Artificial Intelligence
&
Neural Networks

CSE-351

Lecture-12

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Content

Artificial Neural Networks

- Networks

Networks

One efficient way of solving complex problems is following the lemma "divide and conquer".

A complex system may be decomposed into simpler elements, in order to be able to understand it. Also simple elements may be gathered to produce a complex system. Networks are one approach for achieving this.

There are a large number of different types of networks, but they all are characterized by the following components: a set of nodes, and connections between nodes. The nodes can be seen as computational units. They receive inputs, and process them to obtain an output.

Networks

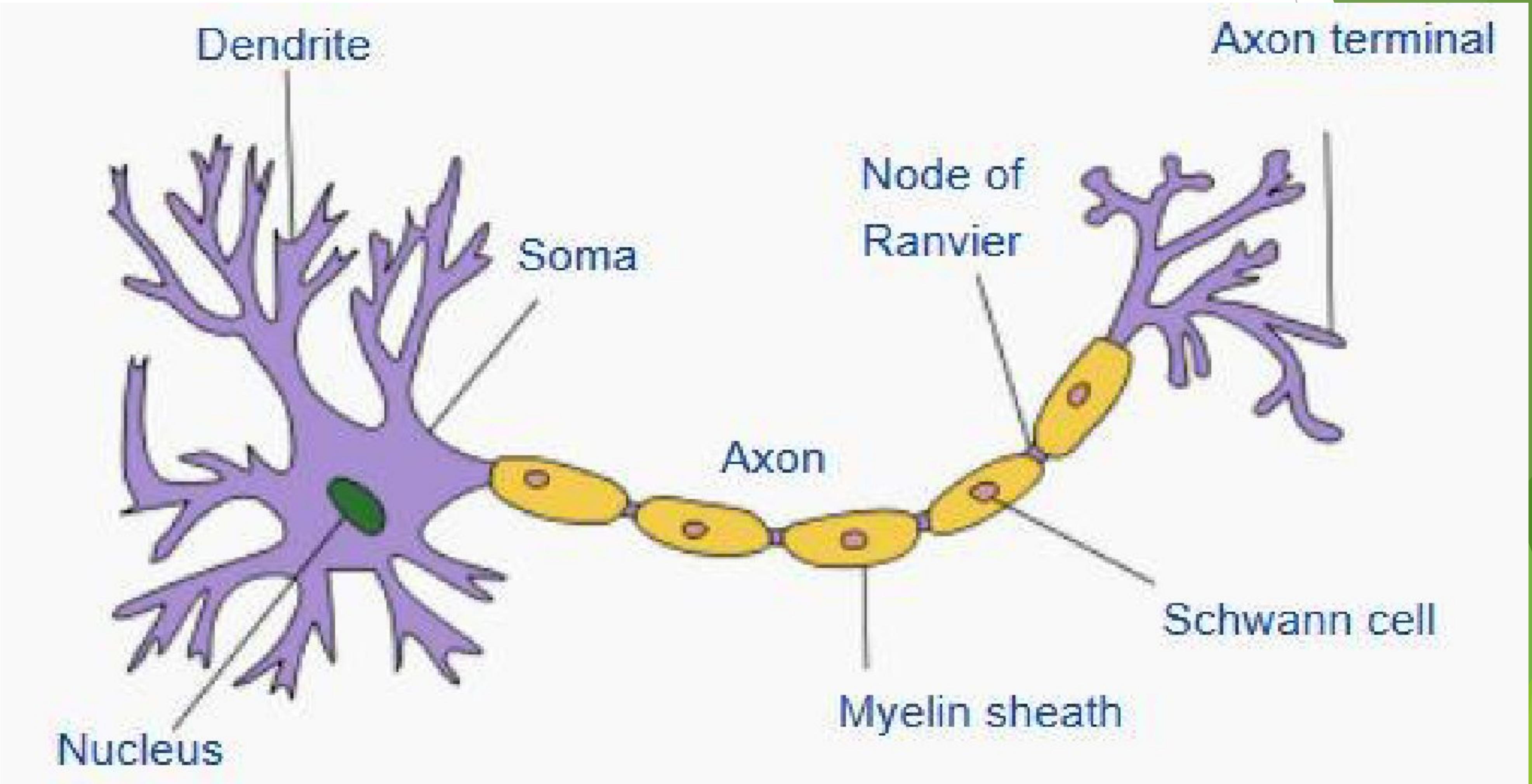
This processing might be very simple (such as summing the inputs), or quite complex (a node might contain another network...) the connections determine the information flow between nodes.

They can be unidirectional, when the information flows only in one sense, and bidirectional, when the information flows in either sense.

Networks are used to model a wide range of phenomena in physics, computer science, biochemistry, ethology, mathematics, sociology, economics, telecommunications, and many other areas.

This is because many systems can be seen as a network: proteins, computers, communities, etc.

Neural Networks



Neural Networks

A biological neuron has three types of components that are of particular interest in understanding an artificial neuron:

1. Dendrites
2. Soma
3. Axon

Dendrites: The many dendrites receive signals from other neurons. The signals are electric impulses that are transmitted across a synaptic gap by means of a chemical process.

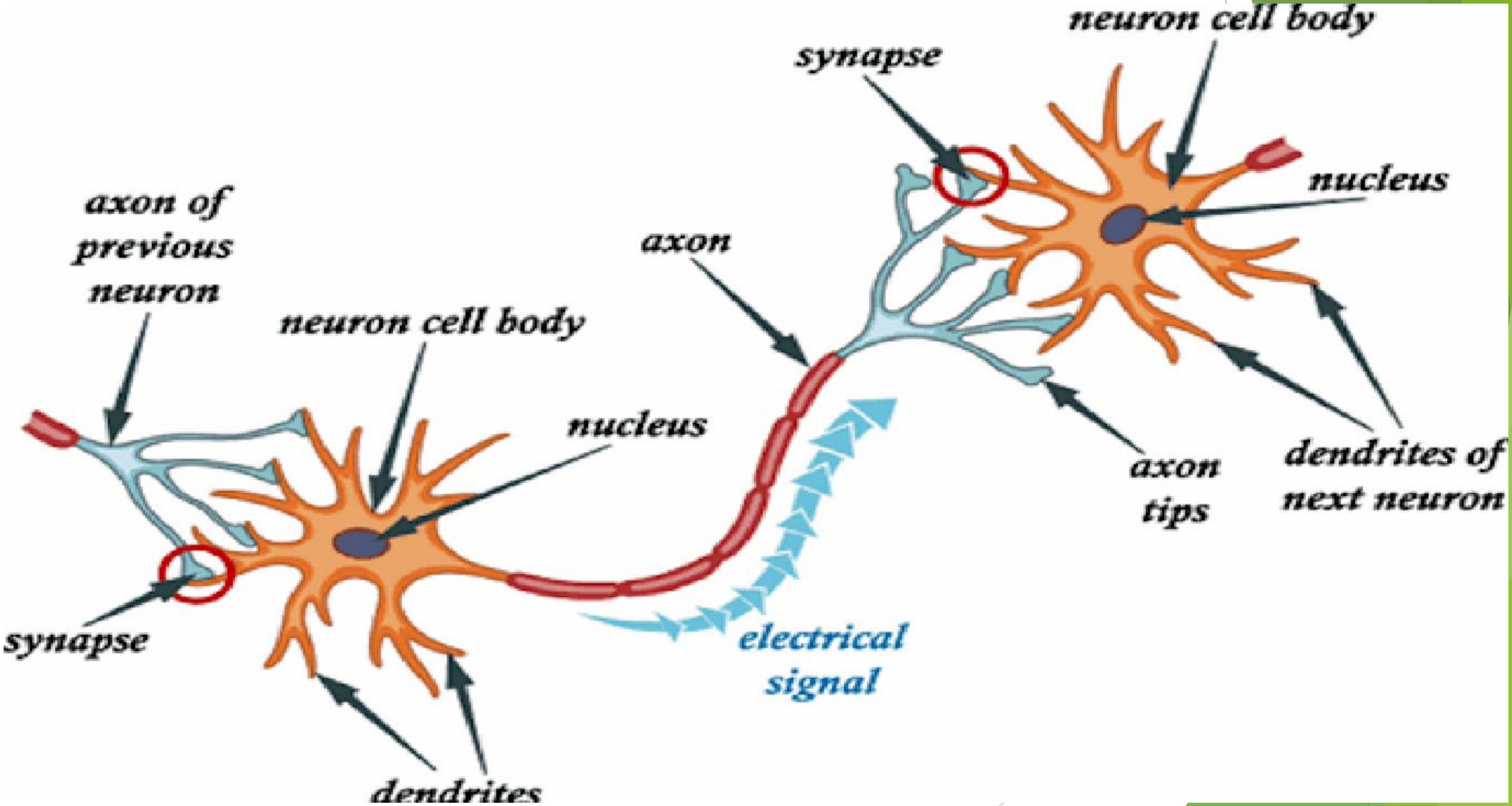
The action of the chemical transmitter modifies the incoming signal (typically, by scaling the frequency of the signals that are received) in a manner similar to the action of the weights in an artificial neural network.

Neural Networks

Soma: The soma, or cell body, sums the incoming signals. When sufficient input is received, the cell fires; that is, it transmits a signal over its axon to other cells. It is often supposed that a cell either fires or doesn't at any instant of time, so that transmitted signals can be treated as binary. However, the frequency of firing varies and can be viewed as a signal of either greater or lesser magnitude. This corresponds to looking at discrete time steps and summing all activity (signals received or signals sent) at a particular point in time.

Axon: The transmission of the signal from a particular neuron is accomplished by an action potential resulting from differential concentrations of ions on either side of the neuron's axon sheath (the brain's "white matter"). The ions most directly involved are potassium, sodium, and chloride.

Neural Networks



Artificial Neural Networks

A artificial neural network is a machine that is designed to model the way in which the brain performs a particular task or function of interest; the network is usually implemented by using electronic components or is simulated in software on a digital computer.

Our interest is confined largely to an important class of neural networks that perform useful computations through a process of learning. To achieve good performance, neural networks employ a massive interconnection of simple computing cells referred to as "neurons" or "processing units."

An artificial neural network is a massively parallel distributed processor made up of simple processing units, which has a natural propensity for storing experiential knowledge and making it available for use.

Artificial Neural Networks

ANN resembles the brain in two respects:

1. Knowledge is acquired by the network from its environment through a learning process.
2. Interneuron connection strengths, known as synaptic weights, are used to store the acquired knowledge.

A neural net consists of a large number of simple processing elements called neurons, units, cells, or nodes. Each neuron is connected to other neurons by means of directed communication links, each with an associated weight. The weights represent information being used by the net to solve a problem.

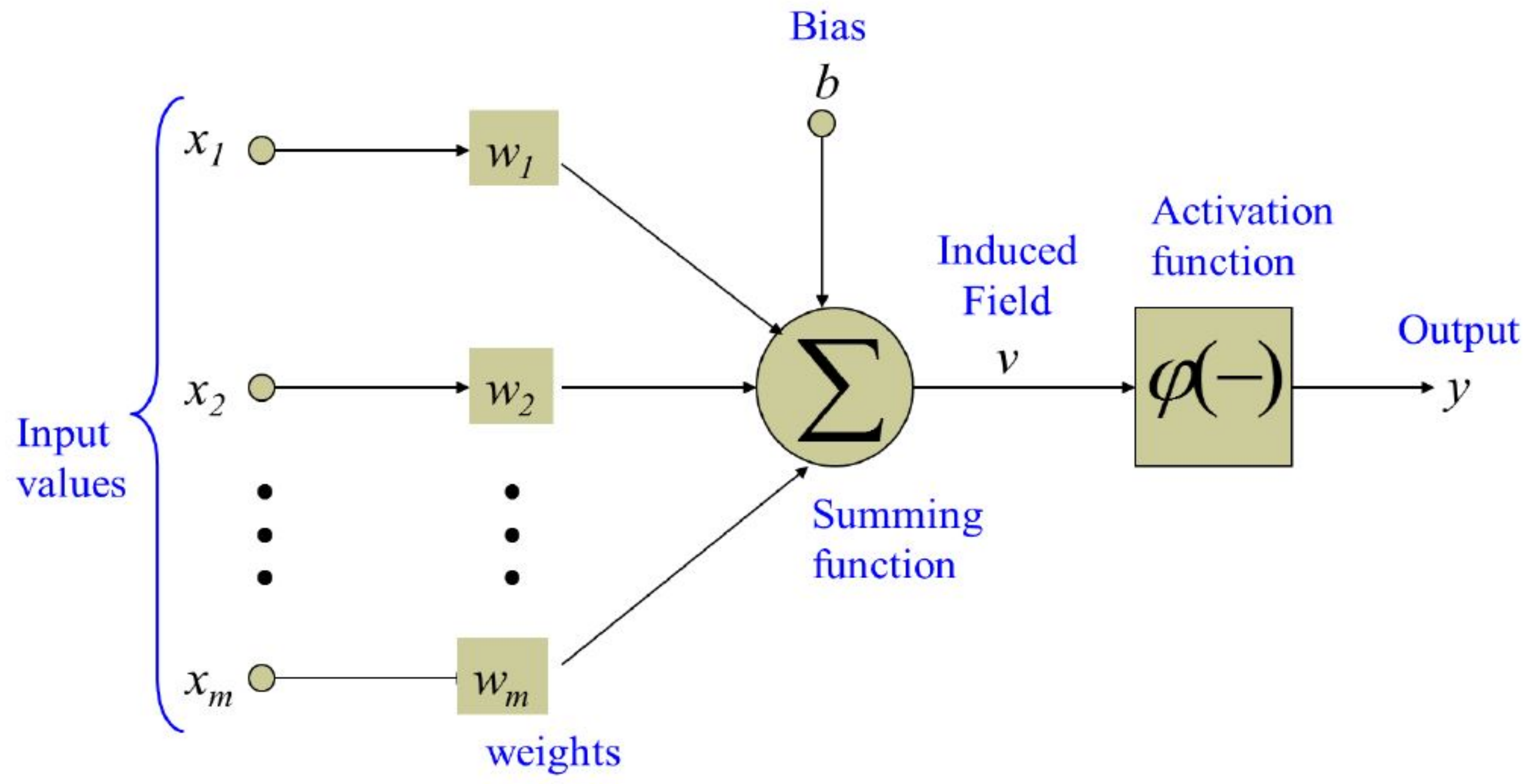
The basic unit of Artificial Neural Networks

The basic unit of neural networks, the artificial neurons, simulates the four basic functions of natural neurons (receives inputs from other sources, combines them in some way, performs a generally nonlinear operation on the result, and then output the final result).

Here we identify four basic elements of the artificial neural model:

1. Inputs
2. Sum Function,
3. Activation Function and
4. Outputs

The basic unit of **Artificial Neural Networks**



The basic unit of Artificial Neural Networks

1. **A set of synapses** or connecting links, each of which is characterized by a weight or strength of its own. Specifically, a signal x_j at the input of synapse j connected to neuron k is multiplied by the synaptic weight w_j.

Unlike a synapse in the brain, the synaptic weight of an artificial neuron may lie in a range that includes negative as well as positive values.

2. **An adder for summing** the input signals, weighted by the respective synapses of the neuron; the operations described here constitute a linear combiner.

3. **An activation function** for limiting the amplitude of the output of a neuron. The activation function is also referred to as a squashing function in that it squashes (limits) the permissible amplitude range of the output signal to some finite value.

The basic unit of Artificial Neural Networks

In mathematical terms, we may describe a neuron by writing the following pair of equations:

$$\mathbf{u} = \sum_{j=1}^{m} \mathbf{w}_j \mathbf{x}_j$$

And

$$y = \varphi(u + b)$$

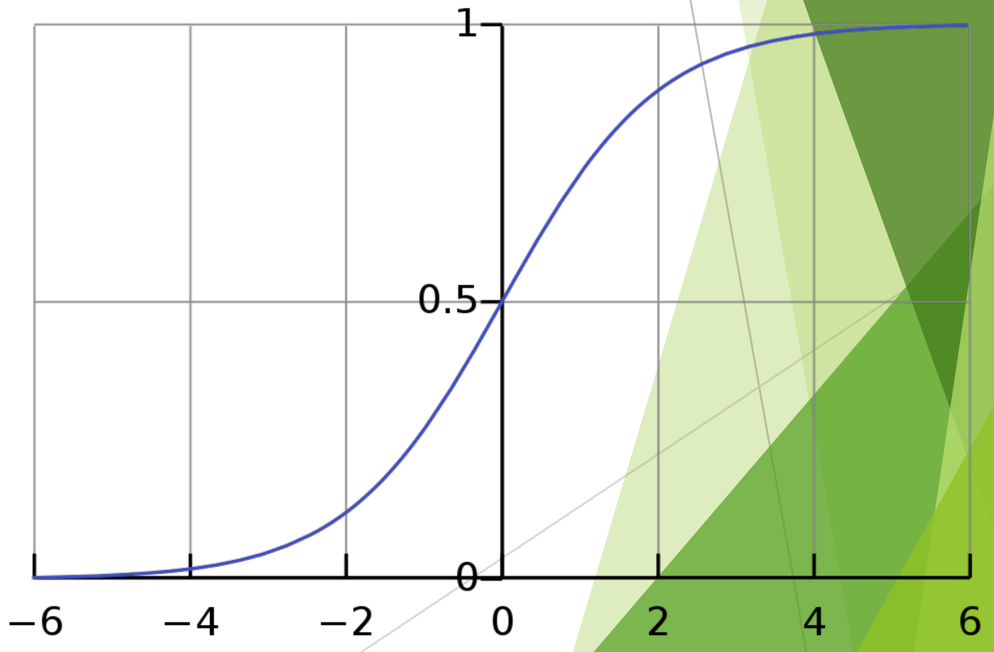
Where $x_1, x_2, \ldots, x_m$ are the input signals, $w_1, w_2, \ldots, w_m$ are the synaptic weights of neuron; u is the linear combiner output due to the input signals; b is the bias; $\varphi(.)$ is the activation function; and y is the output signal of the neuron.

Some Activation Function of ANN

- **Sigmoid function**

A **sigmoid function** is a mathematical function having a characteristic "S"-shaped curve or **sigmoid curve**. Often, *sigmoid function* refers to the special case of the logistic function.

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



Some Activation Function of ANN : Sigmoid function

- *The sigmoid function gives an 'S' shaped curve.*
- *This curve has a finite limit of:*
- *'0' as x approaches $-\infty$*
- *'1' as x approaches $+\infty$*
- *The output of sigmoid function when x=0 is 0.5*

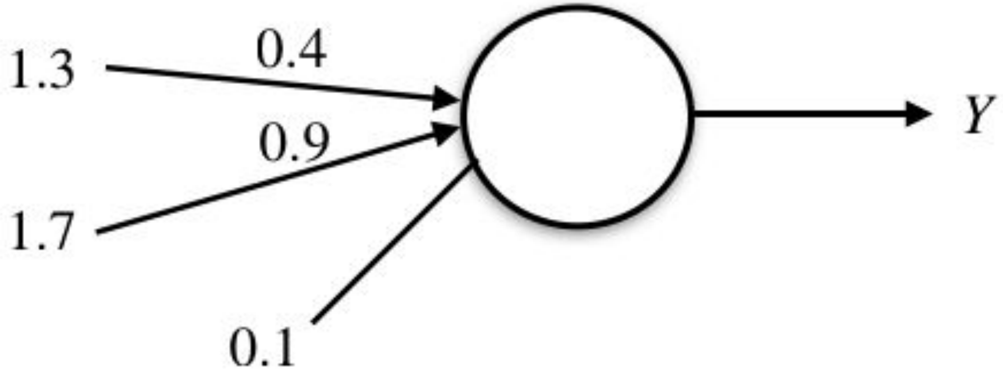
Thus, if the output is more tan 0.5 , we can classify the outcome as 1 (or YES) and if it is less than 0.5 , we can classify it as 0(or NO) .

For example: If the output is 0.65, we can say in terms of probability as:

"There is a 65 percent chance that your favorite foot ball team is going to win today " .

Some Activation Function of ANN : Sigmoid function

Find the output for the following neuron by sigmoid function-



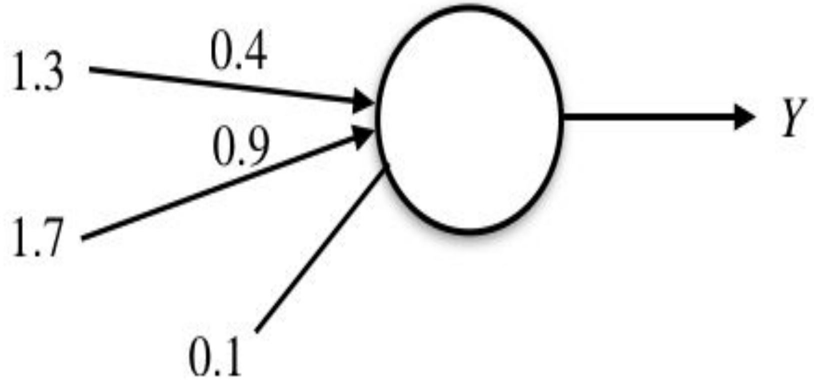
- Here our x_0 and x_1 are 1.3 and 1.7. Weights are 0.4 , 0.9 and bias is 0.1

Some Activation Function of ANN : Sigmoid function

$$\sum = w_0 x_0 + w_1 x_1 + b$$

$$\sum = 1.3 * 0.4 + 1.7 * 0.9 + 0.1$$

$$= 2.15$$



Now by sigmoid function we get-

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

$$\sigma(2.15) = \frac{1}{1 + e^{-2.15}}$$

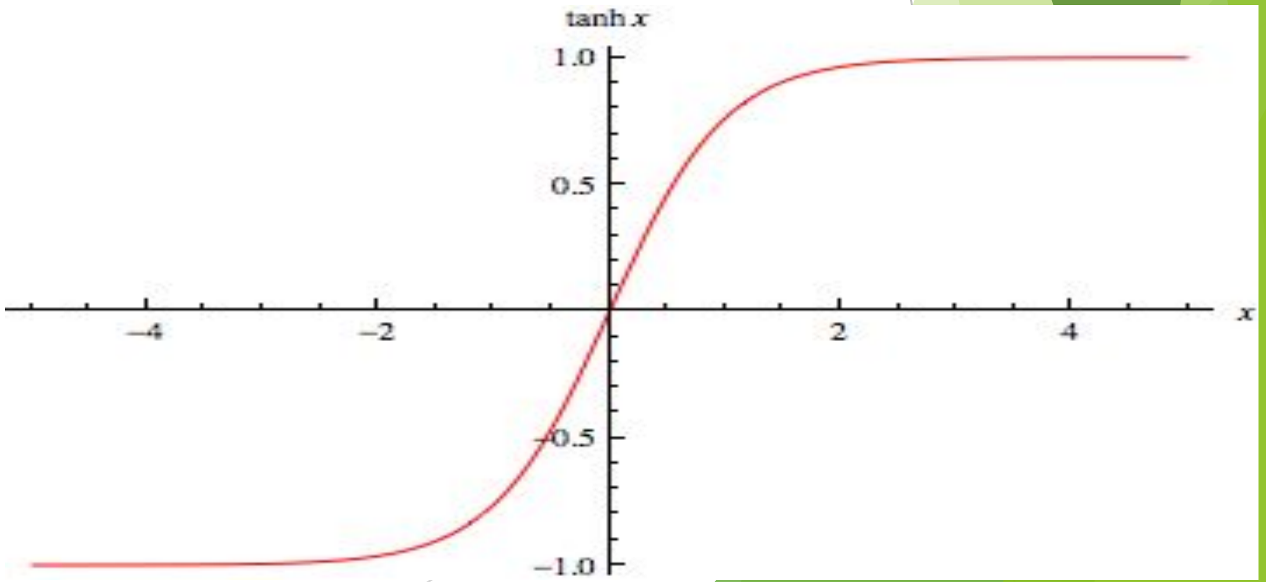
$$\sigma(2.15) = 0.89$$

Some Activation Function of ANN

- ***tanh* function**

A **hyperbolic tangent function** is a mathematical function having a characteristic "S"-shaped curve. The range of ***tanh*** function is -1 to 1. The advantage is that the negative inputs will be mapped strongly negative and the zero inputs will be mapped near zero in the tanh graph.

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

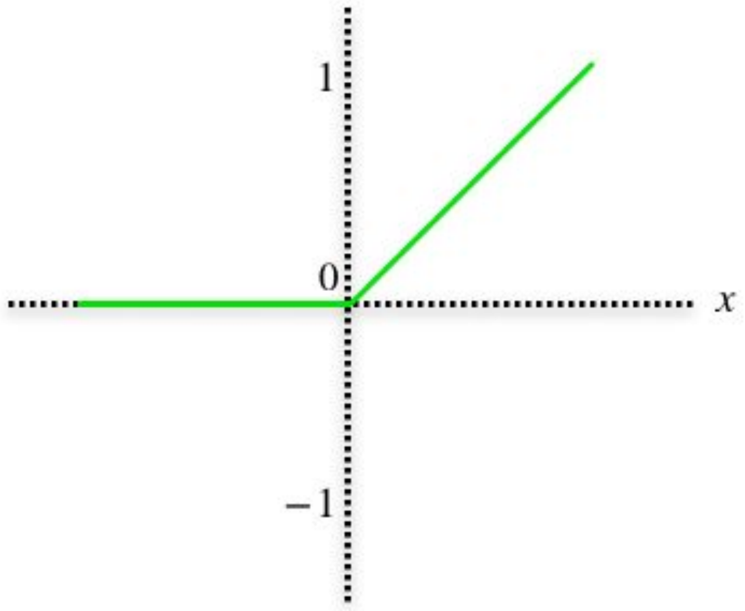


Some Activation Function of ANN

- **ReLU function**

The ReLU is the most used activation function in the world right now. Since, it is used in almost all the convolutional neural networks or deep learning.

$$y = max(0, x)$$



Questions ??

Thanks'