PREDICTION OF MONTHLY RAINFALL IN CHENNAI USING BACK PROPAGATION NEURAL NETWORK MODEL

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Abstract:

This paper presents a new approach using an Artificial Neural Network technique to improve rainfall forecast performance. A real world case study was observed in Chennai for 32 years of monthly mean data with meteorological parameters such as wind speed, mean temperature, relative humidity, aerosol values (RSPM) in the area were used to develop the ANN model .In order to forecast rainfall in Chennai City, Back Propagation Neural Networks (BPNNs), a data driven technique based on the working principle of biological neurons are applied in this study. The mean monthly rainfall is predicted by using ANN model. The model can perform well both in training and independent periods.

Keywords: Artificial neural networks; BPNN; meteorological parameters; RSPM.

1. Introduction

Rainfall prediction is one of the most difficult tasks in operational meteorology. There are several rainfall forecasting methods, such as statistical methods and Numerical Weather Prediction (NWP) models. Because of the nonlinear character of rainfall process, statistical methods cannot generate good results. Rainfall is mainly caused by meso-scale and small-scale weather systems. Local climate situations also can affect the rainfall generation process a lot. NWP models cannot solve this local problem.

Artificial Neural Networks (ANNs) are a type of data driven technique based on the working principle of biological neurons. Since the mechanisms of rainfall are still not understood well, ANNs are a good choice worth trying to analyse the relationship between meteorological parameters and rainfall. The objectives are to differentiate what kinds of atmospheric situation can trigger rainfall, and find out how much rainfall can be generated in such situations.

1.1Data

Air mean temperature, relative humidity, wind speed and aerosol values are given as input data. Monthly rainfall data for Chennai from 1978 to 2009 are selected to be the desired output data for training, and testing. These data have been obtained from Indian Meteorological Department, Chennai. Aerosol values (RSPM) are taken from Tamil Nadu Pollution control Board, Chennai.

2. Theory and methodology

According to Haykin (1999), a neural network contains large amounts of parallel distributed processors made up of simple processing units. By giving a set of measured data, neural networks can learn the stimulus-response relationship within the data set through the training process [Minns and Hall (1996)]. Multilayer BPNN is the most popular network architecture in use today.

From input layer to hidden layer, the logistic sigmoid function is often used as the activation function because of its very simple derivative that makes the subsequent implementation of the learning algorithm much easier [Flood and Kartam, (1994)]. The sigmoid function is shown in eq. (1).

$$f(x) = 1/1+e^{-x} \qquad (1)$$

The input data and the desired output data should be scaled into the range of 0 to 1. The final data pre-processing step is data balancing. Most commonly used "back-propagation learning algorithm" [Rumbelhart *et al*., (1986)] is used for the training.

Table 1. Basic network components of ANN model

Network architecture			
Number of inputs	4	Number of outputs	1
Number of hidden layers	1	Hidden layer sizes	9
Learning parameter	0.3	Initial wt range	(0 +/- w) 0.1
Momentum	0.5	Training options	
Total number of rows in data	384	Number of training data	360
Training mode	On line	Testing data	24
Save network weights	With least training error		
Training/validation set	Partition data into training/validation set		

Initially random weights between ±0.5 are assigned to each weight as initial guesses. The weights are learned through an iterative process. During learning the weights are updated. When the network learns the training set of patterns well enough it can be used for determining the output values for the pattern with unknown outputs (Test period or prediction period).

3. Results and Discussion

The network components are presented in Table 1. In the mode, the initial weights are chosen randomly from -0.5 to +0.5. After each training iterations/epochs the network is tested for its performance on validation data set [Chattopadhyaya and Debnath, (2009)].The training process is stopped when the performance would reach the maximum on validation data set. The results are schematically presented for Chennai in (Figure 1) and (Figure 2).

The result shows that the model produces the lowest prediction error. Figures 1 and 2depict the performance of the model. From the scatter diagram (Figure-2) it is found that, the prediction error of the model is minimum. It is quite interesting to see that, in the case of Chennai, the actual and predicted monsoon rainfall amounts almost coincide except in the sharp peak values. Prediction of error is 9.96% only.

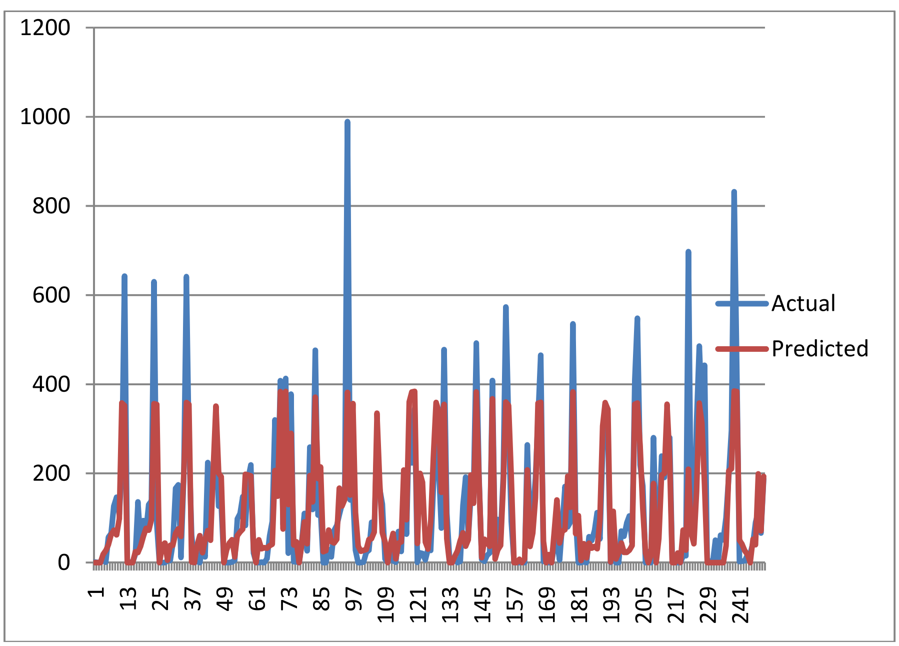

Figure -1 Performance of the neural network model

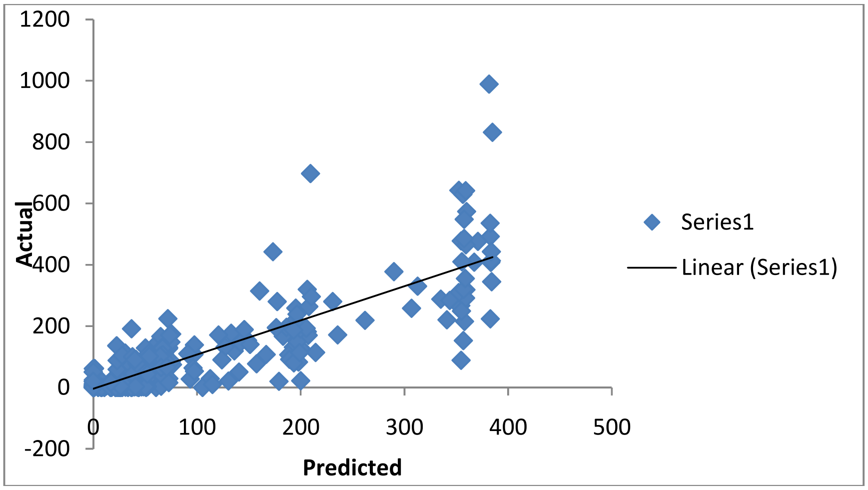

Figure -2 Scatter diagram

4. Conclusion

It can, therefore, be concluded that in Chennai, ANN produces significant forecast yield. To have a complete look into the prediction capability of the model, the actual rainfall amounts are plotted against predicted rainfall amounts in Figures 1and 2. It is apparent from the said figures that in both cases ANN can generate a good forecast for Chennai rainfall. But, in Chennai, the actual rainfall amount almost coincides with the predicted amount except in the sharp peak values. When more input values to be considered then even the peak values can be predicted accurately.

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