Weather Forecasting Using Soft Computing: Minimum Temperature, Maximum Temperature & Pressure

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Abstract:- In a developing country, like India where agriculture is the base for national economy, the weather conditions including Minimum Temperature, Maximum Temperature and Pressure play a leading role. Therefore having accurate weather forecasting information may allow farmers to make their better decisions on managing their farms. Similar statement can be made for industries where accurate weather condition prediction may help them in their proper development as these are the factors that affect them directly or indirectly. Soft computing using ANN is an effective approach to construct a computationally intelligent system that is able to process non-linear weather conditions within a specific domain, and make predictions. The proposed work focus on modeling of such an intelligent system that can forecast with minimum error rate in term of MSE with a better Architecture**.**

I.   INTRODUCTION

The weather is a continuous, data-intensive, multidimensional, dynamic and chaotic process [2] and these Properties make weather forecasting a formidable challenge. . A number of researches have been done focusing on the usefulness of soft computing approach in forecasting area. In this project, the main purpose is to find out how well the proposed soft computing models ANN & Back Propagation Algorithm are suited. This would help one to anticipate with some degree of confidence the Min. Temp, Max. Temp & pressure to be expected next day. In this project data of previous three years (i.e. 2009, 2010 & 2011) about DELHI/NCR is collected from Government of India, India Meteorological Department, Regional Meteorological Centre (IMD-RMC), to be used in the proposed weather forecasting project. For local scale & short term weather forecasting the approach of artificial neural networks (ANNs) is so efficient. ANN provides a methodology for solving many types of non-linear problems that are difficult to solve by traditional techniques. Most meteorological processes often exhibit temporal and spatial variability and are further plagued by issues of non-linearity of physical processes, conflicting spatial and temporal scale and uncertainty in parameter estimates. With ANN, there exists the capability to extract the relationship between the inputs and outputs of a process, without the physics being explicitly provided [11]. Thus, these properties of ANN are well suited to the problem of weather forecasting under consideration.

II.   RELATED WORKS

Many works have done in forecasting of Temperature & Pressure. Some of them are presented here. This will lead us to make better understanding of project work. Some basic concepts, findings & facts will be extracted to make some conventions for our project.

Mohsen Hayati & Zahra Mohebi [1] utilizes ANN for one day ahead prediction of temperature. They used MLP to train & test ten years (1996-2006) meteorological data. For accuracy of prediction they split data into four seasons and then for each seasons one network is presented. Two random unseen days in each season are selected to test the performance. The error in result varies between 0 to 2 MSE.

Dr.S.Santhosh Baboo & I.Kadar Shereef [2], used BPN for doing prediction and tested as the best algorithms for training the ANN. The ANN is trained & tested using complete one year weather data including Temperature, Due Point, Humidity, SLP, Visibility & wind speed etc. ANN is trained with 200 data and tested for unseen data the result varies with 2.16% errors.The research shows Min error 0.0079 & Max. Error 1.2916 RMSE. And the epoch taken are between 1000 to 5000.

S.S. De [3] used ANN to forecast the Max. & Min. Temperature for Monsoon month. The temperature of June, July & August has been predicted with the help of January to May temperature. The data of three months of 1901 to 2003 is used. The ANN model generated here is a single hidden layer model with 2 nodes at hidden layer. After 500epochs the result is validates. The Max. Error appeared is 5%.

Ch.Jyosthna Devi, B.Syam Prasad Reddy, K.Vagdhan Kumar, B.Musala Reddy, N.Raja Nayak [4] they used to show how ANN & BPA are useful in forecasting. A 3-layered neural network is designed and trained. So many parameters are taken, like temperature, humidity, dew point, visibility, atmospheric pressure, sea level, wind speed, wind direction etc. Basically the work is done to check two deferent ANN architecture to check which is better. These are Back Propagation (BPN) feed forward network and Radial basis function network (RBN). And BPN is found the best

Y.Radhika & M.Shashi [5] presents an application of Support Vector Machine for weather prediction. Time series data of daily max temperature at location is studied to predict the max temp of next day.
Arvind Sharma [6 utilizes the usefulness of ANN & Fuzzy system for the next day weather condition prediction like Rain, thunderstorm, sunshine & dry day etc. They deeply analyzed the data record and their inter-relationship. And found the inter-dependencies among these data.

C.N. Schizas'BJ S. Michaelides' C.S. Pattichis3 R.R. Livesay [7] have introduced so many ANN model based on several different architecture to forecast the minimum temperature and compare the results. They took previous year data in so many parameters and train different architecture based ANN with different data set. They found the ANN with BPN is the best suited for forecasting.

Brian A. Smith, Ronald W. McClendon, and Gerrit Hoogenboom [8] focused on developing ANN models with reduced average prediction error by increasing the number of distinct observations used in training.

Arvind Sharma *et.al,* [9] briefly explains how the different connectionist paradigms could be formulated using different learning methods and then investigates whether they can provide the required level of performance, which are sufficiently good and robust so as to provide a reliable forecast model for stock market indices. Experiment results exposes that all the connectionist paradigms considered could represent the stock indices behavior very accurately.

Mike O'Neill [10] focus on two major practical considerations: the relationship between the amounts of training data and error rate and the transferability of models expertise between different datasets.

2.1 Conclusion

After going through the above detailed study we find Applying soft computing could be one of the best alternatives for local and short scale weather forecasting. The Study says any forecasting system using Artificial Neural Network & Back propagation Algorithms depends on the data that should be valid, Authentic and in proper format. The numbers of Variables are dependent on each other so it should be chosen so carefully and according to need. Many the variables, better the result

The amount of data that we acquire for training of our model plays a vital role in forecasting accuracy. The training set is one the most considerable entity of our research work, which contains the collection of unit input & unit output for the ANN. The better the training set, better the result. The architecture of any artificial neural network is defined by the layers, numbers of neuron etc. Different forecasting models requires different forecasting architecture. The best suited ANN architecture for any forecasting model is the subject of research for a researcher.
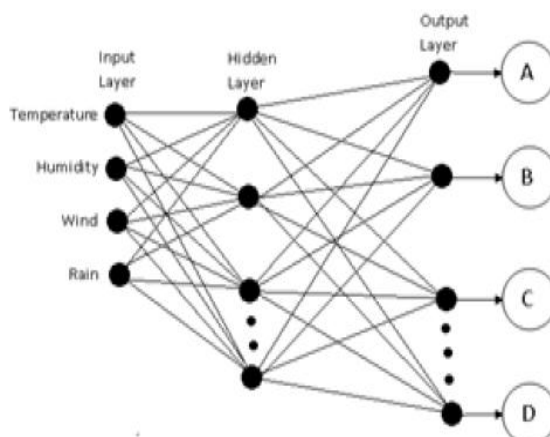

Figure 2.1. Architecture of an ANN based model

Conversion also depends on the number of epochs we take for the training. Less no. of epochs may not converse better (better fitting of network) and high no. of epochs may leads network to produce repeated fitting.

III. METHODOLOGY

In order to perform weather forecasting using ANN with BPA, Firstly we acquired previous 3 year's (that are 2009, 2010 & 2011) data from Indian Meteorological Department (IMD), Regional Meteorological Centre (RMC). Temperature was collected per day were as Mean See Level Pressure(MSLP) & Relative Humidity(RH)

were collected every day at 8:30 AM & 17:30 PM everyday
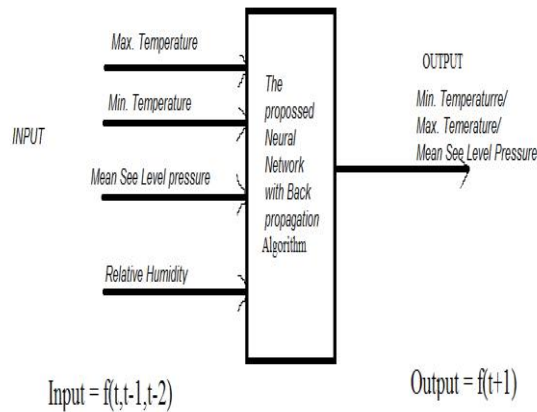

Figure 3.0 The Proposed Model

After that processing of data is done to find out the relevant information that is ranges of values, inter-relationship, dependencies etc. Some of examples are give bellow as figure.3.1 & figure 3.2
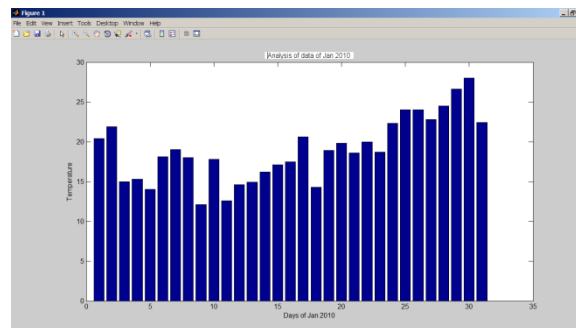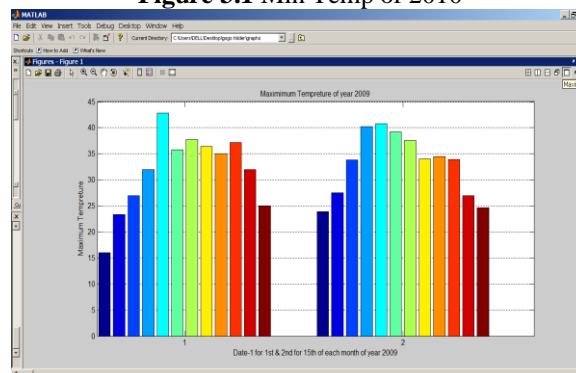

Figure 3.1 Min Temp of 2010

3.2 figure: Max Temp of 2009

Those are to be used for our proper training set preparation. The processed data is used to prepare the training set. The appropriate the training set the accurate the results. For the sake of preparing the training set we use two years data that are 2009 & 2010. We divide the yearly data seasonally as it was concluded from the literature review [1] that for better accuracy the data span should be shortly. According to the Table 2.1

Spring	March 20 to May 20
Summer	May 20 to July 20
Monsoon	July 20 to September20
Autumn	September 20 to November 20
Winter	November 20 to January 20
Winter & Fall	January 20 to March 20

Table 3.1 Seasons in Indian

Once the data modeling is done we used Matlab programming to formulate a database and then to formulate Input dataset and output dataset said input_data & target correspondingly. Here we use input function as-

Input = f (t, t-1, t-2)

And Output function is-

Output = f (t+1)

For all three parameters i.e. Min. Temperature, Max. Temperature & Pressure. The appropriate architecture of the neural network will lead to fast fitting and good results. Initially we took a neural network with single hidden layer with 8 neurons. We applied a number of iteration to decide the optimum architecture and we reached the architecture of ANN with 3 hidden layers with 8-10-12 numbers of neurons correspondingly. BPA is used to train the network that said earlier the best suited algorithm for training of network. We applied the training set prepared in the form of input_data & target to the decided neural network model and performed training of the network. Once the training is done, the network can be tested and validated. The network itself divided the training set into two parts. I.e. Some 75% of data if reserved for training & some 25 % is preserved for testing & validation. The trained network is used to verify and analyze the results so obtained by using the network. The accuracy of prediction will be analyzed and compared with other results. After verification if the result is not accurate the network needs to be retrained unless the required accuracy is achieved.
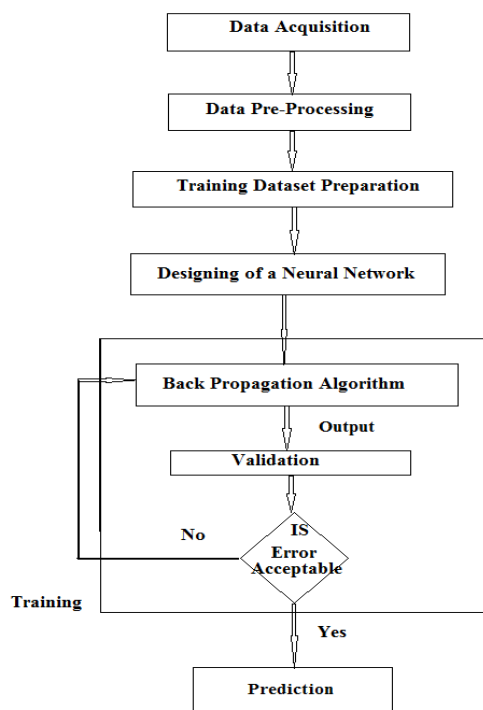
Figure 3.3 Flowchart of Methodology

IV. EXPERIMENTAL RESULTS

Here the study presents & summarizes the results obtained from the above approach and the results will be analyzed to check whether the obtain results meets the hypothesis of the project or not. The results of predictions are evaluated based on its ability to produce the minimum error rate in the terms of Mean Square

Error (MSE).

As we know we are having four parameters to forecast that are- Maximum Temperature, Minimum Temperature & Mean See Level Pressure (MSLP) and we have divided the yearly data into 6 seasons as discussed in Table 2.1 above, this leads to module

<div style="text-align:center; border:1px solid; display:inline-block;">6*3=18 Feed Forward Neural Networks</div>

A global architecture is developed and an instance of that ANN architecture is called for each & every module. Each network is used to train & test for each parameter with corresponding seasonal training set containing input_data & target, means we obtained 6*3=18 seasonal results. Once these neural networks are trained with 2009 & 2010 seasonal training set, we used to test the network performance with 2011 seasonal data to check the performance. Here the results are checked for each 10 days at 5 days interval in each season. For forecasting of Maximum Temperature for all 6 seasons the developed neural network results as-

Seasons	Min. Error(^{o}C)	Max. Error (^{o}C)	Results (mse)
Spring	0.0	1.7	0.96562
Summer	0.3	3.8	1.89778
Monsoon	0.5	2.7	2.23333
Autumn	0.5	2.3	0.28055
Winter	0.0	2.4	1.3286
Winter & fall	0.3	1.8	0.8086

Table 4.1 Results for Max. Temperature

Here we see in above Table-4.1 that the Minimum error occurs in all 6 seasons i.e. in whole year is 0.0 ^{o}C & Maximum error is 3.0 ^{o}C.exept summer season. The Mean Square Error (mse) ranges between 0.28055 to 2.23333 in all the 6 seasons. Means the developed model works well in Max. Temp. Prediction with a good confidence that it can be taken in real time prediction. We can refer to figure 4.1 for regression plots of Max. Temp prediction.
Similarly we can take the results of Minimum Temperature for analysis as-

Seasons	Min. Error(^{o}C)	Max. Error (^{o}C)	Results (mse)
Spring	0.5	3.2	1.8849
Summer	0.1	2.3	1.5043
Monsoon	0.1	2.0	1.0496
Autumn	0.0	2.2	1.06743
Winter	0.0	2.2	1.01835
Winter & fall	0.3	2.2	3.47333

Table 4.2 Results for Min. Temperature

Here we can see in above Table-4.2 that the Minimum error occurs in all 6 seasons i.e. in whole year is 0.0 ^{o}C& Maximum error is 3.2 ^{o}C.The Mean Square Error (mse) ranges between 1.0496 ^{o}C to 3.47333 ^{o}C in all the 6 seasons. And the module also represents a good confidence into real time prediction.
If we talk about Mean See Level Pressure (MSLP). We find the results as follows-

Seasons	Min. Error (mbar)	Max. Error (mbar)	Results (mse)
Spring	0.3	2.9	2.4776
Summer	0.3	2.3	1.95653
Monsoon	0.0	3.7	3.9649
Autumn	0.2	2.6	1.5424
Winter	0.0	2.6	1.11354
Winter & fall	0.2	3.0	2.738

Table 4.3 Results for MSLP

Here we can see that the Minimum error occurs in all 6 seasons i.e. in whole year is 0.0 mbar & Maximum error is 3.7 mbar.The Mean Square Error (mse) ranges between 1.11354 mbar to 3.9649 mbar in all the 6 seasons. This module best predict for winter season & worst for Monsoon Season.The regression plots for MSLP forecasting could be seen in figure

In India weather is so variable in nature & it changes its state in each two months called Ritu/seasons. Due to some errors presented in given data by IMD, the results sometimes produced unexpected results in all seasons at two or three times.

V. CONCLUSION

From the above study & discussion we see that applying soft computing approach for weather modeling to forecast Minimum Temperature, Maximum Temperature & MSLP is most feasible rather than any other short term weather forecasting approach. The study also says that MLFFNN with BPA algorithms is the better combination for weather forecasting..The valid & authentic dataset selection, input variable selection, the proper training set and the proper ANN architecture are most vital for the best prediction results.

In the project work the Conclusion shows a good confidence in the range of overall 0.0 to 2.33 ^{o}C mse for max. Temp. , 0.0 to 2.0 ^{o}C for min. temp. except winter + Fall and 0.0 to 2.73 for MSLP except monsoon that it can be taken into real time forecasting of these parameters. And that fulfills the hypothesis & objective of our project.

This research work also support the result of Mohsen Hayati & Zahra Mohebi[1] who suggest to forecast the weather condition seasonally .
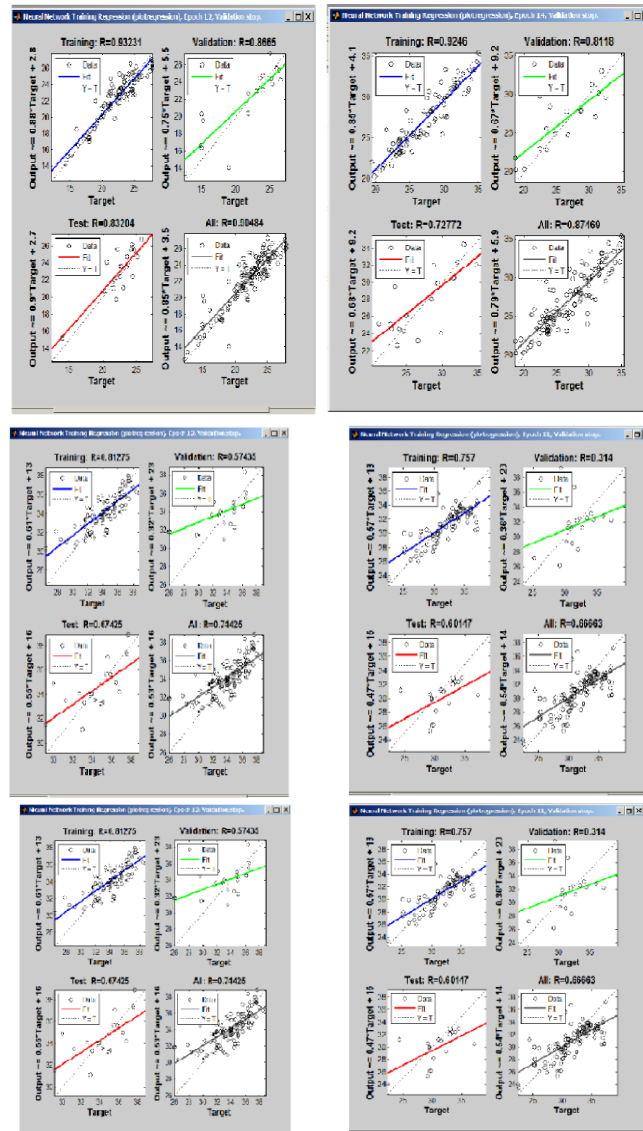

Figure.4.1 Regression plot for Max Temp forecasting in all six (6) seasons from upper-left to right and down-left to right correspondingly
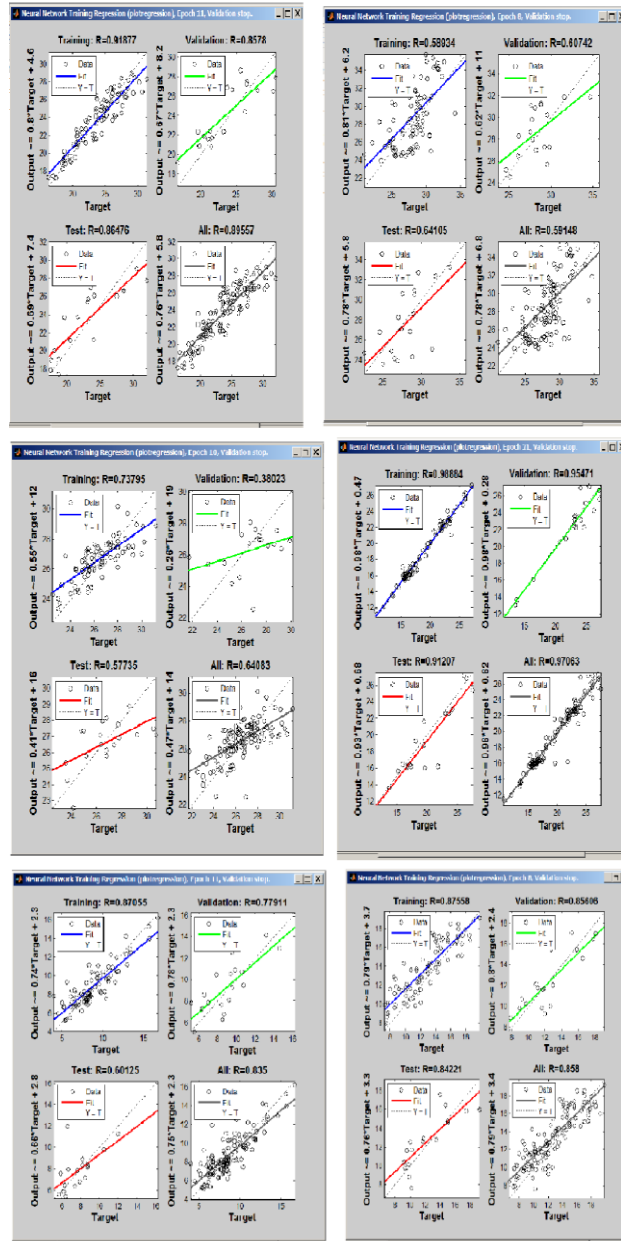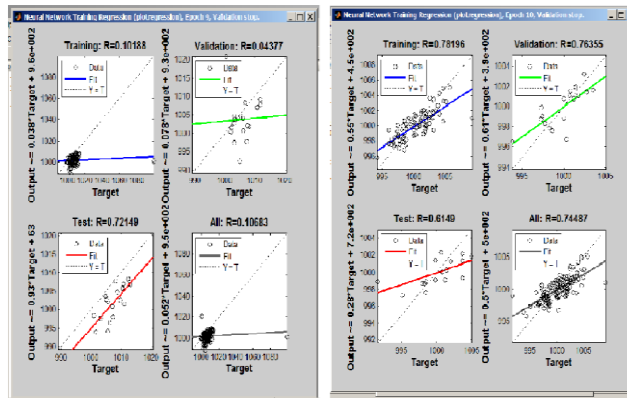
Figure 4.2 Regression plot for Min. Temp forecasting in all six (6) seasons from upper-left to right and down-left to right
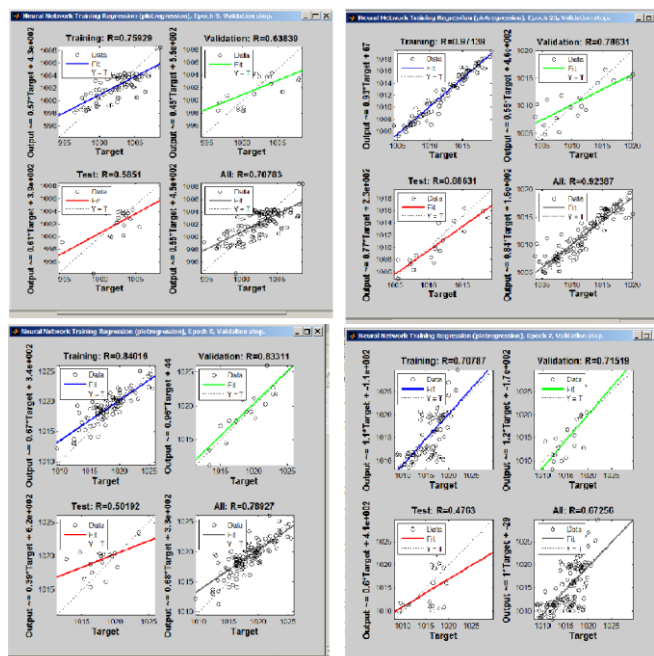
Figure 4.3 Regression plots for MSLP forecasting in all six (6) seasons from upper-left to right and down-left to right

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