A Review Study of Weather Forecasting Using Artificial Neural Network Approach

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ABSTRACT

Weather forecasting is important for people. It helps to make more informed daily decisions, and to keep out of danger. Accurate Weather forecasting has been one of the most challenging problems around the world. Unlike traditional methods, modern Weather forecasting involves a combination of computer models, observation (by use of balloons and satellites), and knowledge of trends and patterns (used by Local weather observers and weather stations). Using these methods, reasonably accurate forecasts can be made. Most of the computer models used for forecasting are run by forecast models based on complex formulas. Artificial Neural Network is adaptive system that changes its structure based on external or internal information that flows through the network. This paper presents the review of Weather Forecasting using Artificial Neural Network (ANN) and studies the benefit of using it. The paper provides a survey of available literatures of some methodologies employed by different researchers to utilize ANN for Weather Forecasting. The technical milestones, that have been achieved by various researchers in this field has been reviewed and presented in this survey paper.

Keywords: **Soft Computing, Artificial Neural Network (ANN), Back Propagation, MLFNN, Mean Square Error (MSE)**

1. INTRODUCTION

Soft Computing became formal area of study in 1990.Earlier computational approaches could model and precisely analyze only relatively simple system. More complex systems often remained intractable to conventional mathematical and analytical methods. Soft Computing deals with impression, uncertainty, partial truth, and approximation to achieve practibility, robustness and low solution cost. Soft Computing is an efficient approach for forecasting, whether it is weather forecasting or any other else. Weather Forecasting is the ultimate goal of atmospheric research. It is described as the most advanced area in meteorology. The nature of modern weather forecasting is not only highly complex but also highly quantitative.

The various methods used in forecasting the weather are as follows:

(1) Synoptic weather forecasting,

(2) Numerical methods, and

(3) Statistical methods.

1) **Synoptic weather forecasting**: The first method is the traditional approach in weather prediction. This primary method continued to be in use until the late 1950s. Synoptic" means that the observation of different weather elements refers to a specific time of observation. Thus, a weather map that depicts atmospheric conditions

at a given time is a synoptic chart to a meteorologist. In order to have an average view of the changing pattern of weather, a meteorological centre prepares a series of synoptic charts every day. Such synoptic charts form the very basis of weather forecasts.

As stated earlier, the task of preparing synoptic charts on a regular basis involves huge collection and analysis of observational data obtained from thousands of weather stations. From the careful study of weather charts over many years, certain empirical rules were formulated. These rules helped the forecaster in estimating the rate and direction of the movement of weather systems.

2) **Numerical Weather Prediction (NWP**): uses the power of computers to make a forecast. Complex computer programs, also known as forecast models, run on supercomputers and provide predictions on many atmospheric variables such as temperature, pressure, wind, and rainfall. A forecaster examines how the features predicted by the computer will interact to produce the day's weather.

The NWP method is flawed in that the equations used by the models to simulate the atmosphere are not precise. If the initial state is not completely known, the computer's prediction of how that initial state will evolve will not be entirely accurate.

3) **Statistical methods**: are used along with the numerical weather prediction. This method often supplements the numerical method. Statistical methods use the past records of weather data on the assumption that future will be a repetition of the past weather. The main purpose of studying the past weather data is to find out those aspects of the weather that are good indicators of the future events. After establishing these relationships, correct data can be safely used to predict the future conditions. Only overall weather can be predicted in this way. It is particularly of use in projecting only one aspect of the weather at a time.

At macro level, weather forecasting is usually done using the data gathered by remote sensing satellites. Weather parameters like maximum temperature, minimum temperature, extent of rainfall, cloud conditions, wind streams and their directions, are projected using images taken by these meteorological satellites to assess future trends. The satellite-based systems are inherently costlier and require complete support system. Moreover, such systems are capable of providing only such information, which is usually generalized over a larger geographical area. The variables defining weather conditions like temperature (maximum or minimum), relative humidity, rainfall etc., vary continuously with time, forming time series of each parameter and can be used to develop a forecasting model either statistically or using some other means like artificial neural networks.

As the climate dataset is highly non-linear so Artificial Neural Network (ANN) can be used for weather forecasting. Neural networks have been in use in numerous meteorological applications including Weather Forecasting. They are found to be more powerful than any traditional expert system.

Artificial Neural Network (ANN) came into existence in 1986 which is able to draw considerable attention of research workers, as it can handle the complex non-linearity problems better than the conventional techniques.ANN has matured to a great extent over few years. The main aim and objective of this paper is to reflect the study of several researches and to present the conclusion that the use of Artificial

Neural Network (ANN) is best suited in Weather Forecasting.

2. LIERATURE REVIEW

On a worldwide scale, large numbers of attempts have been made by different researchers to forecast Weather accurately using various techniques. But due to the nonlinear nature of Weather, prediction accuracy obtained by these techniques is still below the satisfactory level.

Ali, Lin etc [1] developed an ANN technique to estimate tropical cyclone heat potential (TCHP) for estimating the Cyclone and Intensity prediction. They estimated TCHP by 1) an ANN technique, 2) a two-layer reduced gravity model, and 3) a multiple regression technique and compared the estimations with the *in situ* observations. Out of the three methods, they found that ANN approach has given the best results. The results suggest the utility of the ANN technique in estimating TCHP with better accuracy in the North Indian Ocean that certainly, in turn, helps in improving the cyclone track and intensity predictions.

Sarma, Konwar, Das etc [2] showed that Artificial Neural Network (**ANN**) can also be combined with different methods. A neural network model for rainfall retrieval over ocean from remotely sensed microwave (MW) brightness temperature (BT) is described. They Proposed, a soft computing approach for rainfall prate estimation over ocean using online feature selection, clustering, and hybrid neural network. In this study, they applied an online feature selection (FS) algorithm to the BT dataset obtained from TMI. The nine-channel BT data are the input feature to this feature selection algorithm. It selects the most relevant channels both vertical as well as horizontal. A k-means clustering algorithm is then applied to the dataset of selected features. Separate multilayer perceptron (MLP) neural networks are trained for each of the clustered data. These trained MLPs are then combined to form a hybrid network. The results showed that hybrid network ANN-Hyb provided better instantaneous rain fall rate estimation compared to ANN alone.

Chaudhuri & Chattopadhyay [3] designed a Feed forward multi-layered artificial neural network model to estimate the maximum surface temperature and relative humidity needed for the genesis of severe thunderstorms over Calcutta. Prediction error is computed and compared for single layer network and one hidden layer artificial neural network. Result reveals the efficiency of the one hidden layer ANN. The performance of the model is found to be good and showed that the neural network technique is of great use in forecasting the occurrence of high frequency small-scale weather systems. The forecasting from single-layer-neural net is compared with the forecasting from the second order autoregressive process. It is found that forecasting yield is better in case of single-layer-neural net than in it. From this, it can be concluded that one hidden-layer neural network is an efficient forecasting tool by which an estimation of maximum surface temperature and maximum relative humidity can be obtained. This estimation can help in predicting a probable thunderstorm day with one day or 24 hrs in advance.

Another researcher F. Mekanik and M. A. Imteaz [4] found that Australian rainfall is also affected by these key modes of complex climate variables. On the other hand, few attempts have been made to establish the combined effect of these indices on rainfall in order to develop a better understanding and forecasting system. Since rainfall is a complicated atmospheric phenomenon, linear techniques might not be

sufficient enough to capture its characteristics. This research attempts to find a nonlinear relationship between the Victorian rainfall and the lagged-indices affecting the region using Artificial Neural Networks (ANN). It was discovered that ANN modeling is able to provide higher correlations using the lagged-indices to forecast spring rainfall in compared to linear methods. Using these indices in an ANN model increased the model correlation up to 99%, 98% and 43% for the three case study stations of Horsham, Melbourne and Orbost in Victoria, Australia respectively.

Luk, Ball and Sharma [5] described that due to the complexity of the atmospheric processes by which rainfall is generated and the lack of available data on the necessary temporal and spatial scales, it is not feasible generally to forecast rainfall using a physically based process model. They presented the results of a study investigating the application of ANN to forecast the spatial distribution of rainfall for an urban catchment.

Three types of ANNs suitable for this task were identified, developed, and compared; these networks were (i) multilayer feed forward neural network (MLFN),(ii) Elman partial recurrent neural network (Elman), and (iii) time delay neural network (TDNN).All the above alternative networks could make reasonable forecast of rainfall one time step (15 minutes) ahead for **16** gauges concurrently. In addition, the following points were observed. (a)For each type of network, there existed an optimal complexity, which was a function of the number of hidden nodes and the lag of the network. (b)All three networks had comparable performance when they were developed and trained to reach their optimal complexities. (c)Networks with lower lag tended to outperform the ones with higher lag. This **indicates** that the 15 min. rainfall time series have very short term memory characteristics.

Another researcher [6] described a weather forecasting problem-rain fall using different neural network architectures namely Electronic Neural Network (ENN) model and opto-electronic neural network model. They experimented using these two models and the percentage of correctness of the rainfall estimation of the neural network models and the meteorological experts are compared. The results of the ENN are compared with the results of the opto-electronic neural network for the estimation of rainfall. The accuracy of the results, obtained using ENN and opto-electronic neural network models, is compared with two metrological experts. The performance of opto-electronic neural network, which is better than the performance of ENN, is reported.

Hayati and Mohebi [7] shows that how ANN can be used for Forecasting Weather for the city of Iran. They utilizes ANN for one day ahead prediction of weather parameter i.e. temperature of city of Iran. Their study was based on most common neural network model Multilayer Perceptron (MLP) which is trained and tested using ten years past metrological data. In order to improve the accuracy of prediction, they split data into four season's i.e. spring, summer, fall and winter and then for each season one network is presented. They showed that MLP network with this structure has minimum error between exact and predicted values at each day and has a good performance, reasonable prediction accuracy and minimum prediction error in general. The forecasting reliability was evaluated by computing the mean absolute error between the exact and predicted values. The result shows that this network can be an important tool for temperature forecasting.

Kaur and Singh [8] in his work uses Multi-Layer Perceptron (MLP) to model forecasting system and used Back Propagation algorithm to train the network. The network is trained and tested with actual data of the past ten years which comes from meteorological department. The results show that minimum temperature can be predicted with reasonable accuracy by using the Artificial Neural Network. Thus from this work they concluded that a feed-forward NN model using back-propagation algorithm is developed to identify the minimum temperature. The results show that an appropriate accuracy can be achieved using this network. Further, this approach is also able to determine the values of other parameters like maximum relative humidity, minimum relative humidity, maximum temperature etc in a particular year.

Artificial neural networks have been extensively used in these days in various aspects of science and engineering because of its ability to model both linear and non-linear systems without the need to make assumptions as are implicit in most traditional statistical approaches. Vamsidhar, Rao, satapati etc[9] used the back propagation neural network model for predicting the rainfall based on humidity, dew point and pressure in the country INDIA. Two-Third of the data was used for training and One-third for testing. The number of training patterns is 250 training and testing patterns are 120.In the training they obtained 99.79% of accuracy and in Testing they obtained 94.28% of accuracy. These results can predict the rainfall for the future. For rainfall prediction, Artificial Neural Network was applied and the rainfall was predicted in India. According to the results back propagation neural network were acceptably accurate and can be used for predicting the rainfall. So by using this method for prediction we can find the amount of rainfall in the region by using the attributes like humidity, dew point and pressure.

Rainfall prediction is one of the most important and challenging task in the modern world. ANN has been successfully used by most of the researchers in this field for the last twenty-five years. [10] Provides a survey of available literature of some methodologies employed by different researchers to utilize ANN for rainfall prediction. From the survey it has been found that most of the researchers used back propagation network for rainfall prediction and got significant results. The survey reports that rainfall prediction using ANN technique is more suitable and also gives a conclusion that the forecasting techniques that use MLP, BPN, RBFN, SOM and SVM are suitable to predict rainfall than other forecasting techniques such as statistical and numerical methods.

Kadu, Wagh and Chatur [11] proposed a model of temperature prediction which uses new wireless technology for data gathering with the combination of statistica software. They proposed approach of artificial neural network that uses analysis of data and learn from it for future predictions of temperature, with the combination of wireless technology and statistica software.

Another researcher Naik, Pathan [12] proposed a new technique of Weather classification and forecasting using Levenberg Marquardt Back Propagation Feed Forward Neural Network. As there are many BP algorithm but among them Levenberg BP is the fastest. The classification and Prediction of Weather using BPNN is basically a forecasting kit which aims to gather data i.e. weather parameters like temperature, pressure, humidity, wind direction. These predictors are taken as input neuron to BP .Past

and Present data of atmosphere is collected and used to train Neural Network.

Devi, Reddy, Kumar, etc [13] presented a neural network-based algorithm for predicting the temperature. The Neural Networks package supports different types of training or learning algorithms. One such algorithm is Back Propagation Neural Network (BPN) technique. They tested the proposed idea using the real time dataset. The results were compared with practical working of meteorological department and these results confirm that the model have the potential for successful application to temperature forecasting.

[14] Uses Artificial Neural Network (ANN) to predict and classify thunderstorms. ANN has designed to forecasts the occurrence of thunderstorm in two geographical regions. Thus, it is concluded from the results that ANN can be effectively utilized for the prediction and classification of thunderstorm with appreciable level of accuracy.

Rankovic, Divac, Nikola etc [15] showed that how ANN can be beneficial to control floods by ensuring safety of Dams. The safety control of dams is based on seepage flows, seepage water clarity, piezometric levels, water levels, pressures, deformations or movements, temperature variations, loading conditions, etc. Interpretation of these large sets of data is very important for dam health monitoring and it is based on mathematical models. They study to develop a feed forward neural network (FNN) model to predict the piezometric water level in dams. An improved resilient propagation algorithm has been used to train the FNN. The measured data have been compared with the results of FNN models and multiple linear regression (MLR) models. The results of this study show that FNN models can be a powerful and important tool which can be used to assess dams. The nonlinear FNN model approach has been shown to provide a better prediction of water levels in piezometers than MLR.

3. CONCLUSION

This paper presents a survey that using artificial neural network (ANN) approach for weather forecasting yields good results and can be considered as an alternative to traditional metrological approaches. The study describes the capabilities of ANN in predicting several weather phenomenon's such as temperature, thunderstorms, rainfall and concluded that major architecture like BP, MLP are suitable to predict weather phenomenon.

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