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Reliable Modeling Techniques and Approaches for Chaotic Meteorological Behavior

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ABSTRACT

The use of intelligent systems for meteorological predictions has been widely established. In this paper, we investigate how the seemingly chaotic behavior of weather could be well represented with the help of generalized feed forward network using back propagation technique. To this end, we considered the 2-year online data collected for Delhi, the capital city of India. We analyzed temperature [high, average and low], humidity, sea level pressure, precipitation, wind, visibility, gust speed as input parameters and forecasted average temperature. This paper investigates the development of novel reliable and efficient technique to model the seemingly chaotic behavior of weather. The average temperature is predicted for 20% and 50% forecasting horizons each with 1 and 2 hidden layers. The study reveals that it is better to predict the variable using generalized feed forward network rather than multilayer perceptron. This paper investigates whether the proposed method can provide the required level of performance, which is sufficiently good and robust so as to provide a reliable forecast model for weather. Major results of our experimental study demonstrate good scalability and usability of our forecasting model by using statistical comparison results.

Keywords : Prediction, Forecasting, Meteorological predictions, Intelligent system

1. Introduction

Weather has enormous influence on society, but these influences seem to be relatively invisible or poorly understood. We tend to think farmers and fishers are weather sensitive while the rest of society is relatively immune. This is not the case. Energy suppliers, retailers, manufacturing industries, water companies, transport, air traffic, marine and leisure sector are weather dependent. The weather affects hospital admissions, with increased respiratory illness in damp, foggy weather and increased slips and fractures in frosty weather. Every human needs the information on weather. We cannot control the weather but predicting it more accurately can benefit almost every sector of society by allowing for better planning.

Weather forecasting is an application of science and technology to predict the state of atmosphere for a future time at a given location. Human kind has attempted to predict the weather since the time immemorial. The chaotic nature of the atmosphere, the massive computational power required to solve the equations that describe the atmosphere and incomplete understanding of atmospheric processes mean that forecasts become less accurate as the range of forecast increases. The use of a neural network, however, which learns rather than analyzes these complex relationships, has shown a great deal of promise in accomplishing the goals of forecasting.

Neural networks have been successfully employed in variety time series forecasting problems in stock market[1][2][3][4], weather [5][8][9][10][11][12][13], computer interconnection networks [15] and so on. In this paper we forecast the temperature using back propagation neural network and observed the statistics using 50% and 20% of forecasting horizons of the total no. of observations each with 1 and 2 hidden layers and compared with the real data.

Section 2 describes about methodology we adopted. Section 3 consists of graphical and statistical analysis of our results. We concluded that best result is given at 50% forecasting horizon with 1 hidden layer.

2. Data and Methodology

2.1 Index Data

The data used in this study is collected online for a place named Delhi, capital city of India. The data series span from 1st Jan 2005 to 31st Dec 2006, totaling 730 observations. For our technique we used nine variables: high temperature, average temperature, low temperature, humidity, sea level pressure, precipitation, wind, visibility and gust speed. All nine variables are fed as input and average temperature is the output generated by neural network, in fact average temperature acts as input as well as output from the neural network.

The data are divided into two sub periods, one for training and other for forecasting. We use two forecasting periods to examine the potential impact of forecasting horizons on the forecasting accuracy. Forecasting horizons used are 20% and 50% of total number of observations.

The network used to predict the average temperature is Generalized Feed forward network which requires less number of training epochs than the normal multilayer perceptron.

Due to the limitation imposed by the software, observations are made only for 1- and 2- hidden layers.

Transfer function used-----------Sigmoid Axon
Step Size--- 0.1
Momentum-------------------------------------- 0.7
Maximum Epochs--------------------------1000

2.2 Neural Network Forecasting

In this paper, one of the widely used neural network model, called the back-propagation neural network (BPNN) is used for meteorological analysis. The main reason for adopting BPNN is that BPNN is an efficient way to calculate the partial derivatives of the networks error function with respect to the weights and hence to develop a network model that minimizes the discrepancy between real data and the output of the network model.

One of training tool set, a private company software called, the NeuroSolutions NBuilder toolbox, is used to train data for model developments and test data for forecasting accuracy of the models developed. The networks are created as '9-X-1': i.e. nine input layers, X hidden layers and one output layer. In this paper, we analyzed for X= 1 and 2 because of the limitations imposed by the software for more hidden layers. Stop condition for training is based on the condition that training terminates when training time has reached 1000 epochs.

After the training completed, its epochs and the simulation procedure completed successfully, which indicates the network that was trained is predicting the output as desired.

3. Analysis and Discussion

We present the results of the neural network analysis in comparison with real data. Fig. 1 shows forecasted result with 50% training and X=1. Fig. 2 shows forecasted result with 50% training and X=2. Fig. 3 shows forecasted result with 20% training and X=1. Fig. 2(b) shows forecasted result with 20% training and X=2.

From the graphs it is visible that Fig.1 representing forecasted result with 50% training and X=1 is more close to the real data.7

The results of the neural network analysis with 50% and 20% forecasting horizons are described below for 1 and 2 hidden layers.

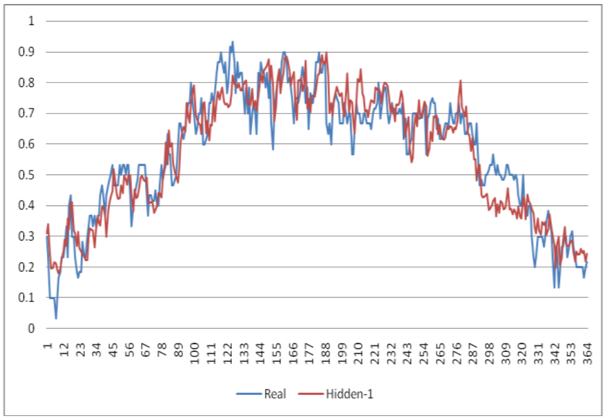

Figure 1. 50% forecasting with X=1
(1 hidden layer)

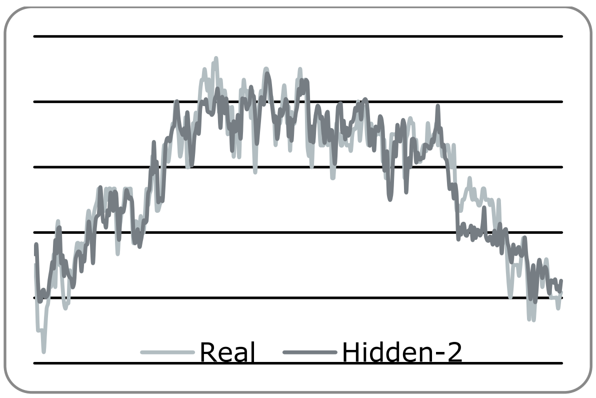

Figure 2. 50% forecasting with X=2

(2 hidden layer)

For more accurate analysis we adopt statistical techniques such as Mean, Standard deviation and Mean Square Error.

The sample description of the real data is shown in Table 1. The mean of the sample is 0.5681963 with standard deviation of 0.2151222 and mean square error 0.046214175.

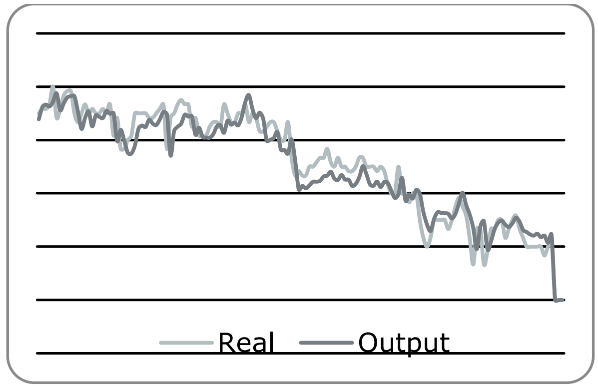

Figure 3. 20% Forecasting with X=1

(1 hidden layer).

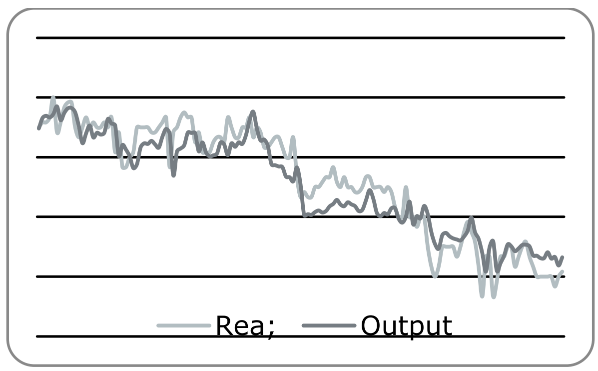

Figure 4. 20% Forecasting with X=2

(2 hidden layer).

Table 1. Statistical analysis of real data

Mean	Std. Deviation	Mean Squ. Error

0.5681963	0.2151222	0.046214175

Descriptive statistics of the output data with 50% and 20% forecasting for 1 and 2 hidden layers are presented in Table 2 and Table 3.

Table 2. Statistics for 50% forecasting

	Mean	Std. Deviation	MSE	Mean Difference
Hidden -1	0.568361298	0.200924483	0.001697222	0.00119
Hidden -2	0.566168057	0.195229656	0.00498811	0.0033832

Table 3. Statistics for 20% forecasting

	Mean	Std. Deviation	MSE	Mean Difference
Hidden-1	0.510272726	0.169227636	0.001985	0.01076
Hidden-2	0.507011988	0.161870606	0.00413102	0.01402

We can visualise that the mean of the sample is decreased when the testing values are increased. But what is important here is, which forecasted data is more close to real data. It is clear from the tables that the mean of 50% forecating with hidden layer 1 is more close to the mean of the real data than its counter parts.

And also the MSE and mean difference is also less when compared to 20% forecasting with 1 and 2 hidden layers and 50% forecating with 2 hidden layers. Due to smallest difference, MSE and close mean, the best forecasting result is given at 50% forecasting with 1 hidden layer.

4. Conclusion

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