Selection of number of hidden neurons in neural networks in renewable energy systems

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This paper presents a new approach to select number of hidden neurons in neural network in renewable energy systems. The random selection of number of hidden neurons might cause over fitting and under fitting problems in neural networks. The proper selection of neurons in hidden layer is important in the design of neural network model. To fix hidden neurons, 91 various criteria are examined based on estimated mean squared error. The convergence analysis is performed for the various proposed criteria. To verify the effectiveness of the proposed model, simulations were conducted on real time wind data. Results show that with minimum error the proposed approach can be used in renewable energy systems.

Keywords: Neural Networks, Hidden Neurons, Mean Squared Error

Introduction

Neural Networks (NN) is computing methodology which resembles a human biological neuron. It is an information processing system. Neural Network has been successfully applied in many fields such as prediction, control system, image processing and classification etc. The random selection of NN model parameter causes the over fitting or under fitting problem. Hidden neurons can influence the error on the neurons to which their output connected. The performance analysis is to estimate the training and generalization errors. The result with minimum estimated generalization error is determined as optimum for the application of neural network model12. The training data and generalization error are likely to be high before learning begins. During training, the network adapts to decrease the error on the training patterns. The accuracy of training is determined by the parameters under consideration. The parameters include NN architecture, number of hidden neuron in hidden layer, activation function, inputs and updation of weights. The fixation of the number of hidden neurons is an important criterion for the design of neural networks.

Materials and Methods

The objective is to devise formula that selects the number of hidden neurons as a function of input neurons and to develop the model in renewable energy systems. The estimate can take the form of a single exact topology to be adopted. The perfect design of NN model is important for challenge of better accuracy of model. The data required for input are wind speed, wind direction and temperature. The data are collected from Suzlon wind farm. The higher valued collected data tend to suppress the influence of smaller variable during training. To overcome this problem, the normalization technique is used. Therefore, data are scaled within range [0 1]. The scaling is carried out to improve accuracy of subsequent numeric computation. The perfect design of NN computing model based on the selection criteria is substantiated using convergence theorem. The training can be learned from previous data after normalization. The performance of trained network is evaluated by two ways. First, the actual and predicted wind speed compared and second, computes MSE of the network.

Proposed Algorithm

The steps involved in the proposed algorithm are as given below.

Step 1: Input the data which collected from wind farm. Select input variable like temperature in Degree C, wind direction in Degree and wind speed in m/s.

Step 2: Calculate normalized value of each input variable using Min Max normalization technique.

Step 3: Assigning the parameter for implementation of NN model, like epochs, number of input, number of output and the goal of network.
Step 4: Consider the 91 proposed criteria for fixing number of hidden neurons. Each criteria is applied to NN model and train the network for develop NN model.

Step 5: Calculate MSE of each criteria using the equation is follows.

\[
\text{MSE} = \frac{\sum_{i=1}^{N} (Y_i - \hat{Y}_i)^2}{N}
\]  

... (1)

Where \(Y_i\) is predicted output, \(\hat{Y}_i\) is actual output and \(N\) is number of samples.

Step 6: Selecting best criteria based on lowest estimation of MSE. This is used to determine number of hidden neurons for a given problems.

Step 7: Applying new criteria for fixing number of neuron in hidden layer to implement a NN model. From the development of proposed NN model, 7000 data is for training and 3000 data is for testing NN model for validates performance of network.

Step 8: Computing Output and MSE of the network and simulate with data.

Step 9: To ensure the effectiveness of proposed approach, actual and predicted wind speed is obtained. Also, MSE is computed. This proposed NN model is to fix hidden neuron in NN used in renewable energy systems. Figure 1.

**Results and Discussions**

**Proof for the chosen proposed criteria**

Based on convergence theorem, the proof for the selection criteria is established henceforth. Lemma 1.1 is an estimate of sequence which proves the convergence of the proposed criteria

**Lemma1.1**

Suppose a sequence \(a_n = \frac{4n}{n-2}\), is converged and \(a_n \geq 0\)

It has limit 1. If there exists constant \(\varepsilon > 0\) such that \(|a_n - l| < \varepsilon\)

then \(\lim_{n \to \infty} a_n = l\)

**Proof:** The proof based on Lemma1.1

According to theorem, parameter converges to finite value

\(a_n = \frac{4n}{n-2}\).

Here 4 is limit of sequence as \(n \to \infty\)

If sequence has limit then it is a convergent sequence.

The considered samples of various criteria for fixing the number of hidden neuron with MSE are shown in Table 1. The selected criteria for NN model is \(4n/n-2\) which used 12 number of hidden neurons and obtained a minimal MSE value of 0.0042 in comparison with other criteria. So this criteria \(4n/n-2\) is effective in renewable energy systems. Several researchers proposed many approaches to select the number of hidden neurons in neural network. The approaches mainly classifies into constructive and pruning approach. The constructive approach, it start with undersized network and then add additional

![Flowchart of proposed approach](image-url)
hidden neuron. The pruning approach, it starts with oversized network and then prunes the less relevant neuron and weights to find the smallest size. The problems of proper number of hidden neuron for a particular problem are to be fixed. The existing methods to determine number of hidden neuron is trial and error rule. This starts with undersized number of hidden neuron and adds neurons to \( n_0 \). The disadvantage of this is the time consuming and there is no guarantee of fixing the hidden neuron. The result with minimum mean squared error is determined as best solution for fixing hidden neurons in neural networks. Simulation results are showing that predicted wind speed is in good agreement with the experimental measured values. Initially real time data are divided into training and testing set. The training set performs in neural network learning and testing set performs to estimating the error. The testing performance stops improving as number of hidden neuron continue to increase; training has begun to fit the noise in the training data, and over fitting occurs. In this paper, proposed criteria are considered for designing a three layer neural networks. It is known that certain approaches produce large size network than necessary and others are expensive. The fixing of number of hidden layer neurons is important in the implementation of neural network.

### Conclusion

A new approach has been proposed in this paper to select number of hidden neurons in network in renewable energy systems. The proposed model builds up an appropriate number of hidden neuron in neural network, results in compact structure. The main advantages include reduce error; improve stability and accuracy of network. The novelty of proposed approach is that it can determine number of hidden neuron with minimal errors. The experimental results demonstrate that the new algorithm is good agreement with the estimation of hidden neurons.

### References