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Review on Estimating Number of Hidden Layer Neurons in ANN

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Abstract* - Artificial Neural Networks are most effective and appropriate for pattern recognition and many other real world problems like signal processing, classification problems etc. Numerous advancements, which have been made in the development of intelligent system, are inspired by the biological activities. Neural network is one such complex adaptive system that is able to capture and represent complex input/output relationships. Selection of hidden neurons in neural network is one of the major problems in the field of Artificial Neural Network. The random selections of hidden neurons may cause the problem of either Underfitting or Overfitting. Overfitting arises because the network matches the data so closely as to lose its generalization ability over the test data. The proposed method finds the near to optimal number of hidden nodes after training the ANN from real world data. The advantage of proposed method is that it is not approximately calculating number of hidden nodes but based on similarity between input data, they are calculated.

***Keywords* –Artificial Neural Network, Neurons, Hidden Layer, Back Propagation Neural Network.**

I. INTRODUCTION

Neural Networks are most effective and appropriate for pattern recognition and many other real world problems like signal processing, Classification problems. Superior results in pattern recognition can be directly provided in the forecasting, classification and data analysis. To bring proper results, NN require correct data pre-processing, architecture

selection and network training but still the performance of a neural network depends on the size of network. Selection of hidden neurons using the neural networks is one of the major problems in the field ofArtificial Neural Network.

Neural Network is a vast domain of technology where one can implement “human brain decision making power” into computer programs on the basis of error and approximation. Also, lot of research and development has been made in the field of Artificial Intelligence with the help of Neural Network, Fuzzy Logic and Genetic Algorithm.

Neural Networks attempt to bridge the gap between the capabilities of computers and human brain by modelling aspects of information in the brain in a highly simplified way. The motivation for research in neural network is due to two prime desires: to obtain a better understanding of the human brain and to develop computers that can deal with abstract and poorly defined problems.

II. ARTIFICIAL NEURAL NETWORK

Artificial neural network (ANN) is a machine learning approach that models human brain and consists of a number of artificial neurons.[1] Neuron in ANNs tend to have fewer connections than biological neurons. Each neuron in ANN receives a number of inputs. An activation function is applied to these inputs which results output value of the neuron. Knowledge about the learning task is given in the form of examples called training examples. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurones as shown in figure 1.

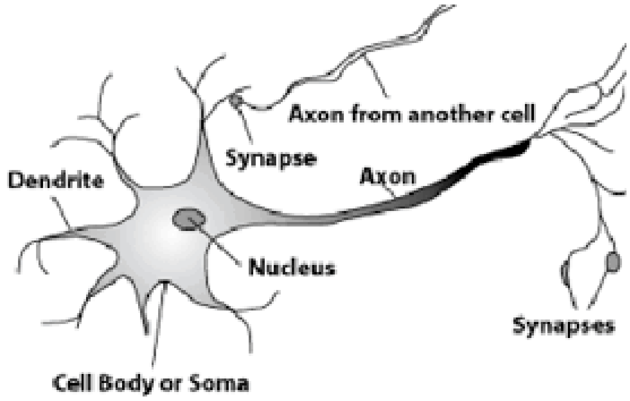

Figure 1. A Biological Neuron[11]

Architecture of the Artificial Neural Network consists Input layer, Hidden layer, Output layer.

2.1.1 Input Layer:

The Input Layer is a layer which communicates with the external environment. Input layer presents a pattern to neural network. Once a pattern is presented to the input layer, the output layer will produce another pattern. It also represents the condition for which purpose we are training the neural network [2].

2.1.2 Output Layer:

The Output layer of the neural network is what actually presents a pattern to the external environment. The pattern presented by the output layer can be directly traced back to the input layer. The number of output neurons should be directly related to the type of work that the neural network is to perform. To determine the number of neurons to use in output layer, first consider the intended use of the neural network. If the neural network is to be used to classify items into groups, then it is often preferable to have one output neuron for each group that input items are to be assigned into. If the neural network is to perform noise reduction on a signal, then it is likely that the number of input neurons will match the number of output neurons. [4].

2.1.3 Hidden Layer:

The Hidden layer of the neural network is the intermediate layer between Input and Output layer. Activation function applies on hidden layer if it is available. Hidden layer consists hidden nodes. Hidden nodes or hidden neurons are the neurons that are neither in the input layer nor the output layer [2].

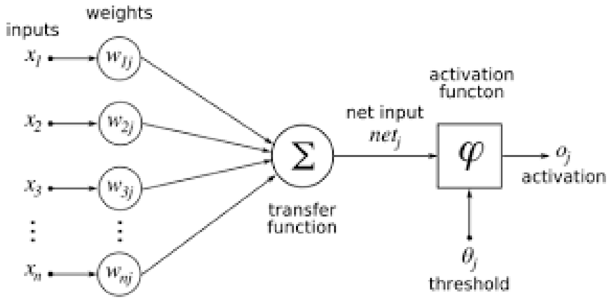

Figure 2. Hidden Layer Architecture[11]

Another question arises that how many hidden layers has to be used when dealing with complex problem. If the data is linearly separable than there is no need to use hidden as the activation function can be implemented to input layer which can solve the problem. But in case of problems which deal with arbitrary decision boundary to arbitrary accuracy with rational activation functions then one has to use two or three hidden layer. Also, the number of neurons that should be kept in each hidden layer need to be calculated. If the number of neurons are less as compared to the complexity of the problem data then “Underfitting” may occur. Underfitting occurs when there are too few neurons in the hidden layers to adequately detect the signals in a complicated data set. If unnecessary more neurons are present in the network then “Overfitting” may occur. Several methods are used till now which do not provide the exact formula for calculating the number of hidden layer as well as number of neurons in each hidden layer. In the next section, different techniques/assumptions are elaborated in the literature survey for calculating the number of hidden layer and the number of neurons in each hidden layer.

III. RELATED WORK

Many researcher put their best effort in analysing the solution to the problem that how many neurons are kept in hidden layer in order to get the best result, but unfortunately no body succeed in finding the optimal formula for calculating the number of neurons that should be kept in the hidden layer so that the neural network training time can be reduced and also accuracy in determining target output can be increased. Basically when dealing with the number of neurons in the input layer, one has to analyse about the data which is trained. Deciding the number of neurons in the hidden layer is a very important part of deciding your overall neural network architecture. Hidden layers do not directly interact with the external environment but still they have a tremendous influence on the final output.

There are some various approaches to find out number of hidden nodes in hidden layer.

1. Try and Error Method [6]

Try and error method characterised by repeated, varied attempts which are continued until success or until the agent stops trying. This method divides in to two approaches.

Forward Approach: This approach begins by selecting a small number of hidden neurons. We usually begin with two hidden neurons. After that, train and test the neural network then increased the number of hidden neurons. Repeat the above procedure until training and testing improved.

Backward Approach: This approach is opposite of Forward approach. In this approach we start with large number of hidden neurons. Then train and test the NN. After that gradually decrease the number of hidden neurons and again train and test the NN. Repeat the above process until training and testing improved.

2. Rule of Thumb Method [7]

Rule of thumb method is for determining the correct number of neurons to use in the hidden layers, such as the following:

- The number of hidden neurons should be in the range between the size of the input layer and the size of the output layer.
- The number of hidden neurons should be 2/3 of the input layer size, plus the size of the output layer
- The number of hidden neurons should be less than twice the input layer size

3. Simple Method [10]

It is a simple method to find out neural network hidden nodes. Assume a back propagation NN configuration is l-m-n. Here l is input nodes, m is hidden nodes and n is output nodes. If we have two inputs and two outputs in our problem then we can take same number of hidden nodes. So our configuration becomes 2-2-2 where 2 is input nodes, 2 is hidden nodes, 2 is output nodes.

4. Two Phase Method [10]

In two phase method the termination condition is same as the trial and error method but in a new approach. In this method data set is dividing into four groups. Among all four groups two groups of data are used in first phase to train the network and one group of remaining data set is used in second phase to test the network. Last group of data set is used to predict the output values of the train network. This experiment is repeated for different number of neurons to get minimum number of error terms for selecting the number of neurons in the hidden layer [3].

5. Sequential Orthogonal Approach [10]

Another approach to fix hidden neuron is the sequential orthogonal approach. This approach is about adding hidden neurons one by one. Initially, increase N_h sequentially until error is sufficiently small. When adding a neuron, the new information introduced by this neuron is caused by that part of its output vector which is orthogonal to the space spanned by the output vectors of previously added hidden neurons .An additional advantage of this method is that it can be used to build and train neural networks with mixed types of hidden neurons and thus to develop hybrid models.

IV. ACTIVATION FUNCTION

Activation function f is performing a mathematical operation on the signal output. Activation functions are chosen depending upon the type of problem to be solved by the network.

There are some common activation functions[9]:

1) Linear activation function

2) Piecewise Linear activation function

3) Tangent hyperbolic function

4) Sigmoidal function

5) Threshold function

Linear activation function will produce positive number over the range of all real number [9].

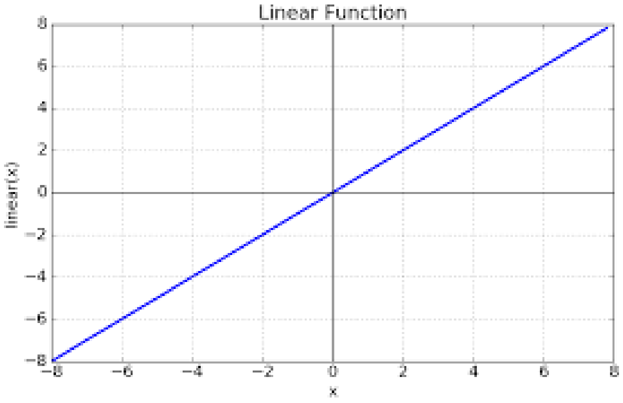

Figure 3. Linear Function

Threshold function is either binary type or bi-polar type. If the threshold function is binary type its range is in between 0 to 1[9].

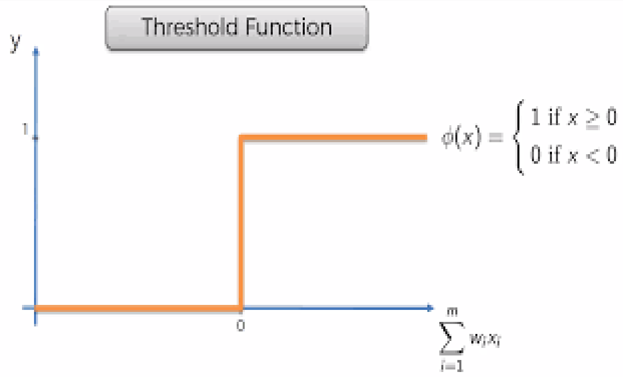

Figure 4. Threshold Function[11]

Piecewise linear function is also named as saturating linear function. This function has binary and bipolar range for saturating limits of the output. Its range lies between -1 to 1 [9].

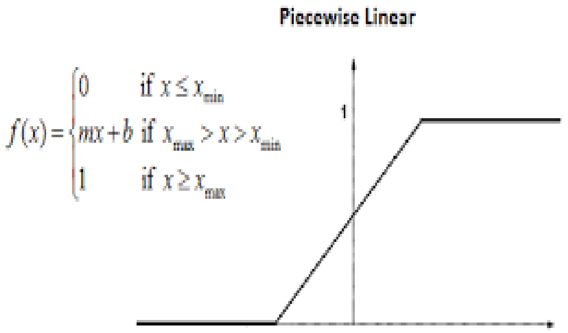

Figure 5. Piecewise Linear Function

Sigmoidal function is non-linear curved S-shaped function. This function is the most common type of activation function used to construct the neuralnetwork [9].

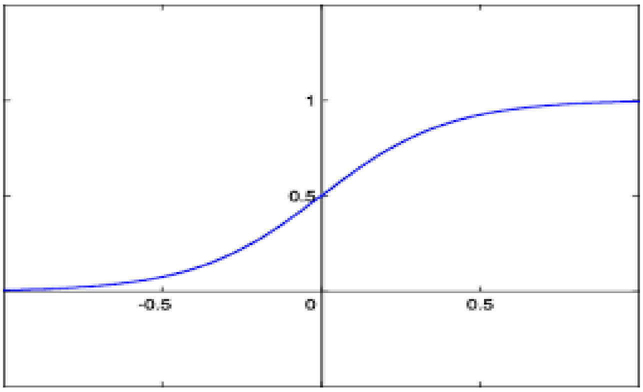

Figure 6.Sigmoidal Function

The Hyperbolic Tangent Activation Function is an alternative to the logistic sigmoid is the hyperbolic tangent, or tanh function (Figure 1, green curves). Like the logistic sigmoid, the tanh function is also sigmoidal ("s"-shaped), but instead outputs values that range[9].

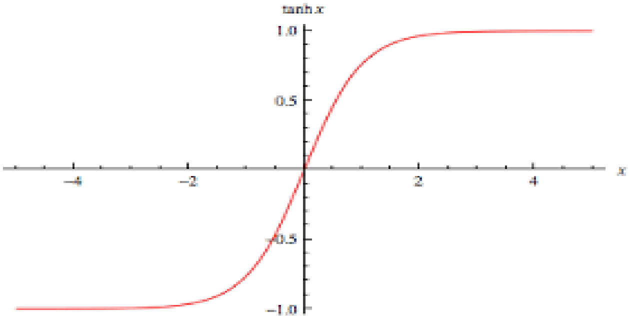

Figure 7.Tangent HyperbolicFunction[11]

V. CONCLUSION

Practically, it is very difficult to determine a good network topology just from the number of inputs and outputs. It depends critically on the number of training examples and the complexity of the classification trying to learn. There are problems with one input and one output that require millions of hidden units, and problems with a million inputs and a million outputs that require only one hidden unit, or none at all. However, this is true fact that by taking suitable number of hidden layers and the number of neurons in each hidden layer, better results in less training time can be obtained. Many researchers develop approach to estimate the number of neurons and hidden layers requirement for a neural network but the approximation also get dependable on the type of the database samples for which the network is designed. By increasing the number of hidden layers up to three layer, accuracy can be achieved up to great extent but complexity of the neural network and training time is increased many folds. If accuracy is the main criteria for designing a neural network then hidden layers can be increased. Also, unnecessary increment in the neurons or layer will lead to Overfitting problem. So it is quiet essential that before designing the neural network, training database samples must be analyzed so that approximation of number of neurons and hidden layers can be guessed properly.

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