A Comparative Study Review of Soft Computing Approach in Weather Forecasting

Govind Kumar Rahul, Madhu Khurana

Abstract-In a developing country, like India where the agriculture & industries are base for the national economy, the weather conditions play leading role for their proper development and smooth running. Therefore having accurate weather forecasting information may allow farmers or industry managers to make better decisions on managing their farms. Soft computing using ANN is an innovative approach to construct a computationally intelligent system that is able to process non-linear weather conditions within a specific domain, and make prediction. A number of researches have been done or being done using Soft Computing Approach for forecasting. In this paper the presentation is all about to present the comparative study of several researches and some key findings that are initials for better start any soft computing model for prediction.

Keywords: Soft Computing, Artificial Neural Network (ANN), Back Propagation Algorithms, Multilayer Feed Forward Neural network (MLFFNN), Mean Square Error (MSE) etc.

I. INTRODUCTION

Soft Computing is an efficient approach for forecasting, whether it is weather forecasting or any other else. A number of researches have been done focusing on the usefulness of soft computing approach in forecasting area. Here the presentation is utilizing some of researches to make some conclusions that are initials to be taken in account when planning forecasting using ANN technique. In traditional Weather forecasting approaches like:

(a) The empirical approach and
(b) The dynamical approach.

The first approach is based upon the occurrence of analogues and is often referred to by meteorologists as analogue forecasting. This approach is useful for predicting local-scale weather if recorded cases are plentiful. The second approach is based upon the equations and forward simulations of the atmosphere, and is often referred to as computer modeling. Because of the grid Coarseness, the dynamical approach is only useful for modeling large-scale weather phenomena and may not predict short-term weather efficiently.

But for local scale & short term weather forecasting the approach of artificial neural networks (ANNs) is so efficient and a little bit easy.

ANNs provide 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.

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With ANNs, there exists the capability to extract the relationship between the inputs and outputs of a process, without the physics being explicitly provided. Thus, these properties of ANNs are well suited to the problem of weather forecasting under consideration.

The popular soft computing techniques is ANN which performs nonlinear mapping between inputs and outputs, has lately provided alternative approaches to weather forecasting and so many researchers have taken in their research and come into the conclusion that ANN is best suited for forecasting. In the following paper the main objective is to find out some basic fundamentals and initials to make conventions about the ANN & forecasting.

II. THE STUDY

A. **Title:** "Temperature Forecasting Based on Neural Network Approach", Mohsen Hayati & Zahra Mohebi, World Applied Science Journal 2(6) 613-620, 2007, ISSN 818-4952 ©IDOSI Publications 2007

The Work Done: Mohsen & Zahra utilizes ANN for one day ahead prediction of temperature. They use MLP to train & test using 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. The global set of patterns is divided into two randomly selected groups. The training group corresponding to 65% of patterns and the rest group, corresponding to 35% of patterns. Two random days in each season are selected as unseen data which have not been used in training. MSE is used to measure the performance. The MLP is best suited for this research. Tan-sig is used as activation function at each hidden layers & pure-linear is used at each layer .The optimum structure of each season is-

	Spring	Summer	Fall	winter
No. Of Neurons:	4	4	6	4
Epochs :	2000	2000	2000	2000

The Error:-The research reaches the result that holds the errors as following

Spring	Summer	Fall	Winter	
0 .001	0.0148	0.0336	0.0019	(Min. Error)
0.3569	1.6417	0.7896	0.5679	(Max. Error)

Means error varies between 0 to 2 degree.

B. Tile:-"An efficient weather forecasting system using Artificial Neural network", Dr.S.Santhosh Baboo & I.Kadar Shereef, International Journal of Environment Science & Development,

W1.1, No.4,October-2010 ISSN: 2010-0264

The work Done: In this paper BPN is used for doing prediction and tested as the best algorithms for training the ANN. The ANN is trained & tested using real training data set. They have taken complete one year weather data including Temperature, Due Point, Humidity, SLP, Visibility, wind speed etc. & did analysis of information in the term of when it goes peeks and when it goes dead end. This activity defines the rang of input to network.

The Result: The results shows that when iteration count goes below 1000 the RMSE is more & when it reaches to 5000 the error value is up to 0.There are various parameters are taken like no. of layers, epochs, no. of neurons at each layer 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.

C. Title:-"Artificial Neural Network Based Prediction of Max. & Min. Temperature in the Summer-Monsoon month over India". S.S. De, University of Kolkata, Applied Physics Research,Vol.1,No.2,Nov-2009.

The work done:-The research includes 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. Max. & Min temperature is greatly predicted in the month of August. The Max. Error appeared is 5%.The present study explore the data of these three month of 1901 to 2003 from the whole dataset the input & the desired output matrices are generated. The output matrix contains 6 columns that corresponds to average monthly temperature over the study period & pertains to the month of December, January, February, March, April &March the ANN model generated here is a single hidden layer model with 2 nodes at hidden layers. After 500 epochs the result is validates.

The result:-The learning rate n (neu) is taken to be 0.9 & three layered feed forward network is designed. Three model are generated for both Max. &Min. Temp. Prediction. Initial weights are set from -0.5 to 0.5.After 500 epochs the ANN has been found to produce a forecast with small prediction error.

Error:-For the month June the predicted Max. Temp & Absolute prediction Error graph

June- Actual temperature Varies- from 32 to 37 'c.
Predicted temperature varies -From 34 to 35'c.
Predicted Errors -Up to 0- 3%.

July- Actual temperature Varies- from 29.5 to 33.5'c.
Predicted temperature varies - From 31 to 32'c.
Predicted Errors- Up to 0- 3%

August- Actual temperature Varies-from 29.5 to 31.5 'c.
Predicted temperature varies From 29.5 to 31.5'c
Predicted Errors- Up to 0-2%

D. Title: "ANN Approach for Weather Prediction using Back propagation ", Ch.Jyosthna Devi #1, B.Syam Prasad Reddy#2, K.Vagdhan Kumar#3, B.Musala Reddy#4, N.Raja Nayak#5,International Journal of Engineering Trends and Technology- Volume3Issue1-2012, ISSN: 2231-5381

The Work Done: How neural networks are useful in forecasting the weather and the working of most powerful prediction algorithm called back propagation algorithm was explained .A 3-layered neural network is designed and trained with the existing dataset and obtained a relationship between the existing non-linear parameters of weather. So many parameters are taken and their relationships are taken into consideration those factors for the temperature forecasting. Like temperature, humidity, dew point, visibility, atmospheric pressure, sea level, wind speed, wind direction etc. The data is normalized using min-max normalization to scale the dataset into the range of 0 to 1.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).

The Result: BPN is found the best and taken for further development for prediction of temperature. The research focus on proper initialization of weights and bias.

E. Title:-"Atmospheric Temperature prediction using Support Vector Machine". Y.Radhika & M.Shashi .International Journal of Computer Theory & Engineering ,Vol.1.No.1.April 2009 1793-8209

The Work Done: The research 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. The experiment is done for a particular location on daily max temperature for a span of previous n days referred to as order of input.

The Result:-Performance of the system is observed for various spans of 2 to 10 days by using optimal value.

Merits: - Better understanding of input data and output data set for the training. And optimum solution is achieved.

F. Title:-"A Weather Forecasting System using concept of Soft Computing: A new approach", Arvind Sharma PG Research Group (M.Tech. CSE), SATI, Vidisha (MP), India1-4244-0716-8/06/$20.00 ©2006 IEEE. 353-356

The Work done:-Mr. Arvind Sharma 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. He aimed to model such a system that could have potential to capture the complex relationships between many factors that contribute to certain weather conditions. It is illustrate how an intelligent system can be efficiently integrated with a Neuro-Fuzzy prediction model to implement an online weather information retrieval, analysis, and prediction system by using electronic sensors.

The Result: - The following key features in atmospheric pressure patterns that were related to the weather conditions and indicated trend of the future weather of a place. These conditions were:

- Stable day-night pressure gradient - indicator of stable weather -sun shine
- Sudden pressure fall - indication of likely thunder storm
- Sudden pressure rise - indicator for windy day
- Change in pressure slope - change of weather state in either way

G. Title:-"Artificial Neural Networks in Forecasting Minimum Temperature". C.N. chizas'BJS. Michaelides' C.S. Pattichis 3R.R.,Livesay','University of Indianapolis, U.S.A* Meteorological Service, Cyprus, The Cyprus institute of Neurology and Genetics, Cyprus, IEEE Paper

The Work done:-In the presented research paper the researcher has introduced so many ANN model based on several different architecture to forecast the minimum temperature and compare the results. They used previous year data in so many parameters and train different architecture based ANN with different -different data set. They found the ANN with BPN is the best suited for this kind of forecasting.

The Result:-Architecture with 36-50-100-40 that is 36 is the numbers of input,50-100 are the neurons within the hidden layers and 40 is the output of the ANN architecture is the best performing in the confidence ranges 5 1 .O and +2.OoC; and a slightly worse performance for the confidence range +3.OoC.

H. Title:-"Improving Air Temperature Prediction with Artificial Neural Networks", Brian A. Smith, Ronald W. McClendon, and Gerrit Hoogenboom, International Journal of Computational Intelligence 3;3 2007.

Brian A. Smith et.al,[6] focused on developing ANN models with reduced average prediction error by increasing the number of distinct observations used in training, adding additional input terms that describe the date of an observation, increasing the duration of prior weather data included in each observation, and reexamining the number of hidden nodes used in the network. Models were created to forecast air temperature at hourly intervals from one to 12 hours ahead. Each ANN model, having a network architecture and set of associated parameters, was evaluated by instantiating and training 30 networks and calculating the mean absolute error (MAE) of the resulting networks for some set of input patterns.

I. Title: -"A Weather Forecasting System using concept of Soft Computing", Arvind Sharma, Prof. Manish Manoria, pp.12-20 (2006)

The work Done: Arvind Sharma et.al, [7] 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.

J. Title:-"Neural Network for Recognition of Handwritten Digits," Mike O'Neill, Standard Reference Data Program National Institute of Standards and Technology.

The work Done: Mike O'Neill [11] focus on two major practical considerations: the relationship between the amounts of training data and error rate (corresponding to the effort to collect training data to build a model with given maximum error rate) and the transferability of models" expertise between different datasets (corresponding to the usefulness for general handwritten digit recognition).Henry A.Rowley eliminates the difficult task of manually selecting nonface training examples, which must be chosen to span the entire space of nonface images. Simple heuristics, like using the fact that faces rarely overlap in images, can further improve the accuracy. Comparisons with more than a few other state-of-the-art face detection systems are presented; showing that our system has comparable performance in terms of detection and false-positive rates.

III. RESULTS & FINDING

After going through the above detailed study we find the following key results that play a major role in any forecasting model building. Apart from the traditional forecasting systems, ANN based forecasting is much feasible & best suited. 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 following:

- **The data**: That we are going to acquire should be valid, Authentic and in proper format.
- **The Variables**: Means how many different kinds of data variables we use for input training set. As Temperature, Pressure, Relative Humidity, Due Point, wind speed, cloud status etc. The training results are dependent on the inter-relationship of these variables so it should be chosen so carefully and according to need. Many the variables, better the result.
- **Data Analysis**: These variables are inter-related & inter-dependent. So the inter-relationships of these variables are a big factor in training set preparation & training of ANN. So the normalization should be done certainly & so carefully before making the training set.
- **Dataset**: The data that we acquire for training of our model plays a vital role in forecasting accuracy. This describes how much data we acquire for the training of proposed model. In other terms the time series duration of data as one year, two years, five years or what?
- **Training set**: The training set is one the most considerable entity of our research work. Even it could be said the backbone of the ANN based forecasting system.

It contains the input matrix & target matrix which contains the collection of unit input & unit output for the ANN correspondingly. The better the training set, better the result. Training set preparation can be done in following two dimensions:

- **Resolution**: Means the particular fashion in which the data set is divided for training set preparation. I.e. Weekly, monthly, seasonally, semester wise or what?
- **Span:** Means time span of unit input of training set e.g. Unit input data can be taken in 3 days span of any semester. It could affect the accuracy of forecasting.

- **Architecture of ANN:** Once the training set is prepared the next most important thing to discuss is Architecture. The architecture of any artificial neural network is defined by the layers, numbers of neurons 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. following are the key points to be taken in account when developing a forecasting model:

- **Types of Network:** The training and forecasting of any model is dependent upon the types of the network i.e. Multi Layer Perception (MLP), Multi Layer Feed Forward network (MLFFN) etc. in some cases MLP may suit best or in some cases it may be MLFFN. The appropriate type of network may converse fast for prediction.

- **No. Of Hidden Layers:** Our forecasting result's accuracy is highly dependent on the numbers of hidden layers. Some problem may converse in single layer ANN or some may converse in multiple layers ANN. Although single layer network is appropriate for solving any problem but it may be so less accurate. For better result multi layer network may be used that may converse slow but produce much better result. One drawback is that it goes complex. Multi layer Feed Forward neural Network (MLFFNN) is found the best for forecasting the weather condition.
- **Algorithms:** There are number of training algorithms are available but appropriate selection of training algorithms may leads fast and accurate forecasting results. Back propagation algorithm is found best suited with MLFFNN for forecasting the weather prediction.
- **Activation function:** A number of activation functions are available for training the network but selection the appropriate activation function may leads to better conversion. We can select any one of following TANSIG, LOGSIG & PURELIN.
- **Weights/Bias:** Apart from all above, another important factor is the initialization of weights and bias. Proper initialization of weights and bias may leads the network to converse fast and in proper direction.
- **Learning Rate:** learning rate is another factor that leads the training of network with a given constant factor. High the learning rate fast the conversion & low the learning rate slow the conversion. A small learning rate may leads smooth conversion better results but slow and a high learning leads fast but less accurate result. Initially we may take any randomly value for learning rate (n).
- **Threshold/Momentum:** If we want an output by any particular condition then we can set threshold value .when the threshold value is achieved the output is generated else not. Another is the momentum that could be set for smooth conversion of network with the provided momentum factor.

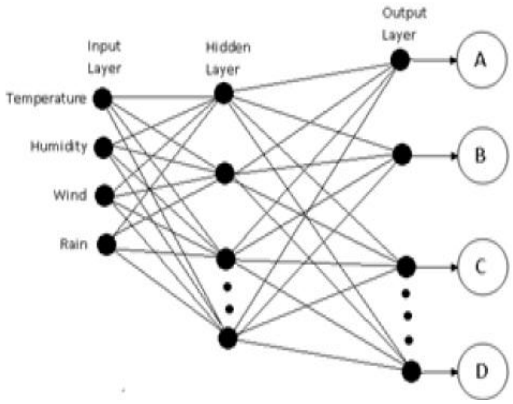

Figure.1: Architecture of an ANN based model

Conversion also depends on the number of epochs we take for the training. It is seen that neither so high nor so low number of epochs are better for training the network. So extra intension is to pay for epochs. Less no. of epochs may not converse better (better fitting of network) and high no. of epochs may leads network to produce repeated fitting. Apart from these proper performance criteria selection, validation and generalization are other factor that should be considered when developing any forecasting model.

IV. CONCLUSION

After going through all the above study & discussion we see that applying soft computing model for forecasting the weather conditions is most feasible rather than any other short term & local based weather forecasting approach. The study also says that MLFFNN with BPN algorithms are the best combination for weather forecasting. The dataset selection, input variable selection, the relationships & inter-dependencies among the data, the proper training set and the proper ANN architecture are most vital for the best prediction results.

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