Artificial neural networks in forecasting maximum and minimum relative humidity

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Abstract:
In this paper, the application of neural networks to study the maximum and minimum relative humidity for Chandigarh city is explored. One important architecture of neural networks named Multi-Layer Perceptron (MLP) to model forecasting system is used and Back Propagation algorithm is used to train the network. The proposed network is trained with actual data of the past 10 years (2000-2010) and tested which comes from meteorological department. The results show that the maximum and minimum relative humidity can be predicted more accurately by using the artificial neural network.

Keywords:
Artificial neural network, Multi-layer perceptron, Back Propagation.

1. Introduction

Weather forecasting for the future is one of the most important attributes to forecast because agriculture sectors as well as many industries are largely dependent on the weather conditions. It is often used to predict and warn about natural disasters that are caused by abrupt change in climatic conditions [1]. The observations of atmospheric pressure, temperature, wind speed, wind direction, relative humidity, and precipitation are made near the earth's surface by trained observers[2]. In this paper we are just concentrated on maximum and minimum relative humidity.

2. Weather Prediction Using ANN:

The artificial neural network "learns" by adjusting the interconnections (called weights) between layers. When the network is adequately trained, it is able to generalize relevant output for a set of input data. A valuable property of neural networks is that of generalization, whereby a trained neural network is able to provide a correct matching in the form of output data for a set of previously unseen input data.

2.1 Artificial neural networks (ANN):

Artificial neural networks (ANN) are parallel computational models, comprising closely interconnected adaptive processing units. The important characteristic of neural network is their adaptive nature, although computing these days is truly advanced even then there are certain tasks that a program made for a common microprocessor is unable to perform. So a software implementation of a neural network can be made with their following advantages [3]:

1. A neural network can perform tasks that a linear program cannot.
2. When an element of the neural network fails, it can continue without any problem by their parallel nature.
3. A neural network learns and does not need to be reprogrammed.
4. It can be implemented in any application.
5. It can be implemented without any problem.

Another aspect of the artificial neural networks is that there are different architectures, which consequently requires different types of algorithms, but despite to be an apparently complex system, a neural network is relatively simple. Our study is based on Multi Layer Perceptron (MLP) which is trained and tested using past ten years (2000-2010) meteorological data.

The objective of this study is to develop ANN-based model by using meteorological data of Chandigarh city.

2.2 Multilayer Perceptron Neural Network

These are networks in which there is an input layer consisting of nodes that simply accept the input values. The outputs of neurons in a layer are inputs to neurons in the next layer. The last layer is called the output layer. Layers between the input and output layers are known as hidden layers. A MLP neural network model showing all these layers is shown in Fig.1.

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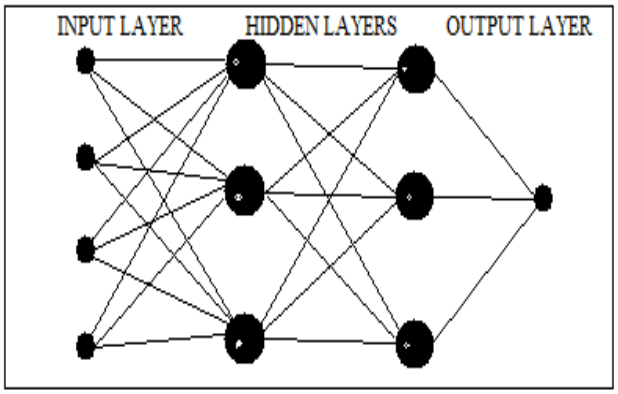


Figure.1: MLP neural network model

2.3 The Back-Propagation Algorithm

Back propagation algorithm is based on multi-layered feed forward topology with supervised learning. In order to train a neural network to perform some task, we must adjust the weights of each unit in such a way that the error between the desired output and the actual output is reduced. This process requires that the neural network compute the error derivative of the weights (E). In other words, it must calculate how the error changes as each weight is increased or decreased slightly. The back propagation algorithm is the most widely used method for determining the E.

Further, in this units are connected to one another. There is a real number associated with each connection, which is called the weight of the connection. We denote by the weight of the connection from unit ui to unit uj. It is then convenient to represent the pattern of connectivity in the network by a weight matrix W whose elements are the weights W_{ij}. Two types of connections are usually used: excitatory and inhibitory. A positive weight represents an excitatory connection whereas a negative weight represents an inhibitory connection. The pattern of connectivity characterizes the architecture of the network.

Moreover, a unit in the output layer determines its activity by following a two step procedure.

First, it computes the total weighted input X_j, using the formula:

[1] $$X_j = \sum_i y_i W_{ij}$$

where y_i is the activity level of the jth unit in the previous layer and W_{ij} is the weight of the connection between the ith and the jth unit.

Second, the unit calculates the activity y_j using some function of the total weighted input. Typically we use the sigmoid function:

[2] $$y_j = \frac{1}{1+e^{-x_j}}$$

Once the activities of all output units have been determined, the network computes the error E, which is defined by the expression:

[3] $$E = \frac{1}{2}\sum_i (y_j - d_j)^2$$

where y_j is the activity level of the jth unit in the top layer and d_j is the desired output of the jth unit.

3. Data collection

Weather data of ten years is collected from the Indian meteorological department of Chandigarh. The chosen weather data is divided into two groups, the training group, corresponding to 50% of the data, and the test group, which is also corresponding to 50% of data; so that the generalization capacity of network could be checked after training phase.

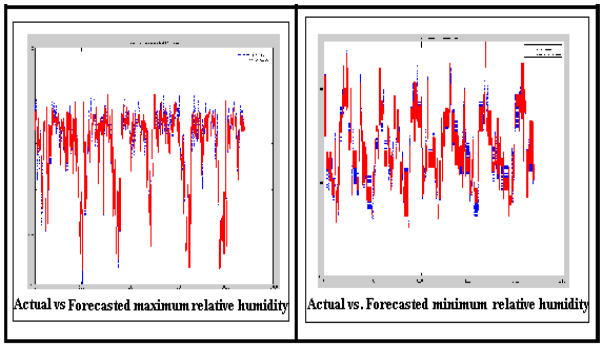
Further, Matlab is used as a simulation tool and first step will be loading the past data and visualizing it then Removal of 'abnormal' data will be done for training the data. Next step will be construction of training inputs and targets and pre-processing for training inputs and targets. Then the Neural Network will be constructed and training the Neural Network will be done and finally testing the Network Performance will be done and comparison of the forecasted relative humidity and the actual relative humidity will be done and the Forecast Accuracy will be computed. The lesser is the error the more is the accuracy. Then number of neurons and layers will be changed to achieve maximum accuracy.

4. Results and Discussion

The results of this paper are in the form of graphs of accuracy of weather prediction.

Below the graphs of actual versus forecasted maximum and minimum relative humidity are plotted for the years (2000-2010) of Chandigarh city.

Also we can calculate the expected maximum and minimum relative humidity for a particular year. For that a query is made on the trained neural network to find the expected value of relative humidity in that particular year.



5. Conclusion

Thus from this work it can be concluded that a feed-forward NN model using back-propagation algorithm is developed to identify the weather parameters like maximum relative humidity and minimum relative humidity. The results show that an appropriate accuracy can be achieved using this network. The neural network approach for weather forecasting is capable of yielding good results and can be considered as an alternative to traditional meteorological approaches. This work can be further extended to predict other parameters such as rainfall etc.

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