Neurons are an important component that translate physiological interactions into signals that are readable by the human brain. The neural system of the human body allows one to determine the location of the affected area, as well as classify the kind of stimulus within the affected area (i.e., heat, pressure, cold, pain, etc.). Overtime, through technology, people have been attempting to simulate the neuron through artificial means. In the field of data science, a neuron has been replicated to make predictions, classify, or create based on past experiences. This artificial neuron is often called a perceptron and its neural system is called an Artificial Neural Network (ANN).

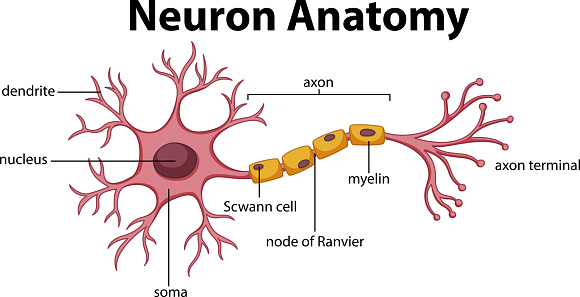


Figure 1: The structure of a neuron.

A neuron is composed of dendrites, a nucleus, Schwann Cells covered in myelin sheets that compose the axon component of a neuron, and an axon terminal. The dendrites are the receptors that receive the signals that then determine whether the neuron sends the signal over through the axon and on to the Axon terminal where there may be another neuron awaiting a response or a different type of cell. Once the neuron has received a signal, it will send the signal through the axon and activate the axon terminal on the condition that the threshold voltage is achieved. The threshold voltage (or the threshold potential) is the threshold signal that needs to be crossed before the neuron decides to send the signal to the axon terminal (this can be a voltage between -55mV to -50mV, once this threshold is crossed, the activation occurs). Whereas the neurons have a threshold potential, its response is binary in that once the threshold is reached, the response is sent regardless of the strength of the signal. This signal continues on to the axon terminal which in turn converts electrical signal to a chemical signal. The axon terminal is near another cell within it’s own receivers that take chemical signals that in turn can either convert once again to an electrical signal or continue on as another chemical signal that causes a reaction in the body.

A Perceptron is composed of inputs, weights, the weighted sum, and a step function which creates an output. In terms of the inputs, some inputs may stem from other perceptrons, but one input is constant and changed based on the training done on the perceptron. This constant input is also called the bias and works to shift the activation function. Once the inputs are in the weights are multiplied by the inputs and the product is summarized before passing through the activation function. This activation function determines whether the perceptron activates or not. The perceptron behaves in a binary manner, in that it will send the signal if it passes the threshold placed by the activation function or it does not. The output is then sent to the next perceptron, or the output is summarized with the outputs of other perceptrons to form the final output of the neural network. Although perceptrons and neurons may seem to be completely different systems, they share many similarities.

Both neurons and perceptrons are subjective to a threshold signal. Before a neuron can activate and send a signal to the next cell, the threshold potential must first be achieved. Similarly, the sum of the products between the inputs and the weights must pass the threshold set by the activation function otherwise the perceptron will not send the signal to the next perceptron. Although their core functionality is incredibly similar, they both have a threshold, take as many inputs as available, and they transform input signals, there are even more differences that make the way in which a perceptron and neuron function differently. Neurons have a rest period between activation and post deactivation. Whereas a perceptron can receive multiple of the same inputs over time, a neuron is limited by the rest period that it is required to take before activating once again. *Training* a neuron is fundamentally different than training a perceptron. A neuron is exposed to stimulation that can be a signal (or data) that will most likely contain unwanted noise and therefore to train a neuron, one would require to accompany the desired signal with a spike in stimulation. This stimulation needs to be accurately timed and must be repeated over a long period of time, whereas one does not need to time and pace the training data for a perceptron. As one inputs and outputs the training data, the output of the perceptron is compared to the expected output, the difference in outputs cause a change in the bias as well as the weights of the perceptron. A second difference between neurons and perceptrons is the nature of the activation. Where neurons have a sigmoid-like activation, perceptrons can have different kinds of activation functions (such as RELU, sigmoid, tan, etc.). A third difference between the two is the nature of the input determines the kind of neuron (i.e., unipolar, purkinje, bipolar, multipolar, pyramidal, etc.).

Diagram

Description automatically generated

Figure 2: Diagram representing a perceptron.

Neuron’s and perceptrons share many similarities, such as its ability to take inputs, it’s threshold, and how they both transform their inputs signals. Although they have many similarities, they are also fundamentally different in other manners. Perceptrons, as opposed to neurons, are capable of training at a faster rate with less exposure to noise at the input which is an advantage when training a perceptron to provide an output. Perceptrons are inspired by the neurons found in biological beings because of how well neurons are able to do simple actions that when accumulated via a series or a network of neurons, can become a complex action. Similarly, a collection of perceptrons contain the potential to individually output simple calculations that when placed together at the end of the Artificial Neural Network, it becomes a complex result. Such an example is the classification of an image, or drawing an image from a text description.

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