I. Biological Neuron:

Biological neurons (also called as neurons or nerves cells) are the basic or fundamental building units of the brain and nervous system in animals; including human beings. These specialized cells are responsible for capturing the sensory inputs from the environment the host is present, processing this data to generate some kinds of commands and further transmitting it to the different body parts to act in the particular scenario [1]. These commands are usually in the chemical and electrical signals that facilitates the communication between brain and body. Alongside the neuron cells, the brain is made up of glial cells which also plays a crucial part in functioning of the brain [2]. The human nervous system roughly consists of approximately 67-86 billion neurons and approximately around 85 billion glial cells [3][4][5].

The structure of the typical biological neuron consists of cell body (or soma), dendrites, an axon and axon terminals as shown in the image.

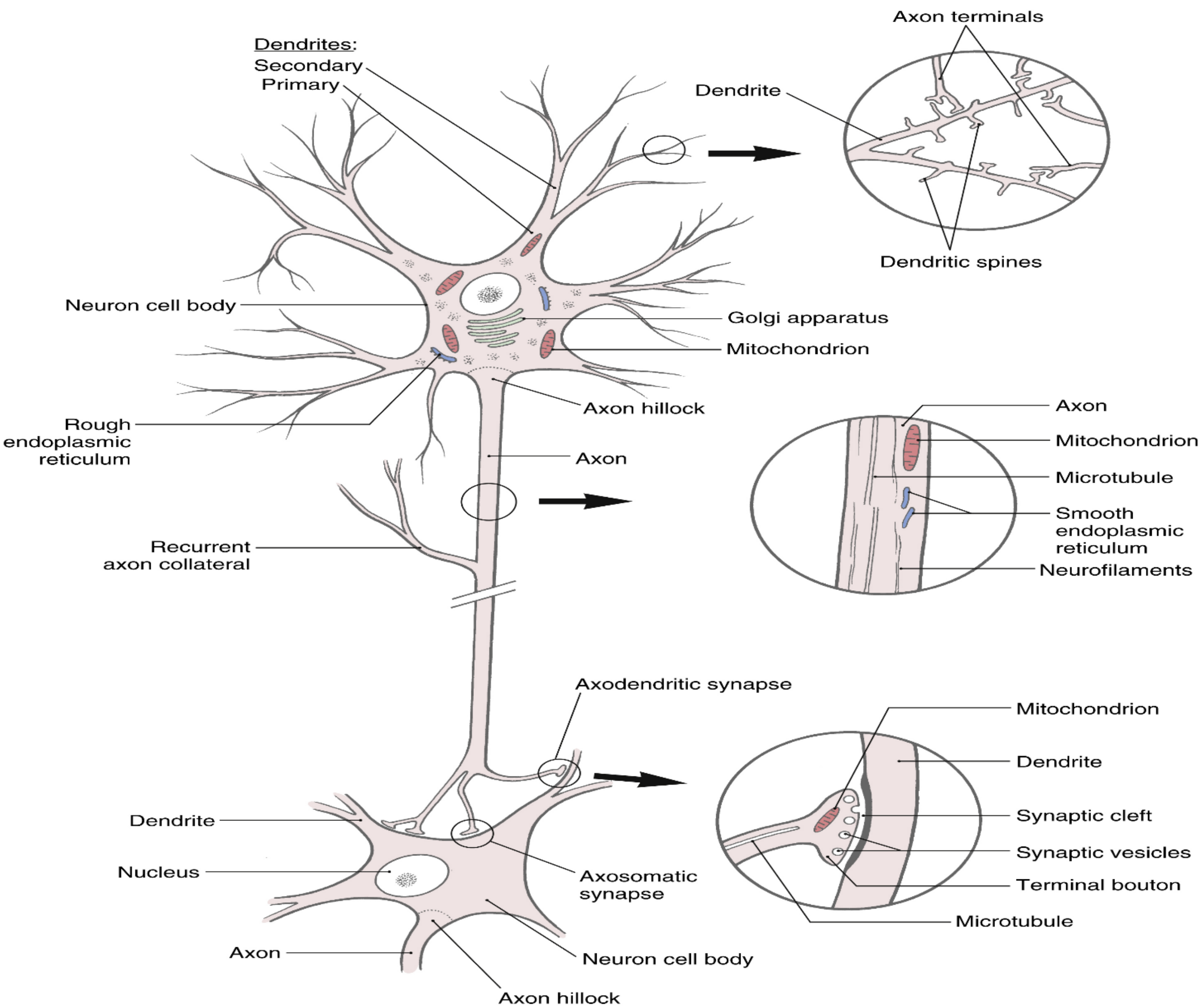


Figure 1: Structure of a Neuron

The cell body or the soma of the neuron consists of the nucleus, endoplasmic reticulum, golgi body, mitochondria and other organelles. An axon, is a tube-like structure, arising from the cell body that carries the electrical signal from cell body to be passed to another neuron (transmitting part of neuron) [2]. Most neurons have several dendrites extending from the cell body are important for reception of signals from other neurons [7]. A synapse is the chemical junction between the axon terminals of first neuron and dendrite of the second. All the information normally flows from the dendrites to the cell body to the axon and its terminals. These are the basic parts of the neurons; yet there are other important organelles that help the neurons to work efficiently.

Another type of cells found in the brain are glial cells which provides neurons with structural support and maintain the appropriate microenvironment essential for neuronal function. The major types of glial cells are astrocytes and oligodendrocytes. Oligodendrocytes occur in both gray matter and white matter and its main function is myelination. It means that it provides the electrochemical insulating sheet around all but smallest axons in the white matter [8]. They are generated from oligodendrocyte progenitor cells following tight orchestrated processes of migration, proliferation and differentiation [9]. They cells are fundamental to myelin formation in developing CNS and also crucial for myelin regeneration following injury. Another fundamental function other than myelination is metabolic support which regulates the extracellular fluid.

As we have studied that oligodendrocyte provides myelination, let us understand what does myelin sheath's significance is. Myelin is a fatty material that is wrapped around the axon to form the myelin sheath. This sheath protects from the data loss i.e., it insulates the axon, isolates them to minimize the dissipation of the electrical signals. This sheet is not continuous along its entire length rather it is covered by the series of myelin segments; these interruptions are called nodes of Ranvier. These interruptions are necessary since the rapid ionic exchanges essential for generating action potential and propagating it down the axon occurs at the modes of Ranvier [8].

The study of biological neurons, their functions and interactions has led many insightful derivations on how the nervous system functions, what happens to the brain when it is affected by any disease; and also, has inspired the development of the artificial intelligence that aims to develop a machine which replicates the fundamental features of biological neurons.

II. Artificial Neurons

It can be said that the artificial neural networks share many similarities with biological neurons and also it has its own share of differences. As the biological neurons has dendrites, synapse, axon, cell body for the proper functioning; ANN has inputs, weights, outputs, hidden layers. Even though the functions of each of them may resemble one another, the significant differences lie in their complexity, flexibility and adaptability. The biological neural network is highly complex and adaptable in contrast to the ANN which are relatively simpler and designed to perform a specific task; using predefined architecture.

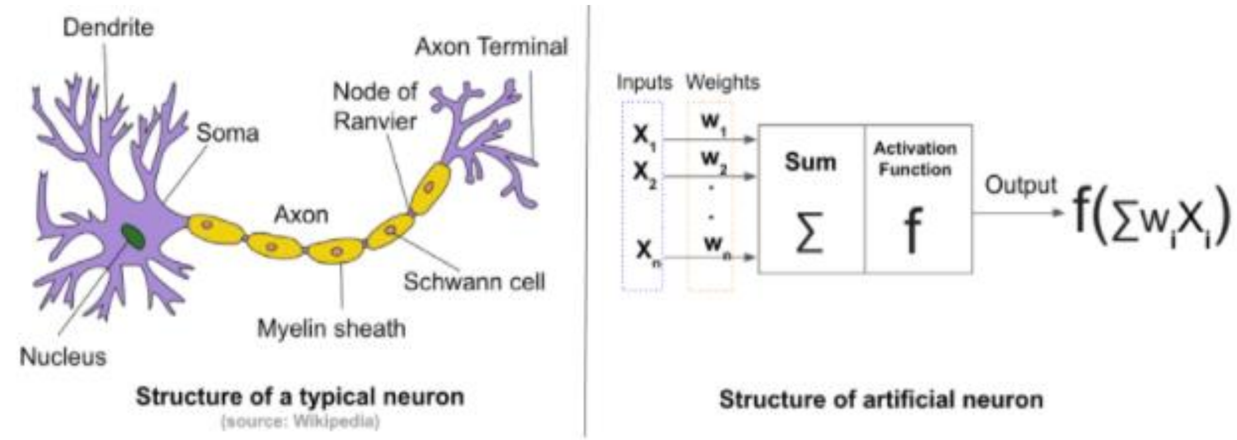


Figure 2: Structure of a Neuron: Brain vs ANN

As from the above image we can see that the node of the ANN consists of an activation function which decides whether a neuron should be activated or not. Basically, the most important function of the activation is to introduce the non-linearity in the output of a neuron. This ensures that the neuron selects the important information while suppressing the irrelevant information. This similar to the firing pattern or generation of sharp electric potential called action potentials (way of transmitting data) in the biological neuron i.e., it only transmits the signal only when the total input signal is greater than or equal to the threshold value.

There are different activation functions that are used in AI today viz. sigmoid, tanh, ReLU and many more. The choice of the activation function depends on the problem at hand and the mathematics involved with each function. For example, if the ANN is used for classification, then sigmoid or generalized softmax function can be used; but sigmoid function can cause vanishing gradient problems and hence the choice of activation function must be done carefully [9].

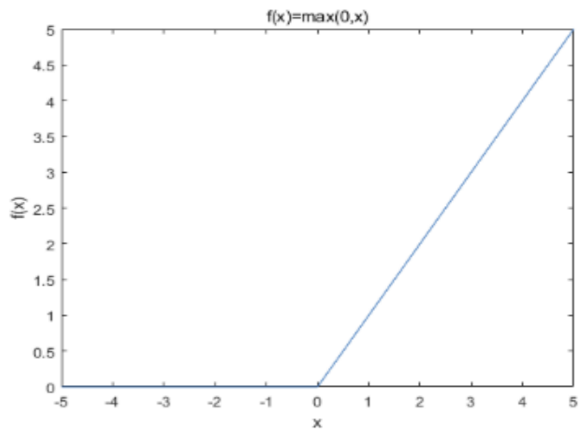
ReLU or rectified linear unit has been very popular and is usually used in the hidden layers of ANN; especially in CNNs and Deep Learning. The mathematical function for this activation is given as:

$$f(x) = \max(0, x_i) = \begin{cases} x_i, & x_i > 0 \\ 0, & x_i < 0 \end{cases}$$

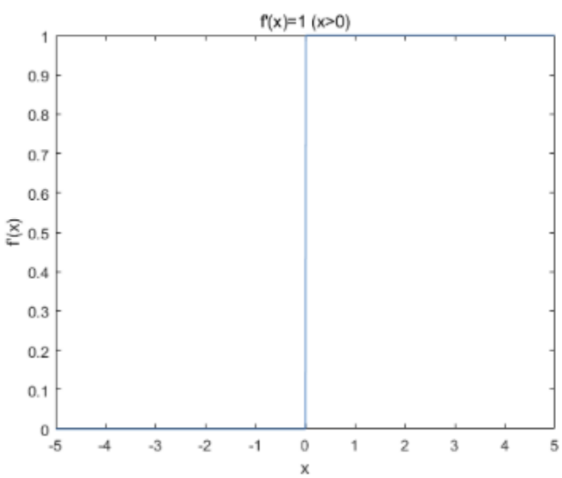
In other words, this can also be written as by taking the derivative of the above function:

$$f'(x) = \begin{cases} 1, & x_i > 0 \\ 0, & x_i < 0 \end{cases}$$

From the above equations, it can be clearly seen that for the values of the x greater than 0 the ReLU function returns the number itself. The first order derivative makes this concept more clear since derivative gives the slope of the function and this slope is 1 when the number are positive and 0 when the numbers are negative. Thus, it is called the positive part function or ramp function. The benefit of this activation function is that it is easy to implement and computationally inexpensive. In contrast, it can face a dying-relu phenomenon; there might be a case during training for neural network that many nodes are inactive; this prevents the algorithms from learning complex hypothesis functions. This happens because of the gradient is 0 for negative inputs and weights will not get adjusted during the descent [10][11].



(a) Curve of function



(b) Curve of derivative

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[2] Introducing the Neuron

[3] Isolation of neurons and glial cells from normal and pathological human brains

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[6] Figure 1: Structure of the Neuron

[7] Neurons

[8] Fundamental Neuroscience for Basic and Clinical Applications

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[11] Activation Functions in Artificial Neural Networks - Lederer, Johannes.