Automated System for Constructing a Neural Network by Back Propagation Error

Khalid Altarawneh
Assistant professor, Faculty of Information Technology, Data Science Department, Mutah University, Jordan

Abstract:
For improving the construction of neural networks, the back propagation method used to increase the intelligence of advanced machines. Stereotypical input data is considered in this paper since we deal with multilayer feed forward network. The backpropagation method is used to not only connect each neuron in each layer to all neuron in the next layer, but also adjust weights between neurons. In this paper, the direct calculation of results by a trained network is very fast even training the network can be a rather lengthy process
Keywords: Neural Network, Back Propagation Error, Feed forward Neural Network, single layer Neural Network and multi layers Neural Network.
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1- Introduction

1.1- Artificial Neural Network

The way of process information in the human brain by using biological neural networks is the way that is used by to Artificial Neural Network (ANN) to do its computational (Nasser, Al-Shawwa et al. 2019). It has been found that there are a lot of excitement in Machine Learning research and industry generated by Artificial Neural Network(Kim, Kim et al. 2019).

In Artificial Neural Network, neuron, which is the basic unit of a real neural network, is called a node or unit and it is used as a main unit of computation. This node is used to compute an output when it receives input that has an associated weight (w) assigned depending on its importance to other inputsfrom other nodes or from an external source(Faris, Mirjalili et al. 2019). The node applies a function *f*as shown in Figure 1the weighted sum of its inputs to find the output.

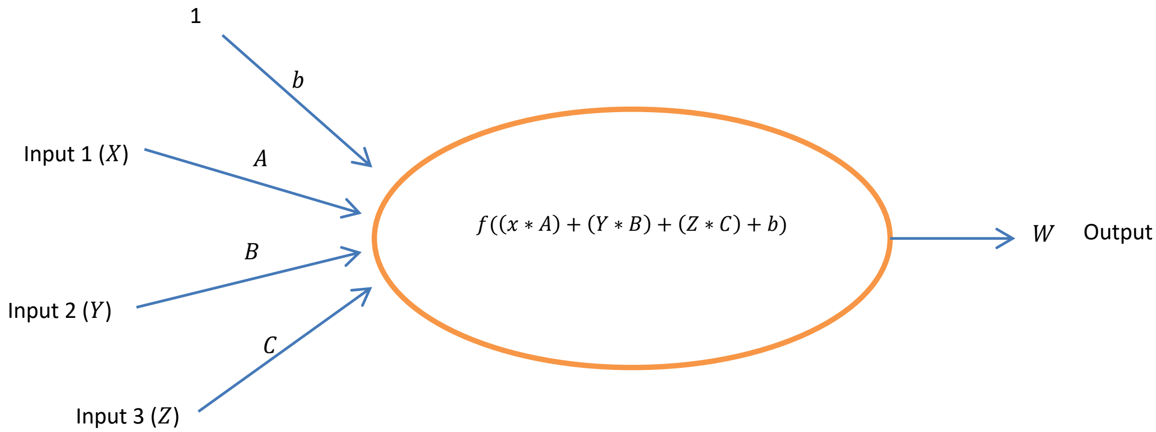

Figure 1: output of neuron$w$ that has three inputs $(x, y\ and\ z)$ with their weights $(A, B\ and\ Z)$. $w = f((x * A) + (Y * B) + (Z * C) + b$where is b called the Bias.

As shown in Figure 1, each node has an input or inputs and a Bias which is used to provide a trainable constant value to every node (Kronman, Richter et al. 2019). For more details about importance of Bias see (Moghim and Bras 2017, Zhang, Yamaguchi et al. 2017, Challen, Denny et al. 2019).

In here, Feedforward Neural Network with its examples Single Layer and Multi-Layer Perceptron is briefly described to give an idea about the first and simplest type of Artificial Neural Network(Huang, Zhu et al. 2004). The feedforward neural network contains nodes arranged on different layers. Connections or edges that have weights associated with them are used to connect nodes from adjacent layers(Svozil, Kvasnicka et al. 1997).

1.2- Feedforward Neural Network

As mentioned above, the feedforward neural network includes nodes arranged on different layers. Connections or edges that have weights associated with them are used to connect nodes from adjacent layers(Svozil, Kvasnicka et al. 1997). An example of the feedforward neural network is shown in Figure 2.

There are two examples of the feedforward neural network. These examples as mentioned previously are single layer and multi-layer perceptron. Single layer perceptron does not contain hidden layer and all computations could be done in input layer (Takagi, Yoshida et al. 2019). Multi-layer perceptron, in contrast, could have one or more hidden layers (Heidari, Faris et al. 2020).

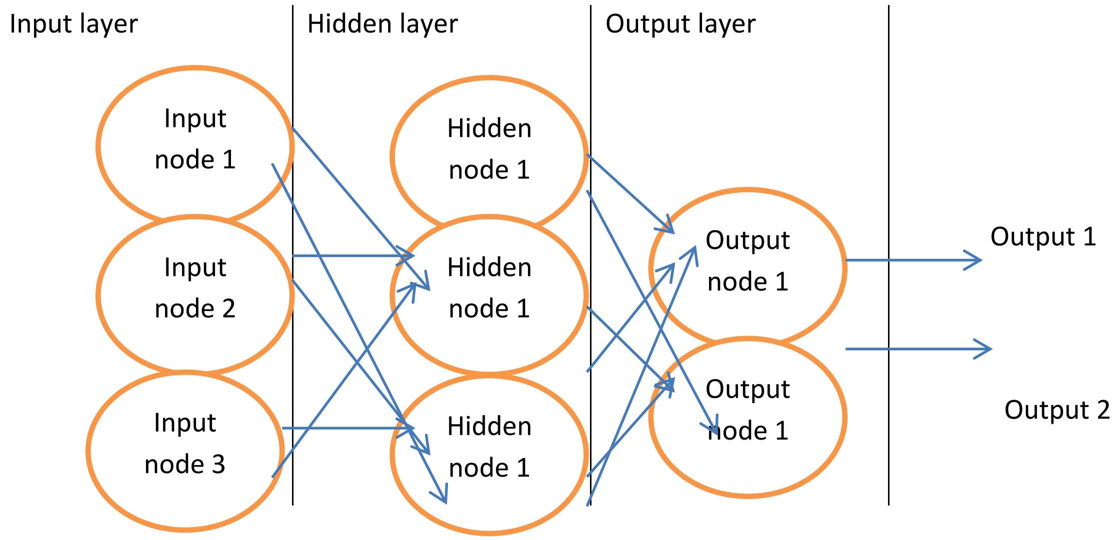

Figure 2: An example of feedforward neural network. Information is provided to the network from outside world using input nodes. Input nodes just passed the information to the network and there is no computation in the input layer. Computations are performed using hidden nodes that they also passed the results to output nodes. Output nodes are used to transfer the results to the outside world.

2- Formulation of the problem:

Multi-layer artificial neural networks have been trained to learn and represent accurate resultsto automatically detect good “internal representations” for images (Jayas, Paliwal et al. 2000). However, stereotypical input datais used to activate a specific node to study a specific object. It has been found that the node has studied the object if its weight and displacement cause activation of this node when the object is present in the input(Jayas, Paliwal et al. 2000).

3- Problem solving methodology

The backpropagation method was one of the first methods able to show that artificial neural networks can perceive “good” internal data. it has been found that many nodes included in multilayer direct distribution networks are similar to those nodes included in the real biological neural networks in the mammalian brain(Goh 1995). For example, some nodes learned to detect edges, while others used filters Gabor. In addition the efficiency of the algorithm, experts have no need to detect the corresponding functions of each node since the error back propagation method allowed artificial neural networks to apply to a much wider range of problems that were previously inaccessible for limitations in time and cost(Chen 2016).

We consider the human brain as a “finite” neural network. Then, ideally it is necessary to create a device that simulates the functions of the brain. However,a simplified design for this finite” neural network since there is no technology could simulate it. A small electronic device needs to be added to transfer function similar to a biological neuron, and then connect each neuron to many other neurons, using RLC networks. RLC networks are used to simulate dendrites, axons and synapses. However, this electronic model is still difficult to implement, and it may be difficult to “train” the network and to use it for practical purposes.

To cope with this limitation, additional restrictions to make the project more manageable are needed. As known, in real biological networks, connections between neurons could be randomly happened and changed so each neuron could have different connections accrossing different layers. In here, as shown in Figure 3 each neuron in each layer is connected to all neurons in the next layer.

Moreover, it is determined that signals flow only in one direction over the network and and the design of the neuron and synapse was simplified so they behave like analog comparators controlled by other neurons through simple resistors. Therefore, this neural network model is easily to be constructed and used.

Since the real uniqueness or “intelligence” of the network exists in the values of weights between neurons, a method to adjust weights between these neurons is needed. Back propagation erroris used for adjusting weights between these neurons.

The network learns by example, it is necessary to provide a training set that comprises some input examples and known correct output data for each case. Therefore, these I/O examples are used to show the network’s behavior that expectedand what algorithm needs to be used to allow the network to be adapted. The learning process using the backpropagation method of the error (Figure 3) occurs in small iterative steps: one example applies to the network, and the network produces some output based on the current state of its synoptic weights (initially the output will be random). The result is compared with the “good” output, and the average error signal is calculated. The error value then propagates back over the network, and small changes are made to the weights in each layer. The whole process is repeated for each of the examples, and then again back to the first case and so on. This cycle is repeated until the total error value falls below a certain threshold. We conclude it that the network has studied the problem “reasonably well.” With all this, the network will never exactly study the ideal function, but asymptotically approach the ideal function.

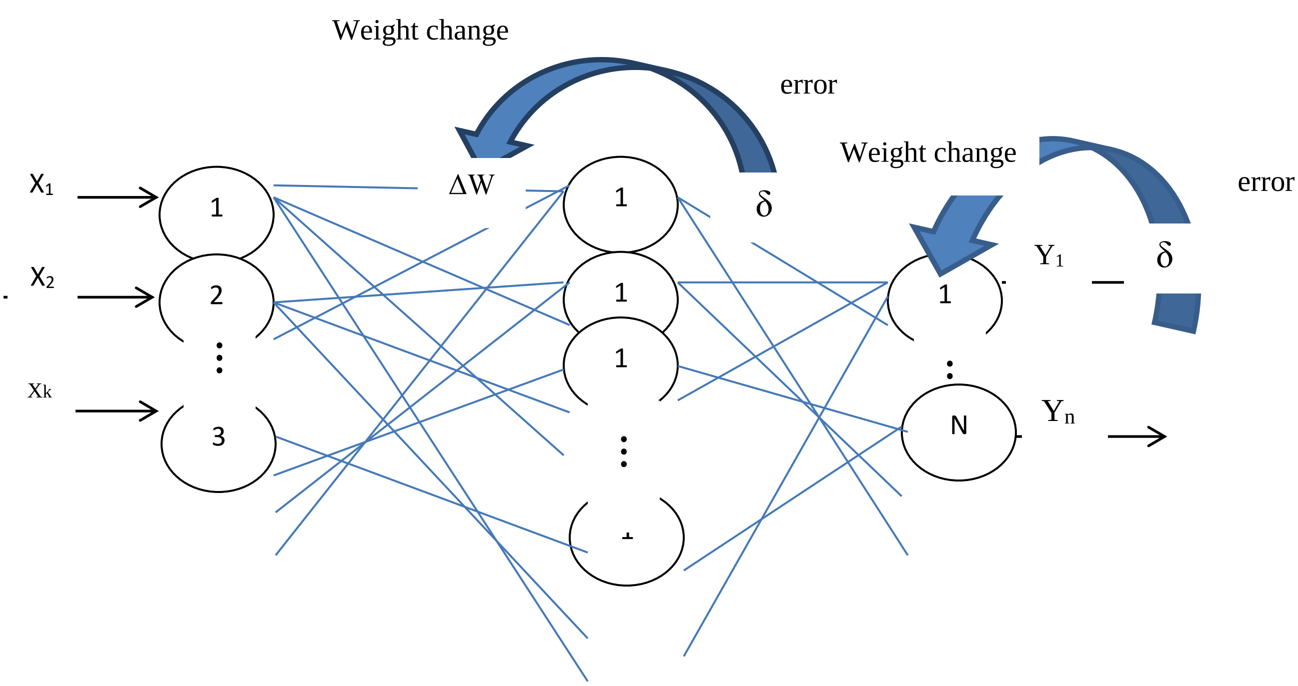

Figure 1 - Network training using the back propagation method

4- Results

Eventraining the network can be a rather lengthy process but the direct calculation of results by a trained network is very fast. In addition, there are numerous variations of the back propagation method designed to increase the speed of the learning process.

A backpropagation neural network is practical only in certain situations. The following are some guidelines for when to use this method:

1- It is easy to create a series of examples of correct behavior.
2- The solution to the problem may change over time, within the specified input and output parameters.
3- The problem seems to be of overwhelming complexity, but the solution clearly exists.

Conclusion:

It is important to remember that when solving a problem using neural networks. It is not important to understand the meaning of the solution. This is a major advantage of neural network approaches. With sufficient training, the network will simulate the function being shown. In addition, with the help of neural networks, you can apply some inputs inappropriate for solution - in the learning process; the network will learn to ignore any inputs that do not contribute to the output.

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