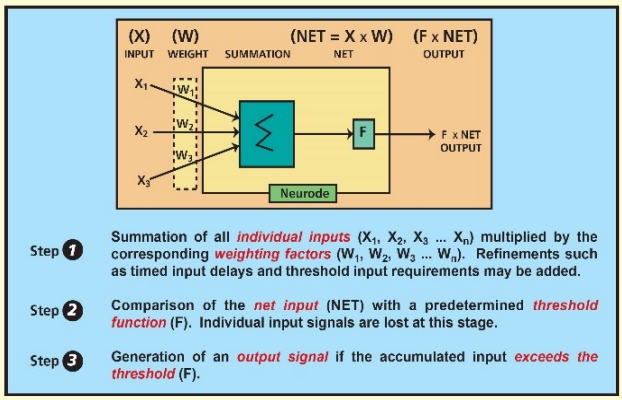
Connectionist Algorithms

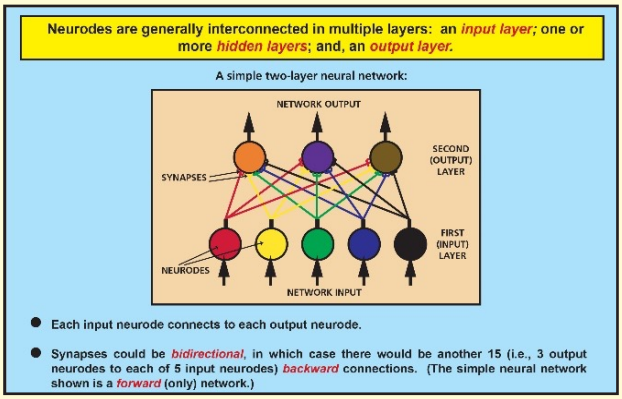
In the human brain the recognition of any image starts with the activation of neurons that respond to very low-level properties of the image such as the luminance of one or more distinct areas or dots or lines or planes in the image. The firing of these neurons will activate other connected neurons that respond to other features that build on the partial interpretations of the previous level neurons, and so on. This is referred to as a synaptic chain in which the chemical connections (i.e., synapses) between neurons play a decisive role. With each successive level of response, the comprehension of the whole image becomes more complete and the contribution of the next level builds more and more on the cumulative results of the previous levels.

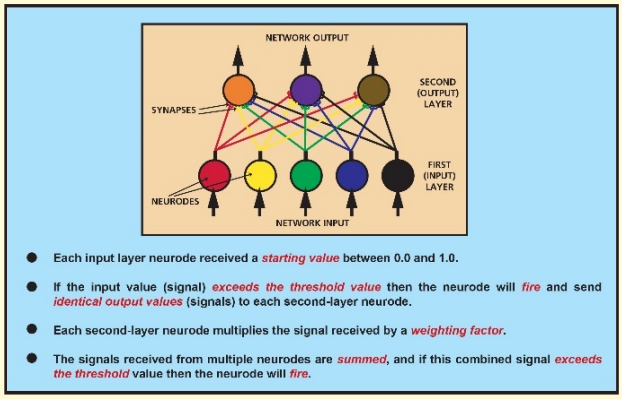


Step 1 Summation of all *individual inputs* (X_1, X_2, X_3 ... X_n) multiplied by the corresponding *weighting factors* (W_1, W_2, W_3 ... W_n). Refinements such as timed input delays and threshold input requirements may be added.

Step 2 Comparison of the *net input* (NET) with a predetermined *threshold function* (F). Individual input signals are lost at this stage.

Step 3 Generation of an *output signal* if the accumulated input *exceeds the threshold* (F).





In the connectionist approach to Machine Learning these synaptic chain operations of the brain are simulated mathematically not only by multiple layers of neurodes (i.e., simulated neurons) in each neural network but also by stacking multiple neural networks vertically with mathematically computed connections between them. Like a neuron, a neurode receives inputs from its connection to other neurodes within the network and multiplies these inputs (X) by a weighting factor (W) to compute a function (F). If this function exceeds a cumulative value, then the neurodes will fire by sending an output to all other neurodes that are connected to it.

When the total input to the function (F) is very negative its value is close to zero. If the input is very large and positive then the value of the function is close to one. The neurodes are connected in one or more (hidden) layers between the input layer and the output layer.

Backpropagation is the connectionist's principal Machine Learning algorithm. After the neural network has processed the input to the output during its forward pass, the output is compared with the desired output and the error is propagated back through the layers of the network and the input. Each neurode adjusts its weighting based on the error and the input that it received during the forward pass. After thousands of repetitions the neural network's output neurodes will closely match the desired output that recognizes the particular input that it was trained to recognize.

Deep Learning utilizes interconnected neural networks to simulate the ability of the human brain to comprehend a visual sensory input (i.e., a scene in the local real-world environment). Several neural networks are stacked vertically to conceptually simulate synaptic chain operations in our brain. During training the neural networks are shown a large number of positive (i.e., correct) examples and the weights between neurodes are incrementally adjusted to produce a positive output (i.e., value of function (F) close to one).