**Associative Learning**	**(07 Hours)**
Unit IV	**Competitive learning Neural Network**	**(07 Hours)**
Unit V	**Convolution Neural Network**	**(07 Hours)**
Unit VI	**Applications of ANN**	**(06 Hours)**



INTRODUCTION TO ANN

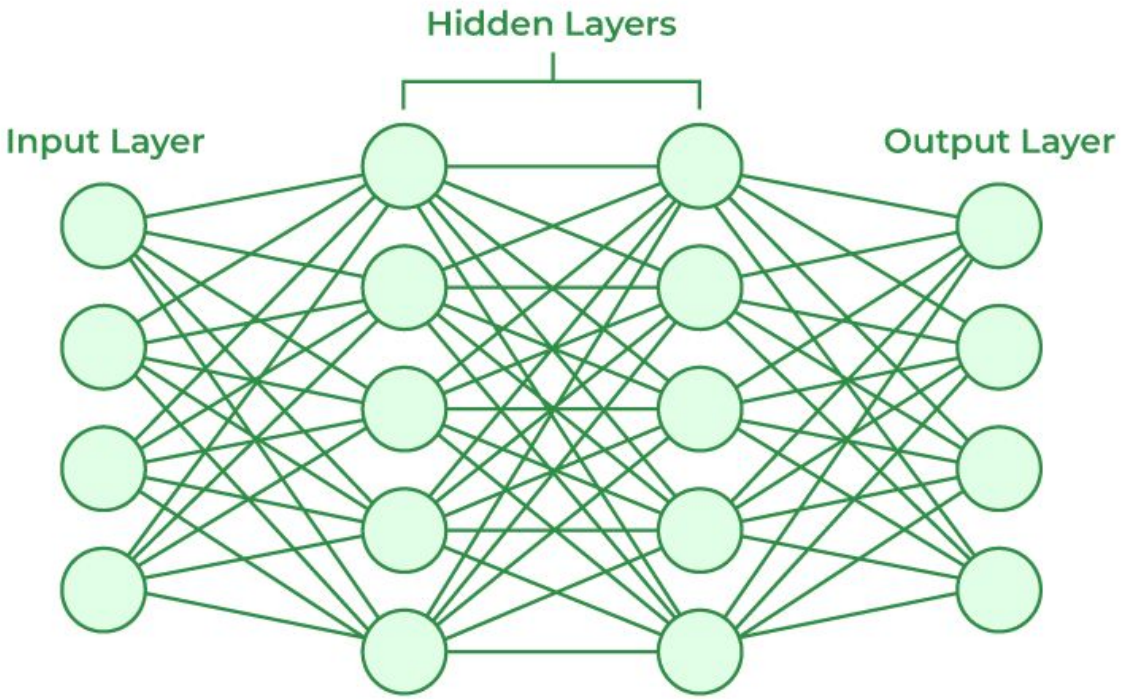
History of the Artificial Neural Networks



- History of the ANNs stems from the 1940s, the decade of the first electronic computer.
- However, the first important step took place in 1957 when Rosenblatt introduced the first concrete neural model, the perceptron. Rosenblatt also took part in constructing the first successful neurocomputer, the Mark I Perceptron. After this, the development of ANNs has proceeded as described in *Figure*.

Conti…

- Rosenblatt's original perceptron model contained only one layer. From this, a multi-layered model was derived in 1960. At first, the use of the multi-layer perceptron (MLP) was complicated by the lack of a appropriate learning algorithm.
- In 1974, Werbos came to introduce a so-called backpropagation algorithm for the three-layered perceptron network.
- In 1986, The application area of the MLP networks remained rather limited until the breakthrough when a general back propagation algorithm for a multi-layered perceptron was introduced by Rummelhart and Mclelland.
- In 1982, Hopfield brought out his idea of a neural network. Unlike the neurons in MLP, the Hopfield network consists of only one layer whose neurons are fully connected with each other.
- Since then, new versions of the Hopfield network have been developed. The Boltzmann machine has been influenced by both the Hopfield network and the MLP.



ANN Architecture

Definition-

- An artificial neural network consists of a pool of simple processing units which communicate by sending signals to each other over a large number of weighted connections.
- An artificial neural network is a collection of simple interconnected algorithms that process information in response to external input. This neural net is loosely modeled after biological neural networks.
- Commonly, Artificial Neural Network has an input layer, an output layer as well as hidden layers

1. Input Layer

•**Purpose**: Receives the raw data input for the network.

•**Description**: Simply passes the input data to the next layer.

The number of nodes in this layer corresponds to the number of features in the input data.

2. Hidden Layers

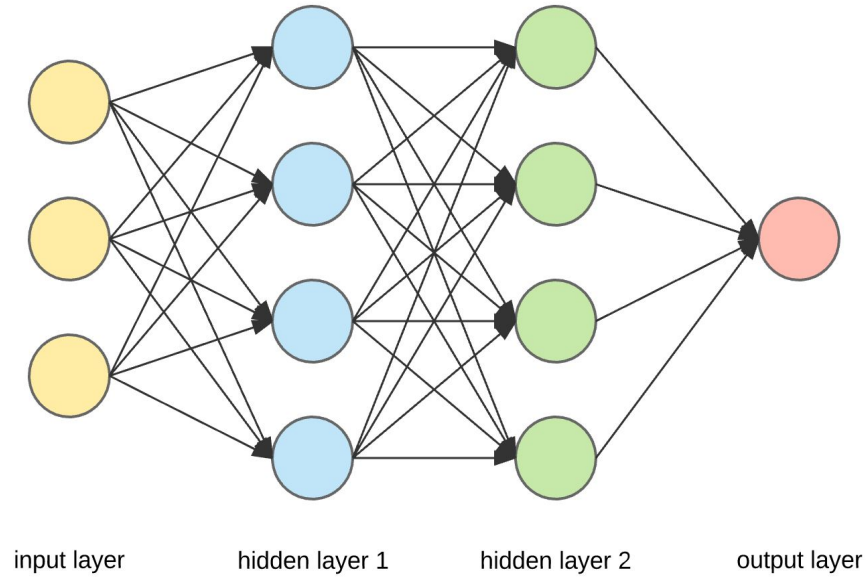
•**Purpose**: Extract features and patterns from the input data.

•**Description**: Each neuron in a hidden layer:

Receives weighted inputs.

Applies a bias.

Passes the result through an activation function



3. Output Layer

•**Purpose**: Produces the final prediction or decision of the network.

•**Description**: Number of neurons corresponds to the number of output categories or values.

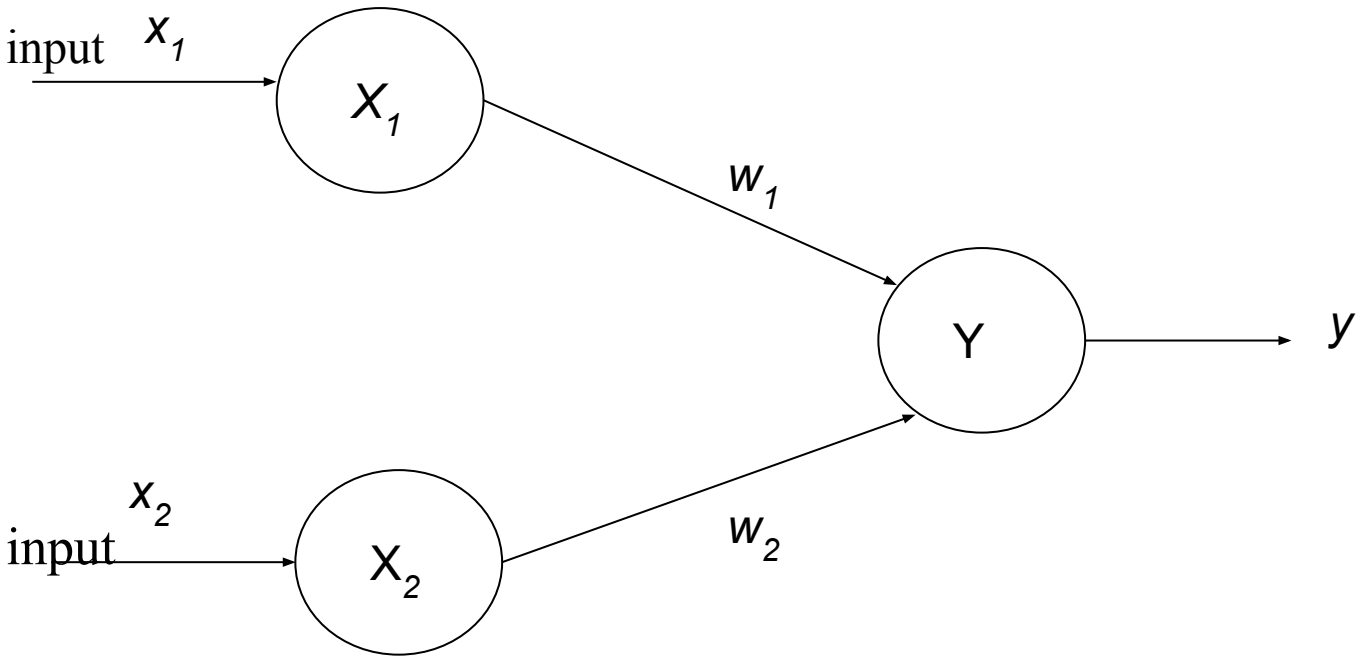
- Artificial Neural Networks contain artificial neurons which are called **units** .
- These units are arranged in a series of layers that together constitute the whole Artificial Neural Network in a system.
- A layer can have only a dozen units or millions of units as this depends on how the complex neural networks will be required to learn the hidden patterns in the dataset.
- The input layer receives data from the outside world which the neural network needs to analyze or learn about. Then this data passes through one or multiple hidden layers that transform the input into data that is valuable for the output layer.
- Finally, the output layer provides an output in the form of a response of the Artificial Neural Networks to input data provided.
- 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 more and more about the data which eventually results in an output from the output layer.

- The structures and operations of human neurons serve as the basis for artificial neural networks.
- It is also known as neural networks or neural nets.
- The input layer of an artificial neural network is the first layer, and it receives input from external sources and releases it to the hidden layer, which is the second layer.
- In the hidden layer, each neuron receives input from the previous layer neurons, computes the weighted sum, and sends it to the neurons in the next layer.
- These connections are weighted means effects of the inputs from the previous layer are optimized more or less by assigning different-different weights to each input and it is adjusted during the training process by optimizing these weights for improved model performance.

What is ANN-

- ANN possess a large number of processing elements called nodes/neurons which operate in parallel.
- Neurons are connected with others by connection link.
- Each link is associated with weights which contain information about the input signal.
- Each neuron has an internal state of its own which is a function of the inputs that neuron receives- Activation level
- ANN are constructed and implemented to model the human brain.
- Performs various tasks such as pattern-matching, classification, optimization function, approximation, vector quantization and data clustering.
- These tasks are difficult for traditional computers

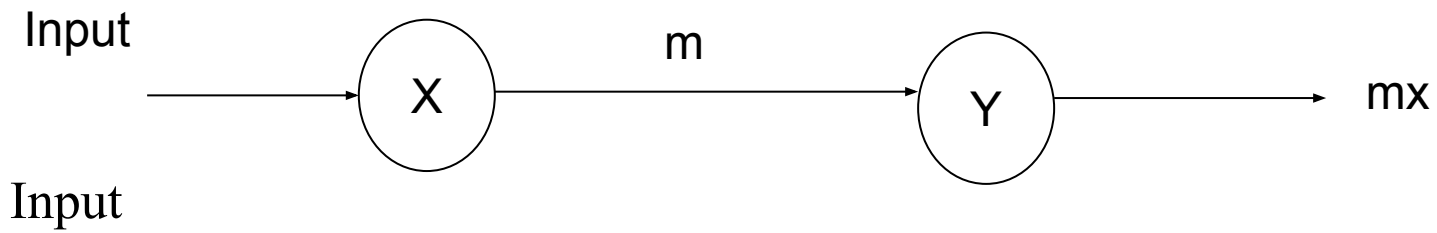
Artificial Neural Networks function-



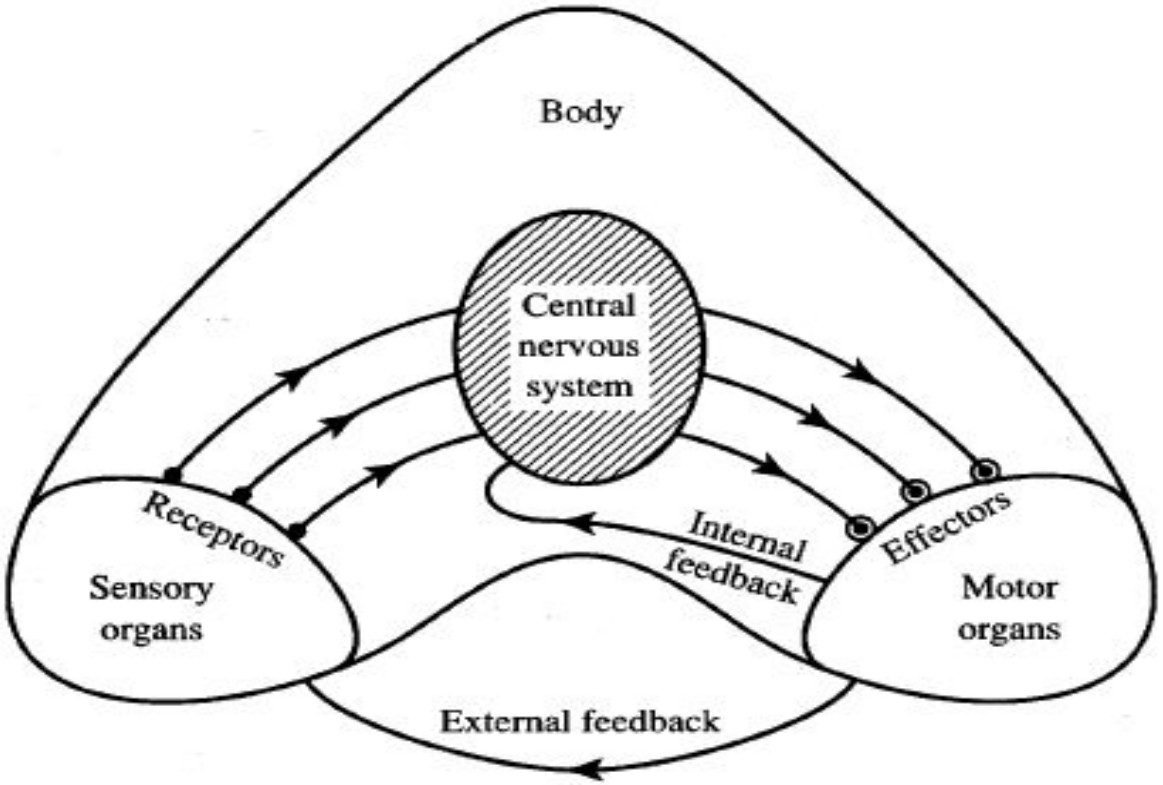
$$y = f(y_{in})$$

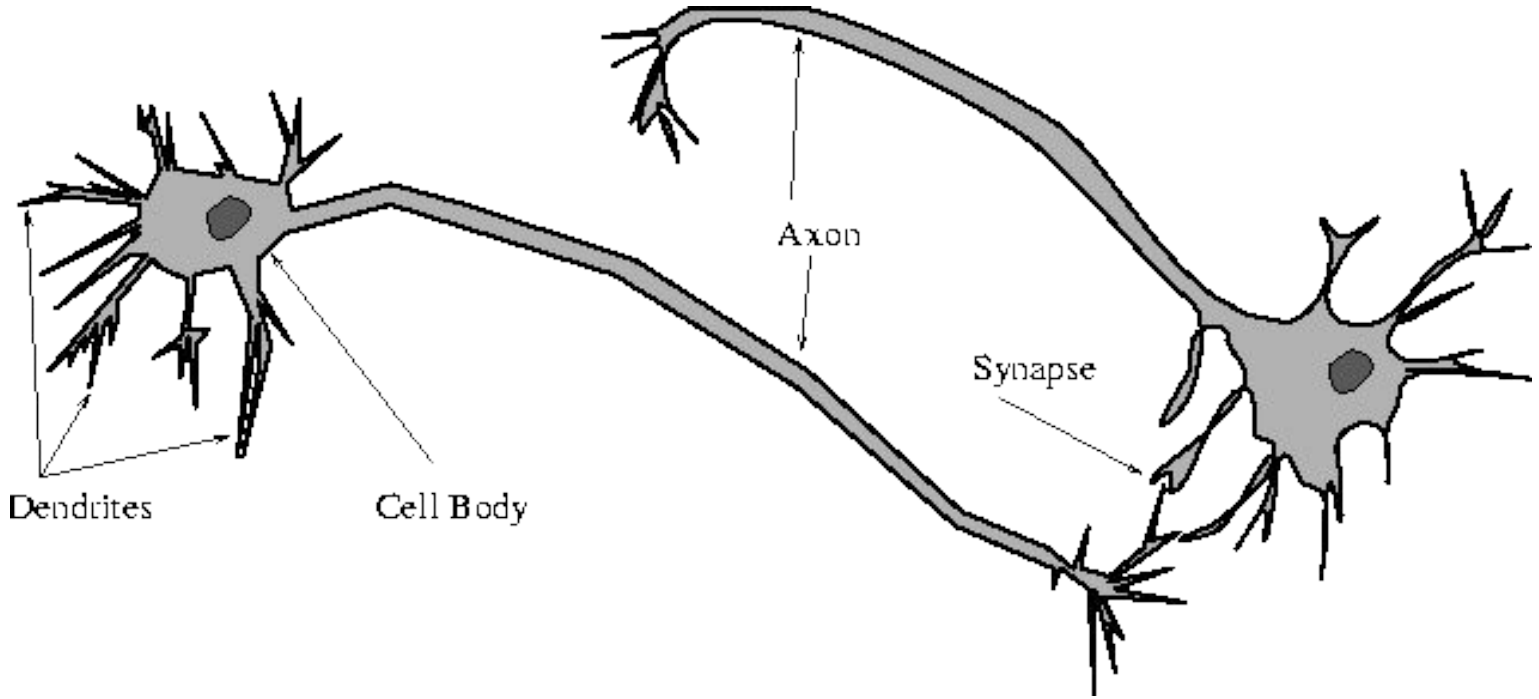
$$y_{in} = x_1 w_1 + x_2 w_2$$

Neural net of pure linear eqn.



Information flow in nervous system





BIOLOGICAL NEURAL NETWORK

Artificial neurons vs Biological neurons

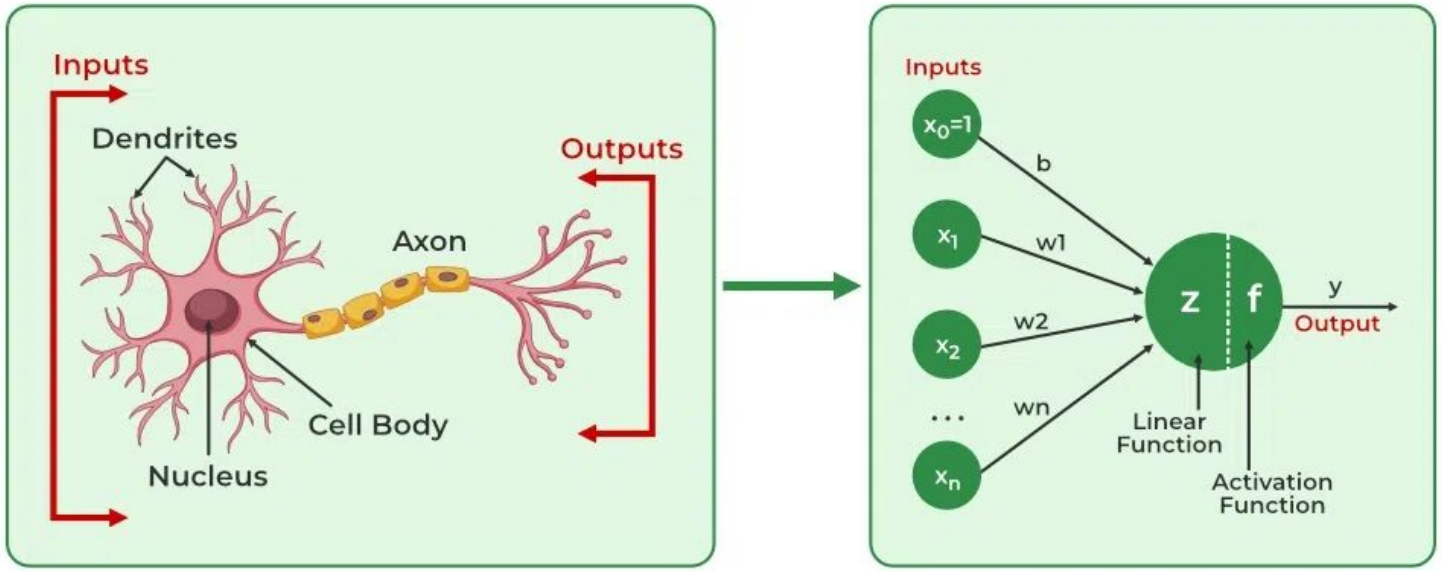
Structure :

- The structure of artificial neural networks 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 transfers them to other neurons.
- The input nodes of artificial neural networks receive input signals, the hidden layer nodes compute these input signals, and the output layer nodes compute the final output by processing the hidden layer's results using activation functions.

Synapses :

- Synapses are the links between biological neurons that enable the transmission of impulses from dendrites to the cell body. Synapses are the weights that join the one-layer nodes to the next-layer nodes in artificial neurons. The strength of the links is determined by the weight value.

Conti..



Biological Neuron	Artificial Neuron
Dendrite	Inputs
Cell nucleus or Soma	Nodes
Synapses	Weights
Axon	Output

Advantages and Disadvantages-

Some advantages of ANN :

- Ability to learn irrespective of the type of data (Linear or Non-Linear).
- ANN is highly volatile and serves best in financial time series forecasting.

Some disadvantages of ANN :

- The simplest architecture makes it difficult to explain the behavior of the network.
- This network is dependent on hardware.

Conti..

- **Biological Neural Network:**

  Biological Neural Network (BNN) is a structure that consists of Synapse, dendrites, cell body, and axon. In this neural network, the processing is carried out by neurons. Dendrites receive signals from other neurons, Soma sums all the incoming signals and axon transmits the signals to other cells.

- **Some advantages of BNN :**

  The synapses are the input processing element.

  It is able to process highly complex parallel inputs.

- **Some disadvantages of BNN :**

  There is no controlling mechanism.

  Speed of processing is slow being it is complex.

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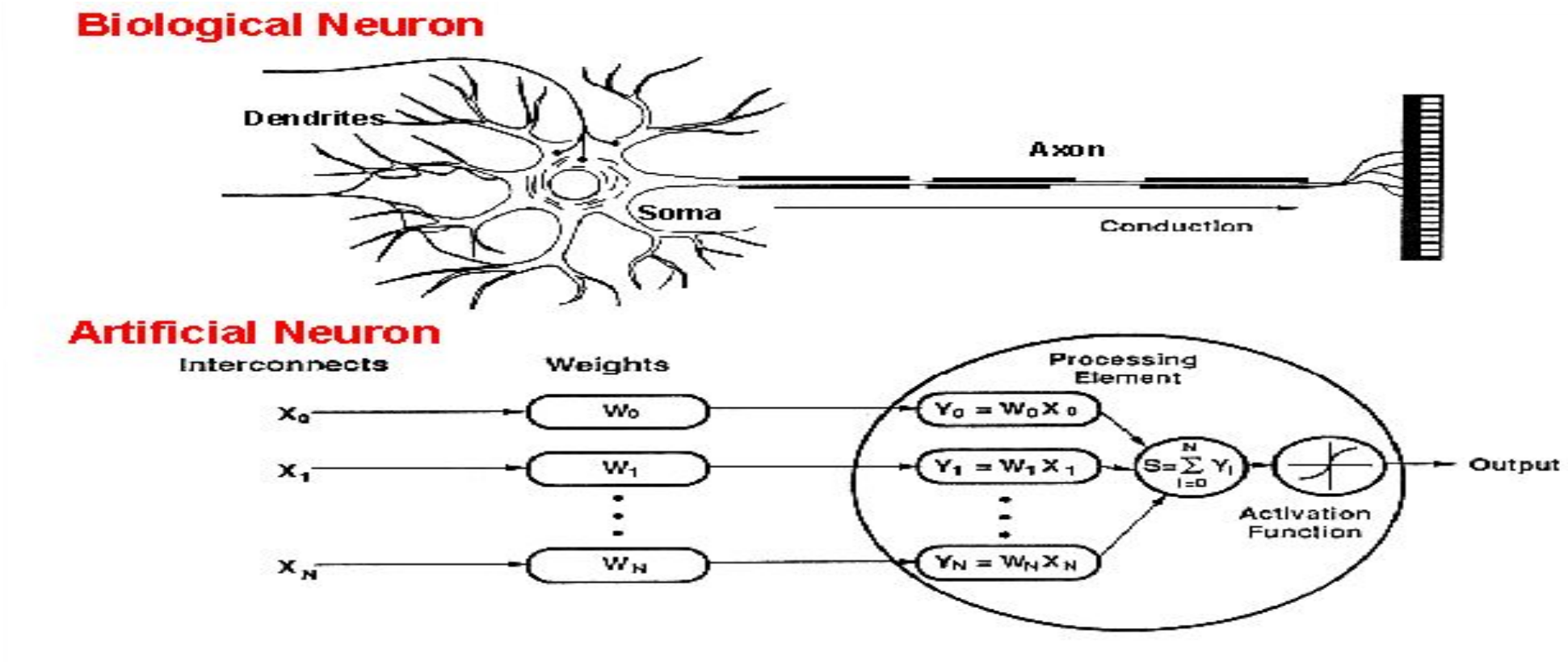
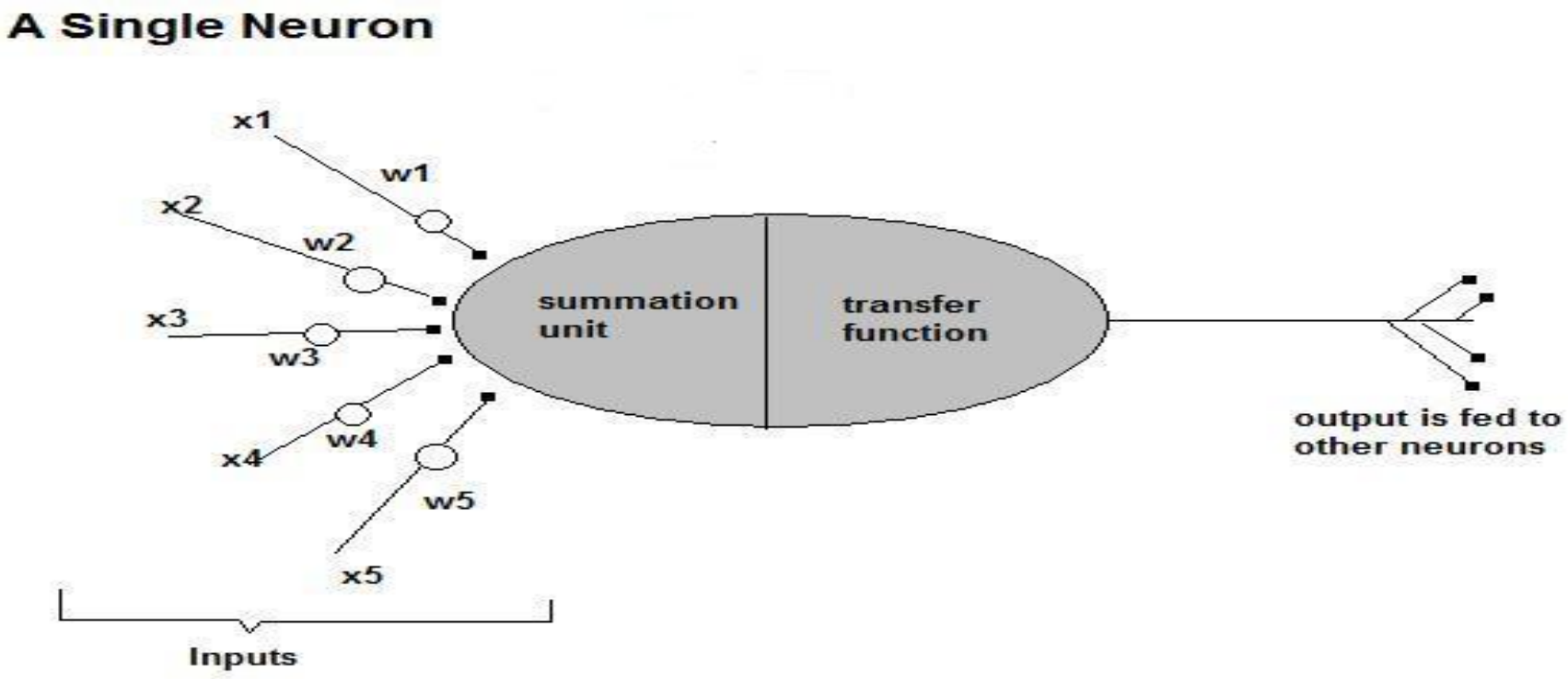
How do ANNs work?



An artificial neuron is an imitation of a human neuron

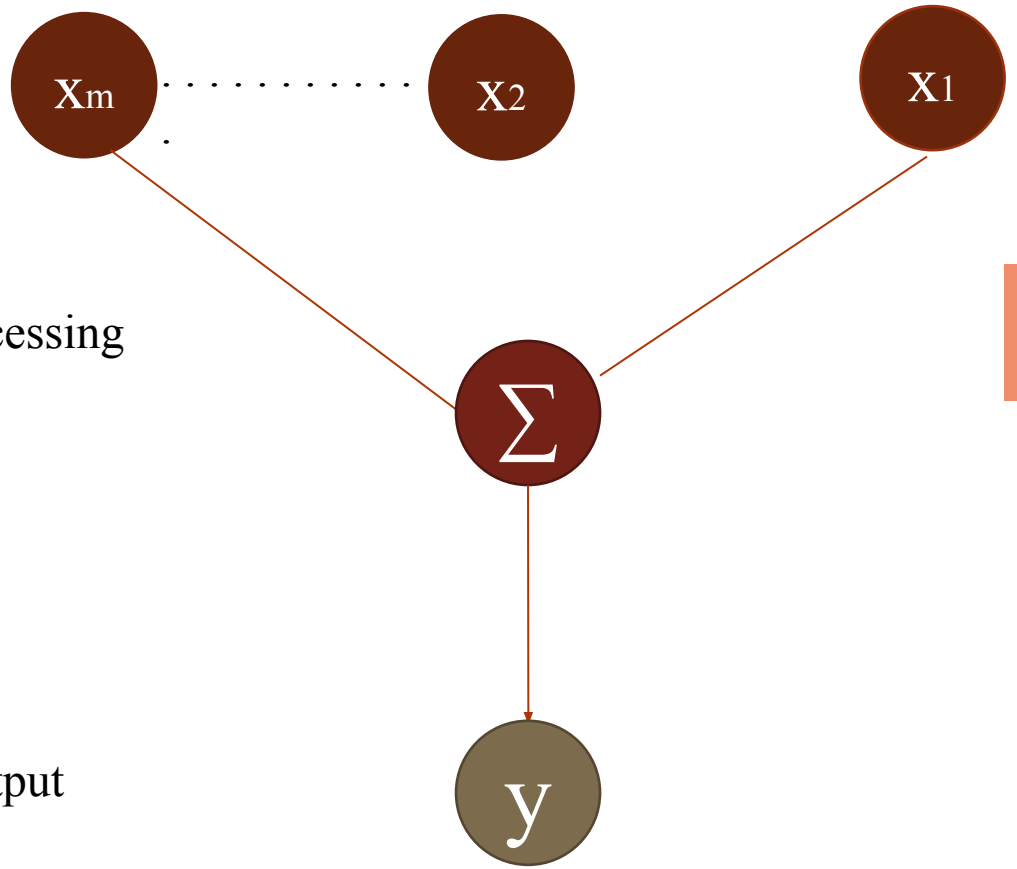
Conti..

Now, let us have a look at the model of an artificial neuron.



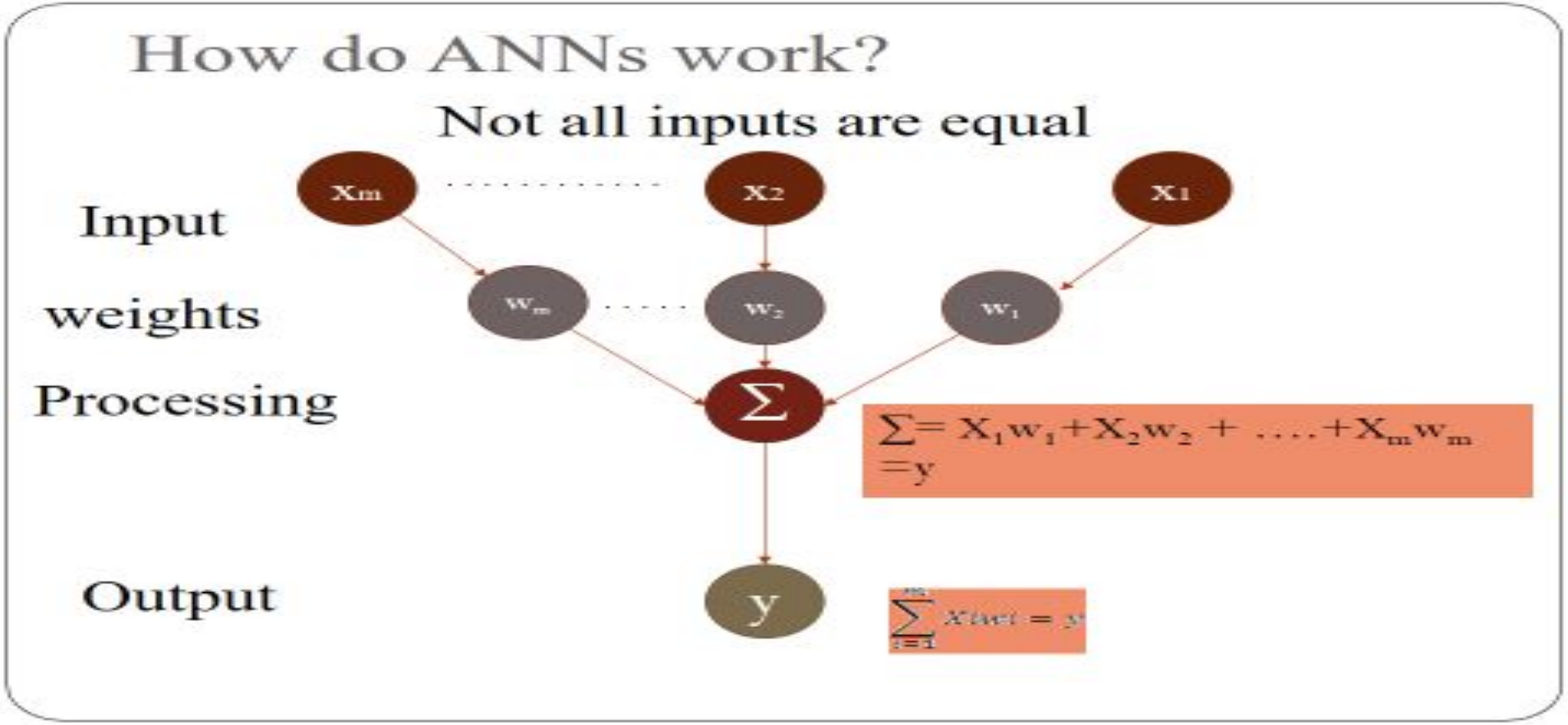
Working of ANN-

Input



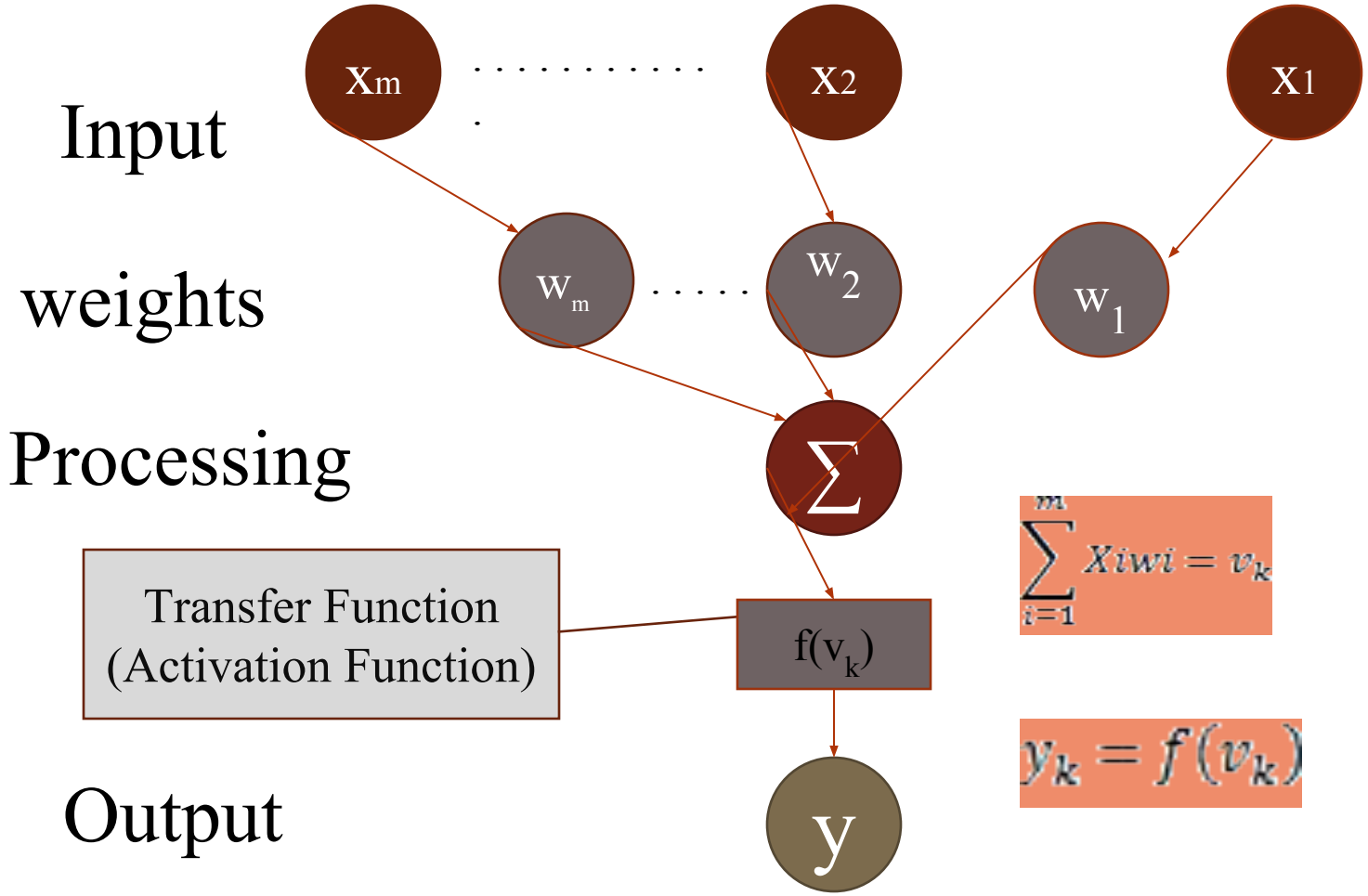
$$\Sigma = X_1 + X_2 + \ldots + X_m = y$$

Conti..

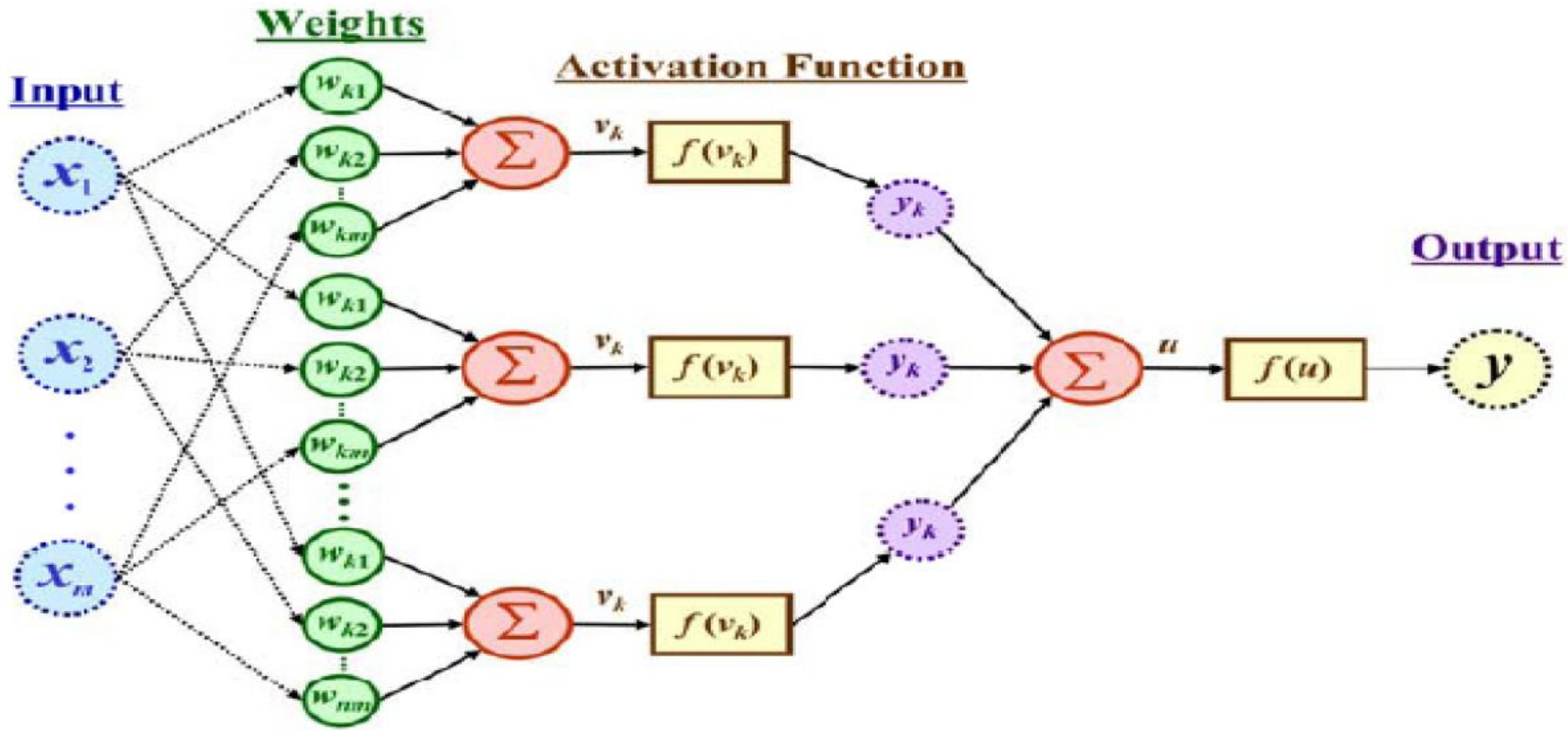

How do ANNs work?
Not all inputs are equal
Input
weights
Processing
Output
x_m
x_2
x_1
w_m
w_2
w_1
Σ
y
$\sum = X_1w_1 + X_2w_2 + \ldots + X_mw_m = y$
$\sum_{i=1}^{m} x_i w_i = y$

How do ANNs work?

The signal is not passed down to the next neuron verbatim



The output is a function of the input, that is affected by the weights, and the transfer functions



Definition Activation Function-

- Activation functions are an integral building block of **neural networks** that enable them to learn complex patterns in data. They transform the input signal of a node in a neural network into an output signal that is then passed on to the next layer. Without activation functions, neural networks would be restricted to modeling only linear relationships between inputs and outputs.
- Activation functions introduce non-linearities, allowing neural networks to learn highly complex mappings between inputs and outputs.
- Choosing the right activation function is crucial for training neural networks that generalize well and provide accurate predictions.

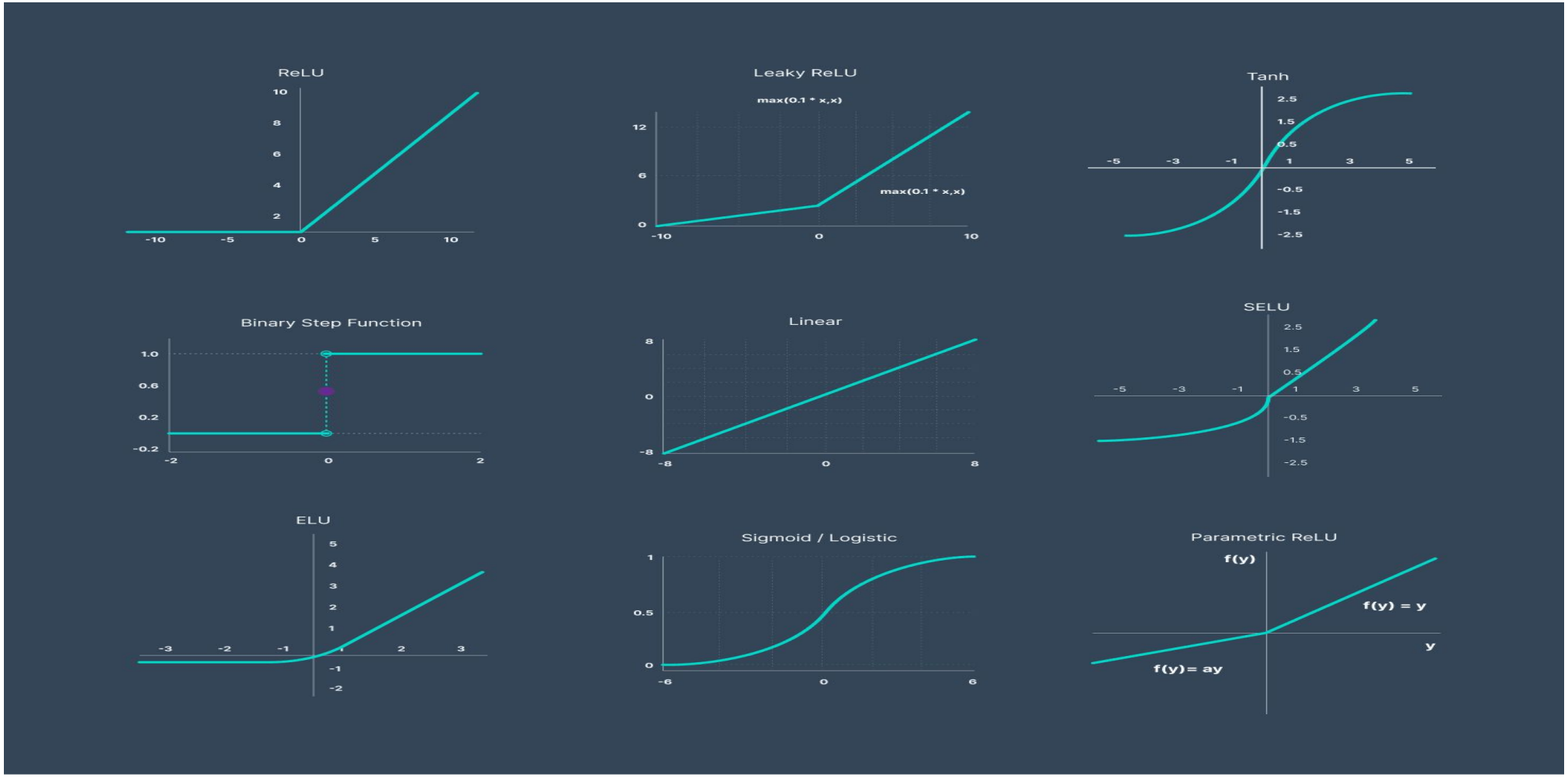
Activation Function-

- An activation function is a mathematical function applied to the output of a neuron. It introduces non-linearity into the model, allowing the network to learn and represent complex patterns in the data. Without this non-linearity feature, a neural network would behave like a linear regression model, no matter how many layers it has.
- The activation function decides whether a neuron should be activated by calculating the weighted sum of inputs and adding a bias term. This helps the model make complex decisions and predictions by introducing non-linearities to the output of each neuron.

Why is Non-Linearity Important in Neural Networks?

- Neural networks consist of neurons that operate using **weights**, **biases**, and **activation functions**.
- In the learning process, these weights and biases are updated based on the error produced at the output—a process known as **backpropagation**. Activation functions enable backpropagation by providing gradients that are essential for updating the weights and biases.
- Without non-linearity, even deep networks would be limited to solving only simple, linearly separable problems. Activation functions empower neural networks to model highly complex data distributions and solve advanced deep learning tasks. Adding non-linear activation functions introduce flexibility and enable the network to learn more complex and abstract patterns from data.

Types of Activation Function-

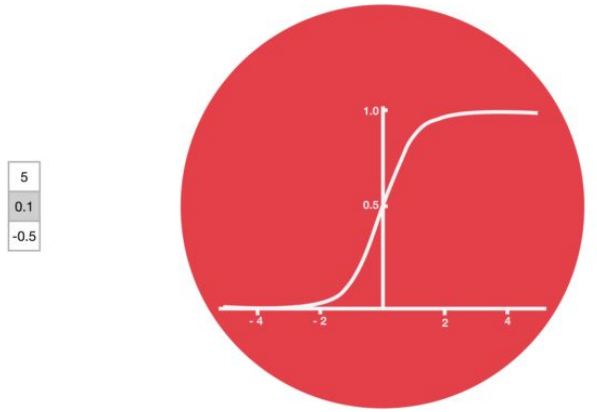


What is Activation functions.

- Neural network's ability to handle intricate tasks by performing crucial non-linear computations.

- Used to compute the weighted sum of inputs and biases, which is in turn used to decide whether a neuron can be activated or not.

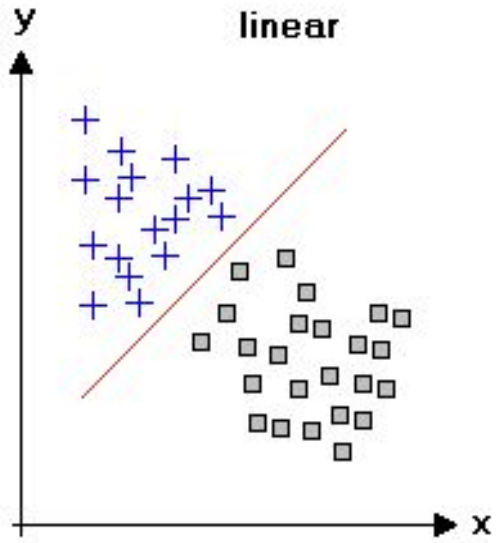
- These can either be linear or nonlinear depending on the function
  - control the output of neural networks across different domains

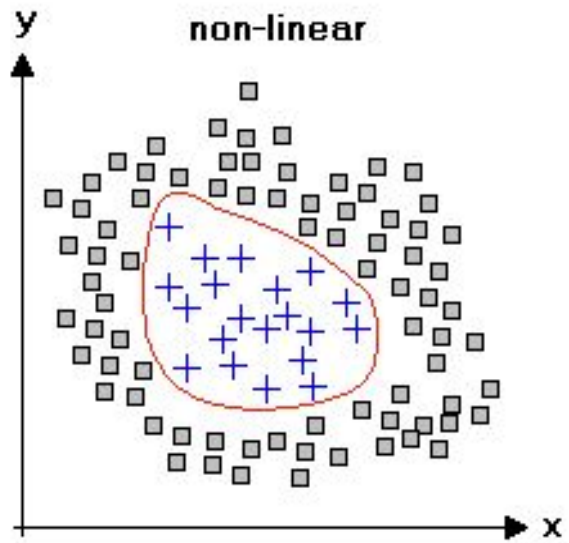


$$y = x_1 * w_1 + x_2 * w_2$$

Why we use Activation functions with Neural Networks?

It is used to determine the output of neural network like yes or no. It maps the resulting values in between 0 to 1 or -1 to 1 etc. (depending upon the function).





The Activation Functions can be basically divided into 2 types-

1. Linear Activation Function
2. Non-linear Activation Functions

1) Linear Activation Function

- $f(x) = x$
- **Description**: The output is proportional to the input. It is rarely used in practice because it lacks non-linearity.
- **Use Case**: Linear regression or the final layer in certain regression problems.
- **Limitations**:
  - Cannot model complex relationships.
  - The gradient is constant, so back propagation cannot adjust weights effectively.

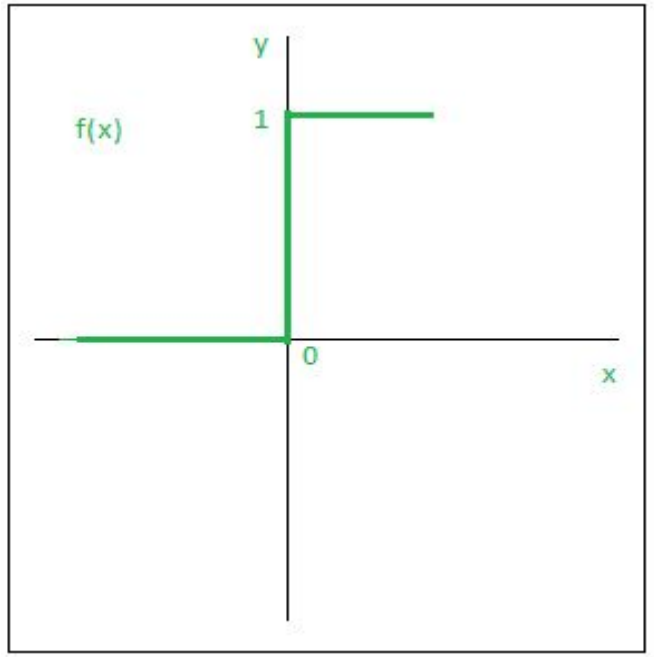
2) Step (Binary) Activation Function

•**Description**: Outputs binary values (0 or 1) based on a threshold.

•**Use Case**: Early perceptron for binary classification.

•**Limitations**:

- Non-differentiable, making it incompatible with gradient-based optimization.
- Cannot model probabilistic outputs.



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

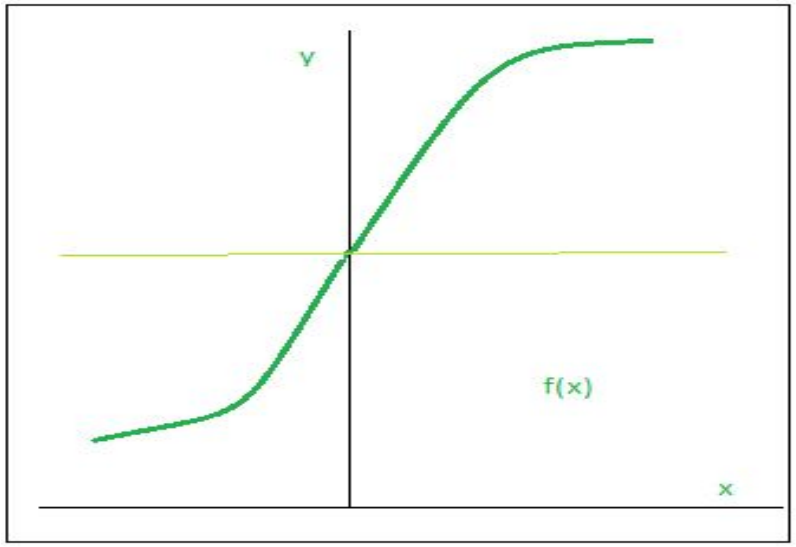
3) Sigmoid Activation Function

•**Description**: Outputs values between 0 and 1. It squashes large input values to a small range.

•**Use Case**: Binary classification tasks, often in the output layer.

•**Limitations**:

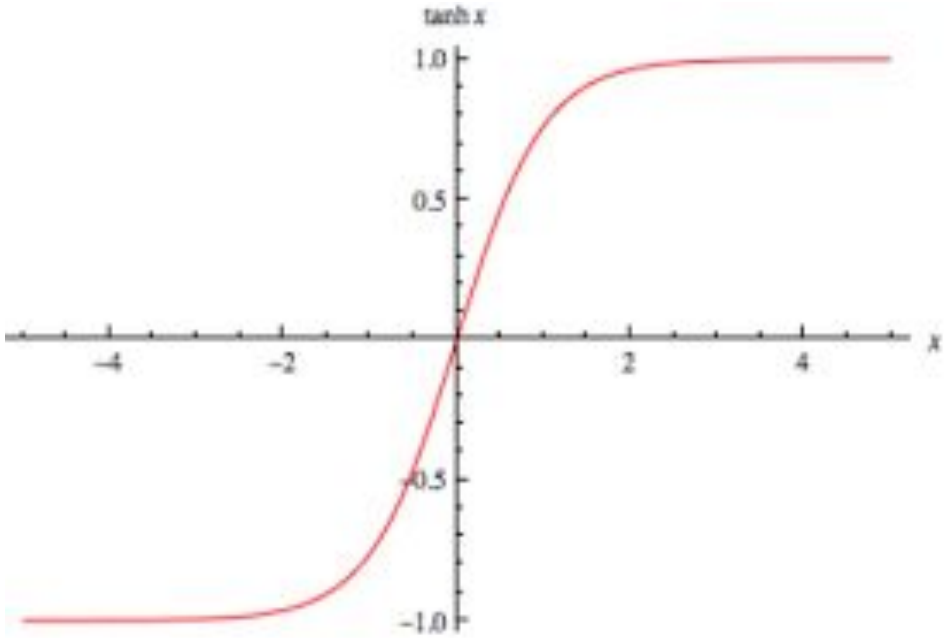
- **Vanishing Gradient Problem**: Gradients become very small for large or small inputs.
- Computationally expensive due to the exponential function.



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

4) Hyperbolic Tangent (Tanh) Activation Function

- **Description**: Outputs values between -1 and 1, making it zero-centered (unlike Sigmoid).
- **Use Case**: Hidden layers in neural networks.
- **Advantages**: Helps gradients flow better than Sigmoid.
- **Limitations**:
  - Still suffers from the vanishing gradient problem.



$$Tanh$$

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

5) ReLU (Rectified Linear Unit)

•**Description**: Outputs the input directly if positive; otherwise, outputs 0.

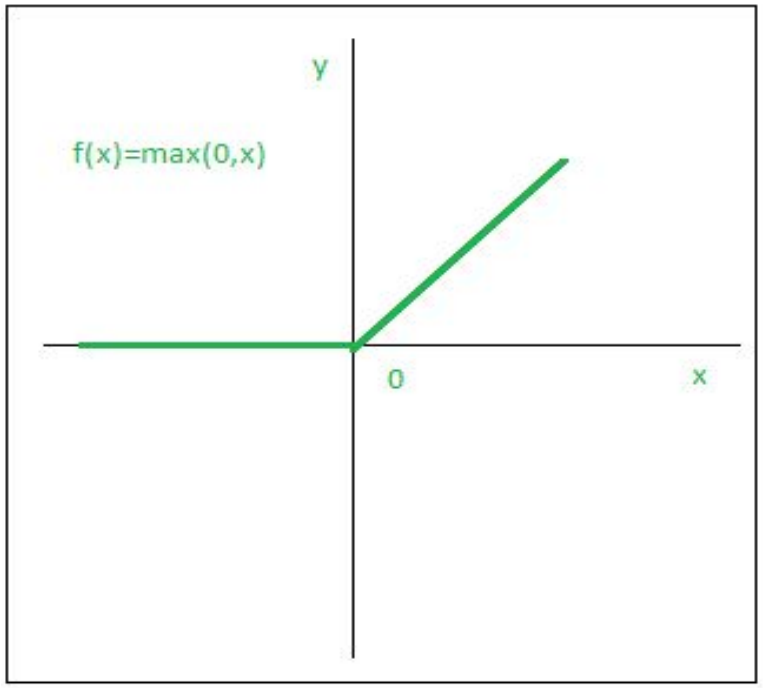
•**Use Case**: Widely used in hidden layers of deep networks.

•**Advantages**:

- Computationally efficient.
- Alleviates the vanishing gradient problem.

•**Limitations**:

- **Dying ReLU Problem**: Neurons can get stuck during training if they output 0 for all inputs.

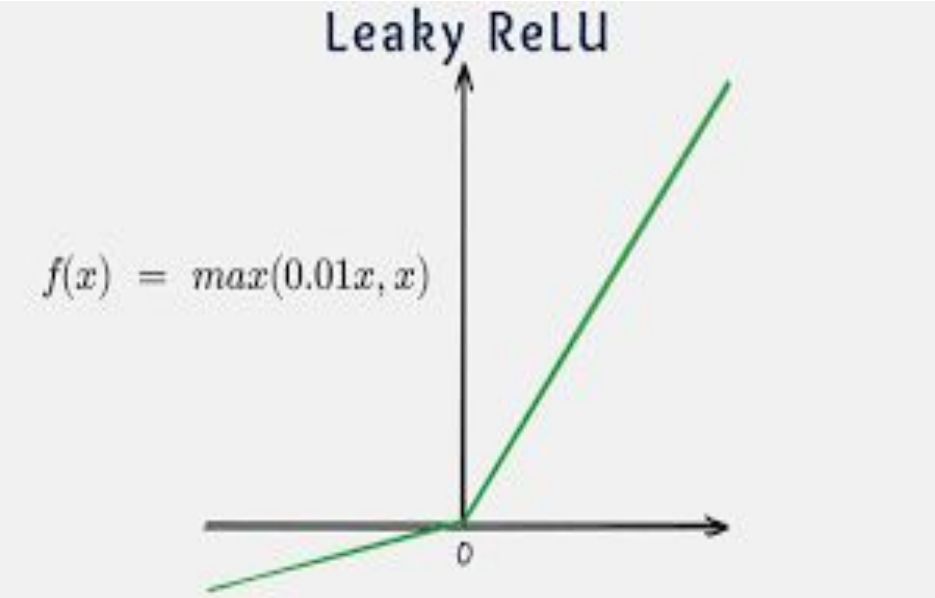


$$ReLU$$

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

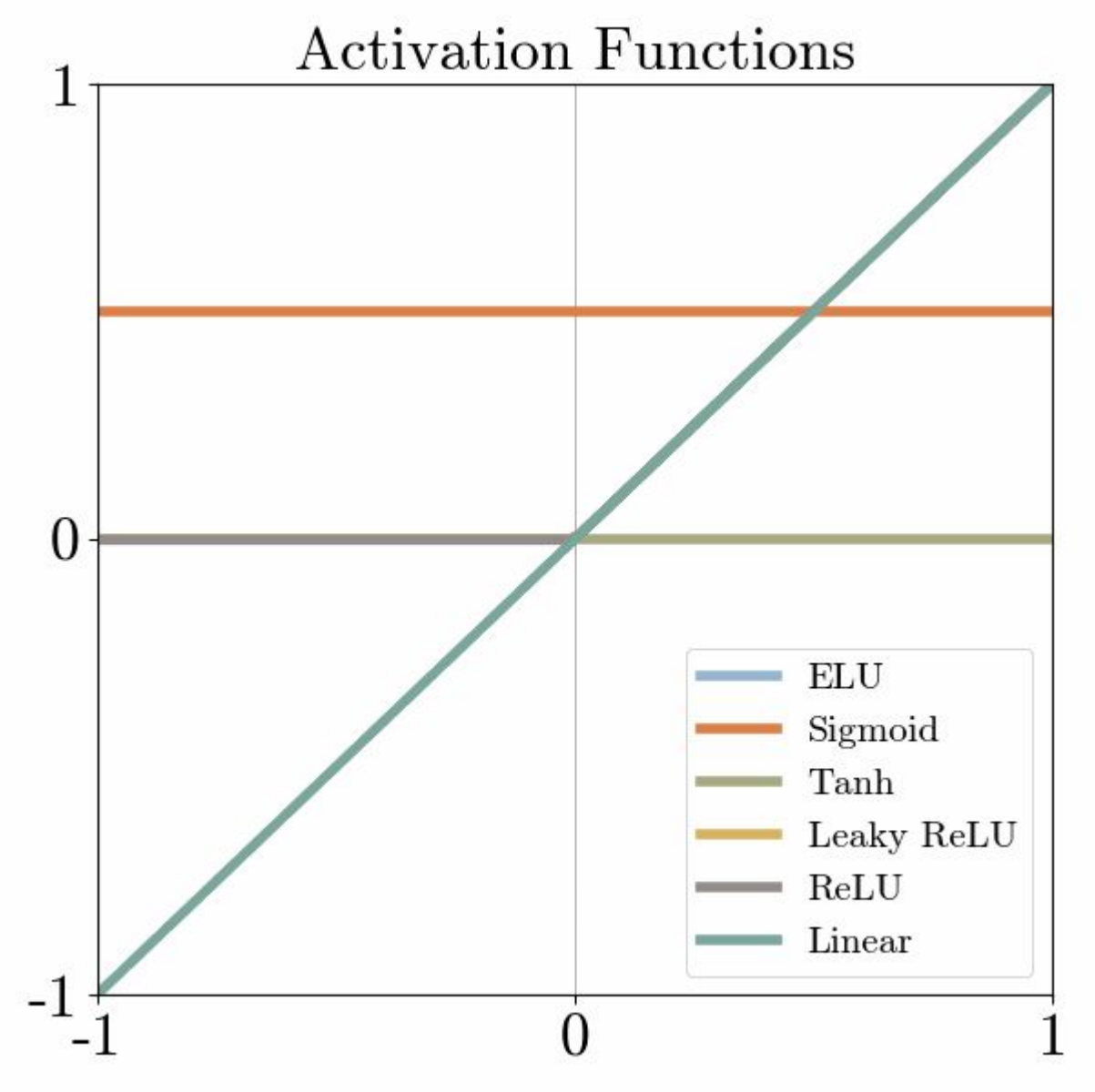
6) Leaky ReLU Activation Function

- **Description**: A variation of ReLU that allows a small slope (α\alphaα) for negative inputs.
- **Use Case**: Overcomes the dying ReLU problem.
- **Advantages**:
- Keeps neurons active even for negative inputs.
- **Limitations**: The slope parameter α\alphaα is fixed and needs careful tuning.



7) Softmax Activation Function

- **Description**: Converts a vector of values into probabilities that sum to 1.
- **Use Case**: Output layer in multi-class classification tasks.
- **Advantages**:
  - Provides a probabilistic interpretation.
- **Limitations**:
  - Computationally expensive for large input sizes.


Activation Functions
1
0
-1
-1
0
1
ELU
Sigmoid
Tanh
Leaky ReLU
ReLU
Linear

McCulloch & Pitts Model

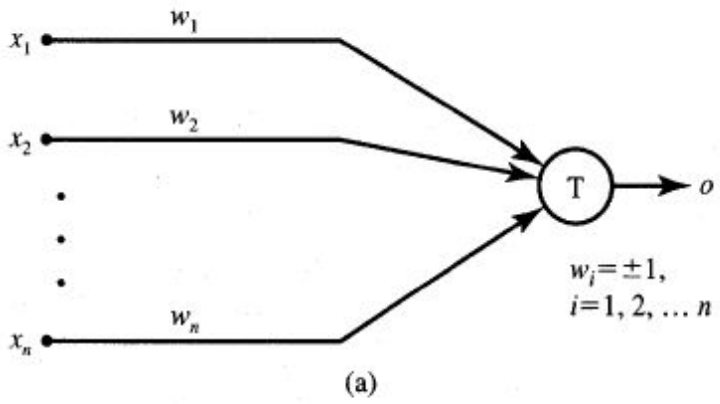
- A mathematical model of a neuron proposed in 1943 by Warren McCulloch and Walter Pitts.
- First computational model of a neural network.
- Pioneered the concept of artificial neural networks (ANNs).
- The MCP neuron is a binary threshold neuron model, which means that the neuron either fires (outputs 1) or doesn't fire (outputs 0) based on whether the sum of its inputs reaches a threshold or not.
- In reality, biological neurons are far more complex than MCP, but this model provided a crucial starting point for the mathematical modeling and understanding of neural networks and the development of modern AI.

Structure of the McCulloch-Pitts Neuron

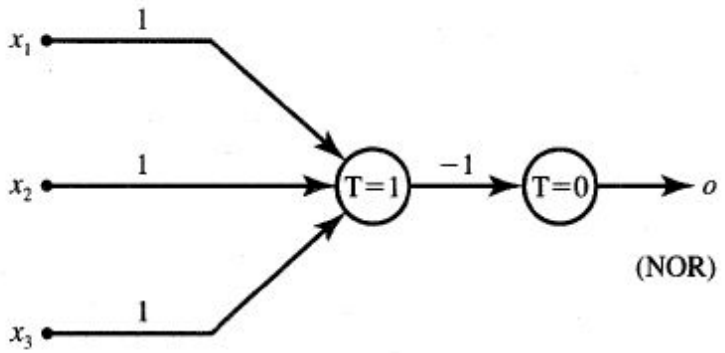
•Components:

- **Inputs (x_1, x_2, ...)**: Signals received from other neurons.
- **Weights (w_1, w_2, ...)**: Importance assigned to each input.
- **Summation (Σ)**: Adds weighted inputs.
- **Threshold (θ)**: Decision boundary for activation.
- **Output (y)**: Binary result (1 or 0).

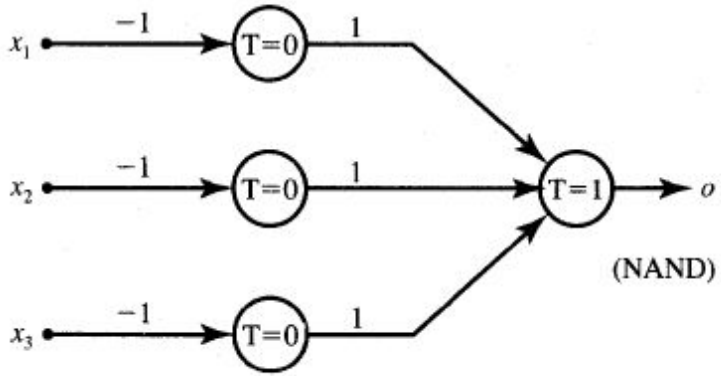
$$o^{k+1} = \begin{cases} 1 & \text{if } \sum_{i=1}^{n} w_i x_i^k \geq T \\ 0 & \text{if } \sum_{i=1}^{n} w_i x_i^k < T \end{cases}$$



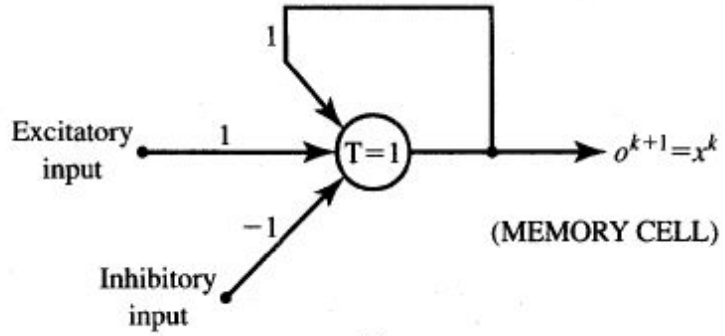
(a)



(b)



(c)

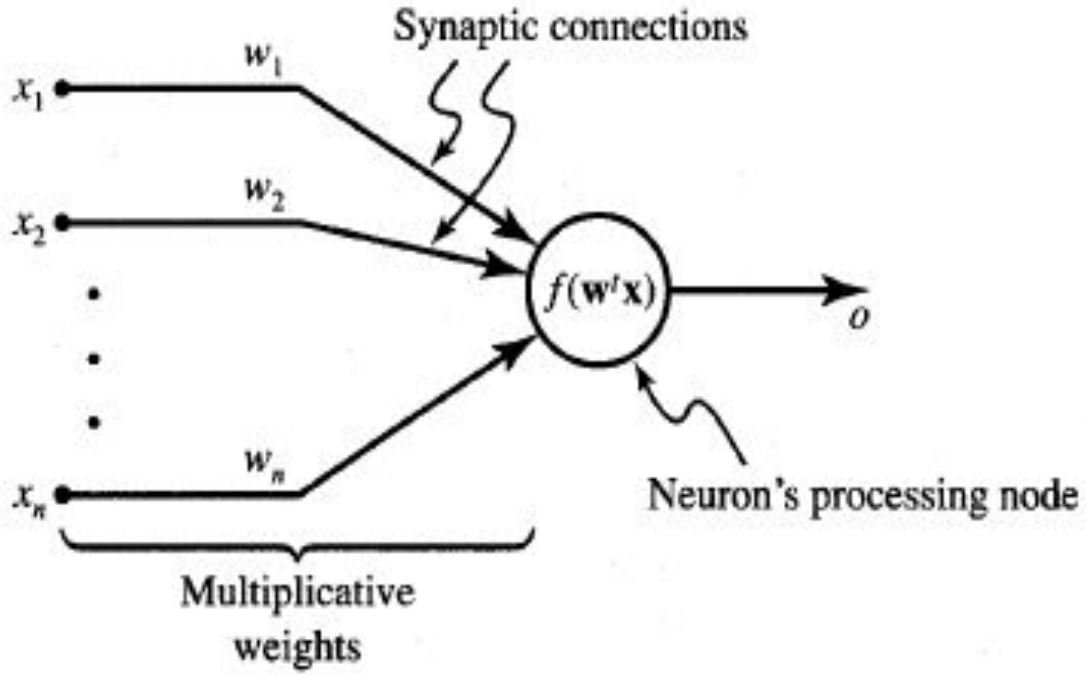


(d)

Features of McCulloch-Pitts model

- Allows binary 0,1 states only
- Operates under a discrete-time assumption
- Weights and the neurons' thresholds are fixed in the model and no interaction among network neurons
- Just a primitive model

General symbol of neuron consisting of processing node and synaptic connections-



$$o = f(\mathbf{w}^t\mathbf{x}), \text{ or}$$

$$o = f\left(\sum_{i=1}^{n} w_i x_i\right)$$

where $\mathbf{w}$ is the *weight vector* defined as

$$\mathbf{w} \triangleq [w_1 \quad w_2 \quad \cdots \quad w_n]^t$$

and $\mathbf{x}$ is the input vector:

$$\mathbf{x} \triangleq [x_1 \quad x_2 \quad \cdots \quad x_n]^t$$

Neuron Modeling for ANN

$$o = f(\mathbf{w}^t\mathbf{x}), \text{ or}$$

$$o = f\left(\sum_{i=1}^{n} w_i x_i\right)$$

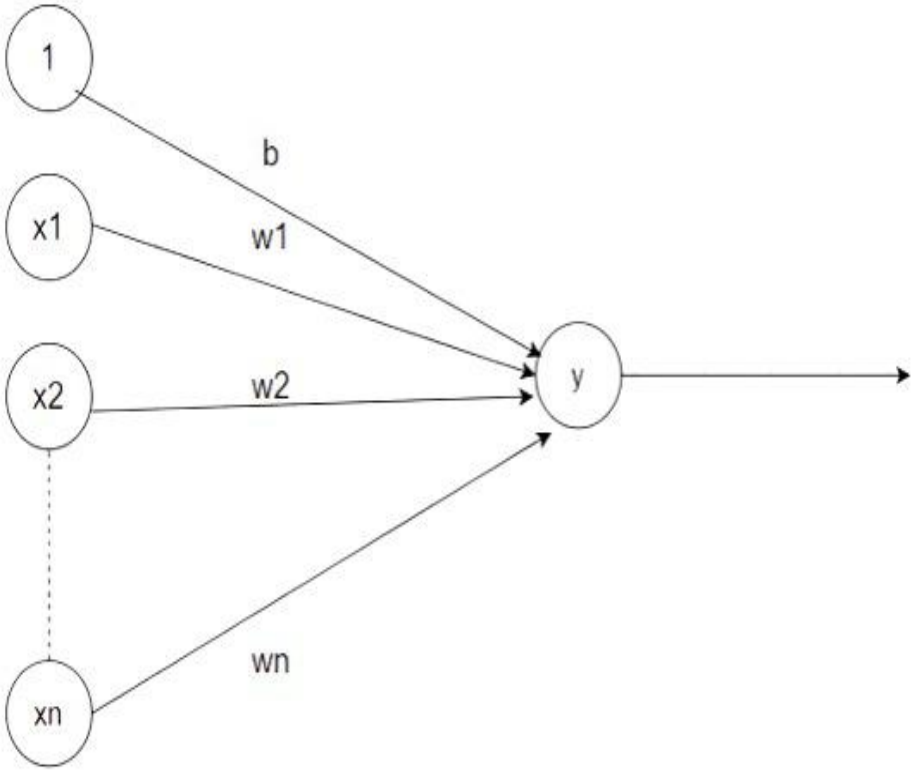
Is referred to activation function. Domain is set of activation values *net.*

$$net \triangleq \mathbf{w}^t\mathbf{x}$$

Scalar product of weight and input vector

Neuron as a processing node performs the operation of summation of its weighted input.

Adaline Model

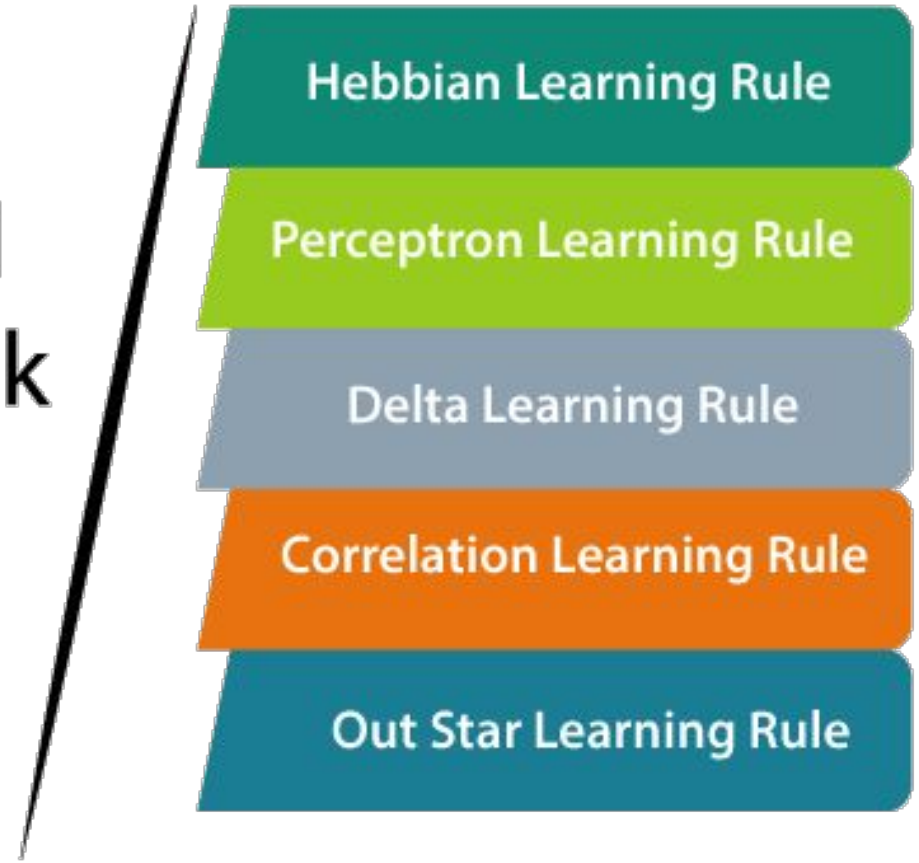


- Proposed by Bernard Widrow and Ted Hoff in 1960.
- A single-layer neural network model.
- Uses a linear activation function for its output.
- A network with a single linear unit is called Adaline (Adaptive Linear Neural)
- **Key Features of ADALINE**
  - Learns via gradient descent.
  - Minimizes the Mean Squared Error (MSE).
- **Applications:**
  - Pattern recognition.
  - Adaptive filtering.
  - Signal processing.

Basic Learning Laws

- **Learning rule** or **Learning process** is a method or a mathematical logic.
- It improves the **Artificial Neural Network** performance and applies this rule over the network.
- Learning rules updates the weights and bias levels of a network when a network simulates in a specific data environment.
- Applying learning rule is an iterative process. It helps a neural network to learn from the existing conditions and improve its performance.

Neural Network Rules



- **Hebbian learning rule –** It identifies, how to modify the weights of nodes of a network.
- **Perceptron learning rule –** Network starts its learning by assigning a random value to each weight.
- **Delta learning rule –** Modification in sympatric weight of a node is equal to the multiplication of error and the input.
- **Correlation learning rule –** The correlation rule is the supervised learning.
- **Outstar learning rule –** We can use it when it assumes that nodes or neurons in a network arranged in a layer.

Applications of Neural Networks

Characteristics of BNN and ANN

Characteristics	Biological Neural Network	Artificial Neural Network
Speed	Processes information at a slower rate. Response time is measured in milliseconds.	Information is processed at a faster rate. The response time is measured in nanoseconds.
Processing	Massively parallel processing.	Serial processing.
Size & Complexity	An extremely intricate and dense network of linked neurons of the order of 1011 neurons and 1015 interconnections.	Size and complexity are reduced. It is incapable of performing sophisticated pattern recognition tasks.
Storage	An extremely intricate and dense network of linked neurons with 1015 interconnections, including neurons on the order of 1011.	The term "replaceable information storage" refers to the practice of replacing fresh data with old data.
Fault tolerance	The fact that information storage is flexible means that new information may be added by altering the connectivity strengths without deleting existing information.	Intolerant of faults. In the event of a system failure, corrupt data cannot be recovered.
Control Mechanism	There is no unique control mechanism outside of the computational task.	Controlling computer activity is handled by a control unit.

Comparison of BNN and ANN

	
Biological neurons or nerve cells	Silicon transistors
200 billion neurons, 32 trillion interconnections.	1 billion bytes RAM, trillion of bytes on disk.
Neuron size: 10-6 m.	Single transistor size: 10-9m.
Energy consumption: 6-10 joules per operation per sec.	Energy consumption: 10-16 joules per operation per second.
Learning capability	Programming capability

Topology of Neural Network Architecture

- Neural networks are computational models inspired by the human brain.
- The topology defines how neurons and layers are structured and connected, and it is a significant factor in network functioning and learning
- Different architectures are suited for different tasks.
- All input values are associated with all neurons in the hidden layer (hidden because they are not noticeable in the input or the output), the output of the hidden neurons are associated to all neurons in the output layer, and the activation functions of the output neurons establish the output of the entire network.

Feedforward Neural Networks (FNN)

- The simplest architecture with layers stacked sequentially.
- Information flows in one direction (input → hidden → output).
- Commonly used for classification and regression tasks.
- The advancement of layered feed-forward networks initiated in the late **1950s**, given by **Rosenblatt's** perceptron and **Widrow's** Adaptive linear Element (ADALINE).
  - The perceptron and ADLINE can be defined as a single layer networks and are usually referred to as single-layer perceptron's.
  - Single-layer perceptron's can only solve linearly separable problems. The limitations of the single-layer network have prompted the advancement of multi-layer feed-forward networks with at least one hidden layer, called multi-layer perceptron (MLP) networks.
  - MLP networks overcome various limitations of single-layer perceptron's and can be prepared to utilize the backpropagation algorithm. The backpropagation method was invented autonomously several times.

- **Feedforward Neural Networks (FNN)**
  - **Single-layer feedforward network**: Rosenblatt first constructed the single-layer feedforward network in the late 1950s and early 1990s. The concept of feedforward artificial neural network having just one weighted layer. In other words, we can say that the input layer is completely associated with the outer layer.
  - **Multilayer feedforward network**: The concept of feedforward artificial neural network having more than one weighted layer. As the system has at least one layer between the input and the output layer, it is called the hidden layer.

Recurrent Neural Networks (RNN)

- Suitable for sequential data processing.
- Has connections that allow information persistence.
- Used in speech recognition, language modeling, and time-series forecasting.
- It can learn numerous behaviors, sequence, processing tasks algorithms, and programs that are not learnable by conventional learning techniques.
- It explains the rapidly growing interest in artificial recurrent networks for technical applications.
- They are computationally more dominant and biologically more conceivable than other adaptive methodologies.

Summary

Introduction to ANN & Historical Evolution

•ANNs are inspired by biological neural networks (BNNs) and aim to replicate human brain functions for computational tasks.

•The development of neural networks has evolved from early theoretical models (e.g., McCulloch-Pitts) to modern deep learning architectures.

Structure and Working of Biological Neural Networks (BNN)

- The human brain consists of interconnected neurons that transmit signals via synapses.
- The structure and functioning of BNNs serve as the basis for artificial models, influencing their learning and adaptation mechanisms.

Neural Network Architecture and Topology

- Neural networks consist of input, hidden, and output layers, where neurons are interconnected through weighted connections.
- Different topologies, such as feedforward and recurrent networks, determine how information flows through the network.

Types of Neural Networks and Activation Functions

- Various types of neural networks, including MP neuron, Adaline model, Perceptrons cater to different problem domains.
- Activation functions like sigmoid, ReLU, Tanh, Step etc play a crucial role in introducing non-linearity and improving learning efficiency.

Neuron Models and Learning Mechanisms

- Classical neuron models like the **McCulloch-Pitts model** and **Perceptron** form the building blocks of ANN.
- Advanced models such as **Adaline (Adaptive Linear Neuron)** introduce weight updates based on learning laws.
- Basic learning laws, including **Hebbian Learning, Perceptron Learning, and Delta Rule**, define how neural networks adjust their parameters to improve performance.

Applications of Neural Networks

- ANNs are widely used in **image recognition, natural language processing, healthcare diagnostics, financial forecasting, and IoT applications**.
- Their ability to learn patterns and make intelligent decisions has revolutionized numerous industries.

Comparison of Biological and Artificial Neural Networks

- While ANNs attempt to mimic BNNs, they differ in terms of complexity, efficiency, and adaptability.
- BNNs exhibit higher computational power and parallel processing, whereas ANNs rely on mathematical models and structured learning.

Case Study:-Concept of a Reservoir - Investigation and Reservoir Planning

https://www.youtube.com/watch?v=V9pwPY_loVU


Thank
you

MCQ Test – UNIT 1

1. What does ANN stand for?

a) Artificial Network Node

b) Advanced Neural Network

c) Artificial Neural Network

d) Automated Network Neuron

2.Who proposed the first mathematical model of a neuron?

a)Warren McCulloch and Walter Pitts

b) Alan Turing

c) John von Neumann

d) Frank Rosenblatt

5.Which type of neural network architecture allows information to flow in one direction only?

a) Recurrent Neural Network

b) Feedforward Neural Network

c) Radial Basis Function Network

d) Self-Organizing Map

6.Which of the following activation functions converts the input into a binary output?

a) Sigmoid

b) Tanh

c) Step

d) ReLU

7.The McCulloch and Pitts model of a neuron is based on:

a) Continuous activation functions
b) Linear threshold function
c) Hyperbolic tangent function
d) Sigmoid function

8. How do Biological Neural Networks differ from Artificial Neural Networks?

a) Biological Neural Networks operate in parallel, while Artificial Neural Networks typically operate sequentially

b) Artificial Neural Networks have fixed structures, while Biological Neural Networks are highly flexible.

c) Biological Neural Networks consist of nodes and connections, while Artificial Neural Networks consist of neurons and synapses.

9. Which activation function is commonly used in the output layer of a neural network for binary classification tasks?

a) ReLU

b) Tanh

c) Sigmoid

d) Softmax

10. In the McCulloch and Pitts model, what happens if the weighted sum of inputs exceeds a certain threshold?

a) The neuron fires

b) The neuron's output is set to zero

c) The neuron's output becomes negative

d) The neuron's output remains unchanged

11. What is the primary function of activation functions in ANNs?

a) To determine the output of a neuron

b) To introduce non-linearity to the network

c) To enable the network to learn complex patterns

d) All of the above

12. Which activation function is commonly used in the output layer for binary classification in ANNs?

a) Sigmoid

1.b) ReLU

2.c) Tanh

3.d) Softmax

13. In the context of neural networks, what does "vanishing gradient problem" refer to?

a) Gradients become too large during training, causing instability.

b) b) Gradients become too small, hindering weight updates in deep networks.

c) Gradients do not change during backpropagation.

d) Gradients are not required for training neural networks.

14. Who introduced the concept of the perceptron, and in which year?

a) Warren McCulloch & Walter Pitts, 1943

b) Frank Rosenblatt, 1958

c) Geoffrey Hinton, 1986

d) Yann LeCun, 1998

15. Which of the following is NOT a key characteristic of a biological neuron?

a) Dendrites receive input signals

b) Axon transmits output signals

c) Synapses regulate neurotransmitter flow

d) Activation functions determine synaptic weight

16. The McCulloch-Pitts model of a neuron operates on:

a) Continuous values

b) Probabilistic weights

c) Binary threshold logic

d) Convolutional filters

17. Which learning law suggests that synaptic weight increases if the pre-synaptic and post-synaptic neurons fire together?

a) Hebbian Learning

b) Delta Rule

c) Boltzmann Learning

d) Backpropagation

18. Which neural network topology is commonly used for time-series prediction?

a) Feedforward neural network

b) Recurrent neural network

c) Radial basis function network

d) Hopfield network

19. The softmax activation function is primarily used in:

a) Regression problems

b) Multi-class classification problems

c) Binary classification problems

d) Reinforcement learning

20. The main limitation of the McCulloch-Pitts neuron model is that it:

a) Can only perform multi-class classification

b) Lacks a mechanism for learning

c) Requires backpropagation to work

d) Uses complex non-linear activation functions

Answers-

1. c) Artificial Neural Network (ANSWER)
2. a) Warren McCulloch and Walter Pitts (ANSWER)
3. a) Neuron (ANSWER)
4. d) Loop (ANSWER)
5. b) Feedforward Neural Network (ANSWER)
6. c) Step (ANSWER)
7. b) Linear threshold function (ANSWER)
8. a) Biological Neural Networks operate in parallel, while Artificial Neural Networks typically operate sequentially (ANSWER)
9. c) Sigmoid (ANSWER)
10. a) The neuron fires (ANSWER)
11 d) All of the above
12 a) Sigmoid
13. Answer: b) Gradients become too small, hindering weight updates in deep networks.
14. Frank Rosenblatt, 1958
15. d) Activation functions determine synaptic weight
16. c) Binary threshold logic
17. a) Hebbian Learning
18. b) Recurrent neural network
19. b) Multi-class classification problems
20. b) Lacks a mechanism for learning