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Overview And Applications of Artificial Neural Networks

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Abstract: *ARTIFICIAL NEURAL NETWORK INTRODUCTION The simplest definition of a neural network, more properly referred to as an 'artificial' neural network (ANN), is provided by the inventor of one of the first neurocomputers, Dr. Robert Hecht-Nielsen. He defines a neural network as: "...a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs. ANNs are processing devices (algorithms or actual hardware) that are loosely modeled after the neuronal structure of the mammalian cerebral cortex but on much smaller scales. A large ANN might have hundreds or thousands of processor units, whereas a mammalian brain has billions of neurons with a corresponding increase in magnitude of their overall interaction and emergent behavior. Although ANN researchers are generally not concerned with whether their networks accurately resemble biological systems, some have. For example, researchers have accurately simulated the function of the retina and modeled the eye rather well. Although the mathematics involved with neural networking is not a trivial matter, a user can rather easily gain at least an operational understanding of their structure and function. PROBLEM STATEMENT Computers are great at solving algorithmic and math problems, but often the world can't easily be defined with a mathematical algorithm. Facial recognition and language processing are a couple of examples of problems that can't easily be quantified into an algorithm, however these tasks are trivial to humans. The key to Artificial Neural Networks is that their design enables them to process information in a similar way to our own biological brains, by drawing inspiration from how our own nervous system functions. This makes them useful tool for solving problems like facial reorganization, which our biological brain can do easily.*

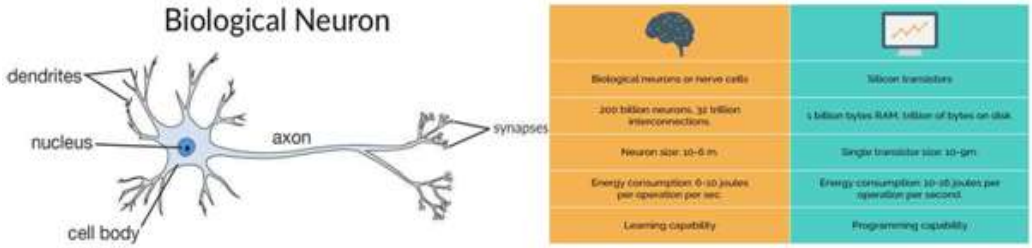
Keywords: *Statistical modeling, neural network, back propagation, artificial intelligence.*

I. Introduction

Computers are great at solving algorithmic and math problems, but often the world can't easily be defined with a mathematical algorithm. Facial recognition and language processing are a couple of examples of problems that can't easily be quantified into an algorithm, however these tasks are trivial to humans. The key to Artificial Neural Networks is that their design enables them to process information in a similar way to our own biological brains, by drawing inspiration from how our own nervous system functions. This makes them useful tools for solving problems like facial recognition, which our biological brains can do easily.

II. Structure Of Neurons In Brain

The term Neural Network is derived from the Human (Animal) nervous system's basic functional unit 'NEURON' or nerve cells which are present in the brain and other parts of human.The typical nerve cell of human brain comprises of four parts. Human brain is different from computer.



Dendrite—It receives signals from other neurons.
Soma (cell body)—It sums all the incoming signals to generate input.

Axon—when the sum reaches a threshold value, neuron fires and the signal travels down the axon to the other neurons.

Synapses—The point of interconnection of one neuron with other neurons. The amounts of signal transmitted depend upon the strength (synaptic weights) of the connections.
The connections can be inhibitory (decreasing strength) or excitatory (increasing strength) in nature. So, neural network, in general, is a highly interconnected network of billions of neuron with trillion of interconnections between them.

Artificial Neural Networks -are the biologically inspired simulations performed on the computer to perform certain specific tasks like clustering, classification, pattern recognition etc.
Artificial Neural Networks, in general—is a biologically inspired network of artificial neurons configured to perform specific tasks.
Similarity of ANN with Biological Neural Network
Neural networks resemble the human brain in the following two ways - A neural network acquires knowledge through learning.
A neural network's knowledge is stored within inter-neuron connection strengths known as synaptic weights.

III. Analogy Of Artificial Neural Network With Biological Neural Network

Artificial neural nets were originally designed to model in some small way the functionality of the biological neural networks which are a part of the human brain. Our brains contain about 1011 neurons. Each biological neuron consists of a cell body, a collection of dendrites which bring electrochemical information into the cell and an axon which transmits electrochemical information out of the cell.

A neuron produces an output along its axon i.e. it fires when the collective effect of its inputs reaches a certain threshold. The axon from one neuron can influence the dendrites of another neuron across junctions called synapses. Some synapses will generate a positive effect in the dendrite, ie one which encourages its neuron to fire, and others will produce a negative effect, i.e. one which discourages the neuron from firing. A single neuron receives inputs from perhaps 105 synapses and the total number of synapses in our brains may be of the order of 1016 . It is still not clear exactly how our brains learn and remember but it appears to be associated with the interconnections between the neurons (i.e. at the synapses).

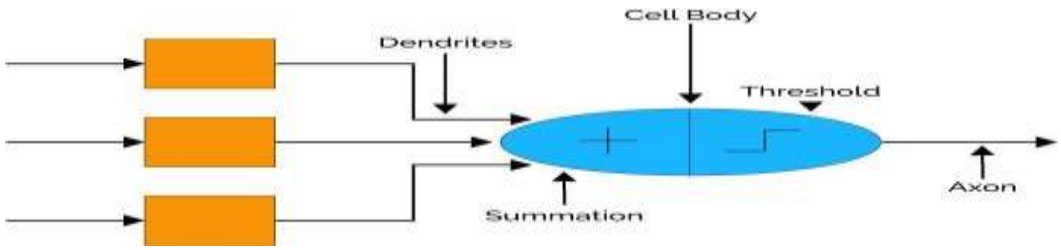
Artificial neural nets try to model this low level functionality of the brain. This contrasts with high level symbolic reasoning in artificial intelligence which tries to model the high level reasoning processes of the brain. When we think we are conscious of manipulating concepts to which we attach names (or symbols) example for people or objects. We are not conscious of the low level electrochemical processes which are going on underneath. The argument for the neural net approach to AI is that, if we can model the low level activities correctly, the high level functionality may be produced as an emergent property.

A single software artificial neuron consists of a processing element which has a number of input connections, each with an associated weight, a transfer function which determines the output, given the weighted sum of the inputs, and the output connection itself.

An artificial neural network is a network of interconnected neurons.

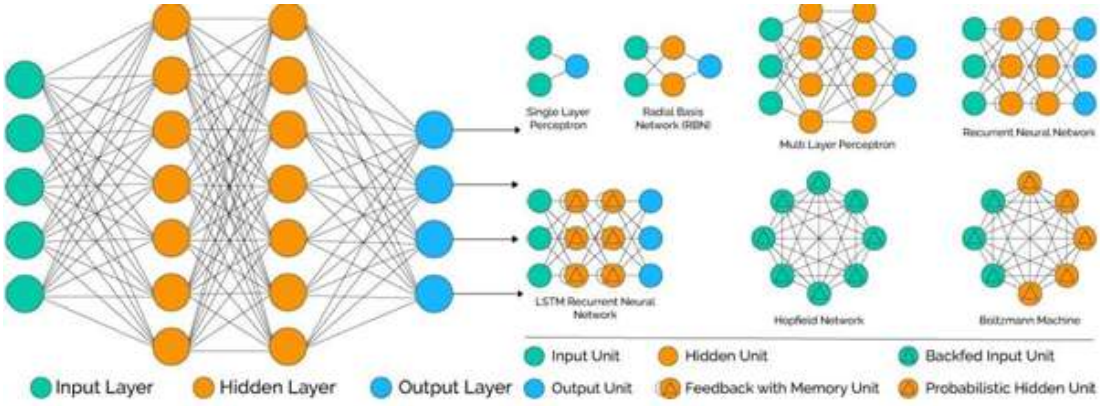
The network may be trained by adjusting the weights associated with the connections in the net to try and obtain the required outputs for given inputs from a training set.

Note that the threshold values and the weights can be adjusted together by adding an extra connection to each neuron with an input value of -1 and a weight representing the threshold. The neuron then fires if the sum is greater than zero. The dendrites in biological neural network are analogous to the weighted inputs based on their synaptic interconnection in artificial neural network. Cell body is analogous to the artificial neuron unit in artificial neural network which also comprises of summation and threshold unit. Axon carries output that is analogous to the output unit in case of artificial neural network. So, ANN is modeled using the working of basic biological neurons.



IV. Architecture And Working Principal Of Artificial Neural Network

A typical neural network contains a large number of artificial neurons called units arranged in a series of layers. In typical artificial neural network, comprise different layers -



 Input layer—It contains those units (artificial neurons) which receive input from the outside world on which network will learn, recognize about or otherwise process.

 Output layer—It contains units that respond to the information about how it's learned any task.

 Hidden layer—These units are in between input and output layers. The job of hidden layer is to transform the input into something that output unit can use in some way.

Most neural networks are fully connected that means to say each hidden neuron is fully connected to the every neuron in its previous layer (input) and to the next layer (output) layer.

Perceptron—Neural Network having two input units and one output units with no hidden layers.

These are also known as 'single layer perceptrons.

Radial Basis Function Network—These networks are similar to the feed forward neural network except radial basis function is used as activation function of these neurons.

Multilayer Perceptron—These networks use more than one hidden layer of neurons, unlike single layer perceptron. These are also known as deep feedforward neural networks.

Recurrent Neural Network—Type of neural network in which hidden layer neurons has self- connections. Recurrent neural networks possess memory. At any instance, hidden layer neuron receives activation from the lower layer as well as it previous activation value.

Long /Short Term Memory Network (LSTM)—Type of neural network in which memory cell is incorporated inside hidden layer neurons is called LSTM network.

Hopfield Network—A fully interconnected network of neurons in which each neuron is connected to every other neuron. The network is trained with input pattern by setting a value of neurons to the desired pattern. Then its weights are computed. The weights are not changed. Once trained for one or more patterns, the network will converge to the learned patterns. It is different from other neural networks.

Boltzmann Machine Network—These networks are similar to Hopfield network except some neurons are input, while other is hidden in nature. The weights are initialized randomly and learn through back propagation algorithm.

V. Learning Happen In Neural Network

Learning occurs when the weights inside the network get updated after much iteration.
For example—suppose we have inputs in the form of patterns for two different classes of patterns—I & 0 as shown and b -bias and y as desired output.
We want to classify input patterns into either pattern 'I' & 'O'.
Following are the steps performed:
 9 inputs from x1—x9 along with bias b (input having weight value 1) is fed to the network for the first pattern.
 Initially, weights are initialized to zero.
 Then weights are updated for each neuron using the formulae: Δ wi = xi y for i = 1 to 9 (Hebb's Rule)
 Finally, new weights are found using the formulae:
 wi(new) = wi(old) + Δwi
 Wi(new) = [111–11–1 1111]
 The second pattern is input to the network. This time, weights are not initialized to zero. The initial weights used here are the final weights obtained after presenting the first pattern. By doing so, the network
The steps from 1–4 are repeated for second inputs.

 The new weights are Wi(new) = [0 0 0 -2 -2 -2 000]
So, these weights correspond to the learning ability of network to classify the input patterns successfully.

Four Different Uses of Neural Networks

 Classification—A neural network can be trained to classify given pattern or data set into predefined class. It uses feedforward networks.

 Prediction—A neural network can be trained to produce outputs that are expected from given input. Eg:— Stock market prediction.

 Clustering—The Neural network can be used to identify a special feature of the data and classify them into different categories without any prior knowledge of the data.
Following networks are used for clustering -
 Competitive networks
 Adaptive Resonance Theory Networks
Kohonen Self-Organizing Maps.
 Association—A neural network can be trained to remember the certain pattern, so that when the noise pattern is presented to the network, the network associates it with the closest one in the memory or discard it.
Example—Hopfield Networks which performs recognition, classification, and clustering etc.

VI. Real World Applications

 Self-driving car by taking the video as input
 Speech recognition
 Face recognition
 Cancer cell analysis
 Heart attack predictions
 Currency predictions and stock price predictions
 Credit card default and loan predictions
 Marketing and advertising by predicting the response probability
 Weather forecasting and rainfall prediction

VII. Conclusion

Neural network is a vast subject. Many data scientists solely focus only on neural network techniques. In this session, we practiced the introductory concepts only. Neural Networks has much more advanced techniques. There are many algorithms other than back propagation. Neural networks particularly work well on some particular class of problems like image recognition. The neural network algorithms are very calculation intensive. They require highly efficient computing machines. Large datasets take a significant amount of runtime on R. We need to try different types of options and packages. Currently, there is a lot of exciting research going on, around neural networks. After gaining sufficient knowledge in this basic session, you may want to explore reinforced learning, deep learning.

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