VOL. 14, NO. 24, DECEMBER 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences


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# WEATHER PREDICTION USING NEURAL NETWORK BACKPROPAGATION

Anusha N., Sai Seeta M. G. K. M and Bhavana Lakshmi M
Department of Computer Science and Engineering, Sathyabama Institute of Science and Technology, Chennai, India
E-Mail: anusha.nallapareddy@gmail.com

## ABSTRACT

Rainfall is one of the main attributes of climate changes in atmosphere. In this paper a method is proposed using Neural Network Backpropagation (BPP) for quantitative prediction of Rainfall rate. The architecture of Neural Network backpropagation is built on N different attributes as input layer. This model is trained using five parameters as inputs in input layer and data over five years (2011-2016) received from Indian Meteorological Department. The configured Neural Network is applied on some portion of collected data of the state of Uttar Pradesh in India. In this study, we predicted the rainfall rate using Neural Network backpropagation. The error is determined which can be less than the existing models and this achieved by handling outliers by applying K-Means algorithm which enhances the performance of Neural Network backpropagation.

**Keywords:** multi-Linear regression, neural network backpropagation, statistical approaches, support vector machine (SVM), weather forecasting.

## INTRODUCTION

Weather forecasting is one of the areas that involve a complex process in meteorology. Ancient weather forecasting methods used by our ancestors usually relied on observing patterns of events. For example, if the sunset in the day looks brighter, assumption was made that the following day will have fair weather. However, not all these predictions proved reliable. In literature, there are different algorithms which can be used for rainfall prediction and are classified into the different types like cloudy, partially cloudy, full cloudy, etc., Out of which some of the methods predicts numerical values but each method as their own merits and demerits.

More precision in predicted values can be obtained by taking the weather attributes periodically with a very high level of accuracy, in the controlled environment and mainly with the knowledge of current weather condition over the wide area. The small error in initial stage can lead to drastic change in outcome. Accuracy in prediction is more important in many sectors like Marine, Agriculture, Transportation, Aircraft, disaster management, defense etc.

Wenying Zhang, *et al* compared the predicted with the actual weather and detected fault rate using Support Vector Machine (SVM). Failed to do numerical weather prediction and also requires a large amount of data for training in order to get more accuracy. Serkan Buhan, *et al* correlated between Numerical Weather Prediction (NWP) and Reference Wind Mast (RWM) models to localize the data used to get wind patterns by using Support Vector Machine (SVM). Failed to get more accuracy and not able to apply correlation to all data sets.

C. R. Rivero, *et al* used Bayesian Enhanced Modified Approach (BEMA) combined with Relative Entropy in order to issue short rainfall series prediction. Classified the data into clusters and not able to predict numerical value. (Swati Bhomia, *et al*) The Dynamic-model-selection-based-multi-model-ensemble technique is developed for monsoon rain prediction. Calculates Root Mean Square Error and proceed according to the rate of estimation for next hour prediction. Not able to apply at different levels.

S. Laboret, *et al* altered the parameters using Bayesian and Artificial Neural Network filter methods for cumulative rainfall forecasting. Fair distribution is obtained from the selected data set and computational cost is high. (Julian Pucheta, *et al*) Forecaster method was implemented to eradicate noisy data and Mackay-Glass chaotic time series was used to predict numerical value. Failed to maintain consistency with predicted values due to the eradication of noisy data.

(Andrew Kusiak, *et al)* Broyden-Fletcher-Goldfarb-Shanno (BFGS) used various data mining techniques (SVM, Simple Linear Regression, and Random Forest) and compared the results on the basis of error rate. High cost is involved to estimate rainfall rate in real time scenario. (Na Chen, *et al*) Weather prediction was done using Hydrodynamic and Thermodynamic models based on boundary conditions of the atmosphere. Not able to predict rainfall rate more than four hours and model was purely based on wind rate.

(José L. Aznarte and Nils Siebert) Naïve predictor, trivial predictor, Multivariate adaptive Regression, the generalized linear models and random forests were the used techniques for prediction. Unable to apply on datasets and high cost because of using different models. (Hagit Messer and Omry Sendik) Wireless processing was used to exploit diversity in data. Due to Wireless communication data transmission rate was slow.

(Wenyu Gong, *et al*) The Atmospheric filtering approach that combines lagged values of the computed rating series, measuring Meteorological variables and NWP values. Dealing with statistical data and rate of significance was varying from 0.67 to 0.77. (Sheikh Nurunnahar, *et al*) Weather Forecasting was done by Data

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ARPN Journal of Engineering and Applied Sciences

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Mining Techniques, Classification and Regression Tree (CART). Not able to predict numerical values.

Application of Neural Network backpropagation on available data gives more accurate prediction than the contemporary strategies that are available. Based on literature survey, Temperature, Wind Speed, Wind Direction, Humidity, Atmospheric Pressure and Rainfall rate, are observed to be the parameters that have more impact on prediction. Information on these parameters on an hourly premise, more than five years (9-08-2011 to 19-10-2016) has been procured (N. Anusha, *et al*) from the Indian Meteorological Department (IMD).

The proposed framework comprises of a particular way of dealing with Meteorological data by applying specialized techniques like K-Means algorithm and Neural Network Backpropagation. During the technical analysis phase, the system analyzes the given input data by preprocessing and then the results are converted into a particular scale. This preprocessed information is check for outliers and handled using K-Means algorithm. This processed data further fed as input to the Neural Network Backpropagation algorithm. The framework is ready to estimate the quantitative rainfall by considering attributes as mentioned in Table-1.

## ABOUT STUDY AREA AND DATA SET USED

The Figure-1 below shows the study area. This Prediction is mainly concerned with Uttar Pradesh (UP) which is located in the North-Eastern part of India. The latitude and longitude of study area are 26.8467° N, 80.9462° E respectively. Variations exist in different parts of the state because of Indo-Gangetic plain forming a single parametric pattern throughout the state. Indo-Gangetic plain, also known as Indus-Ganga plain, is the main reason for a tropical monsoon in UP [12]. UP has a climate of extremes with cyclic climatic conditions like temperature fluctuating from $0^0$ to $46^0$C, droughts, and floods due to unpredictable rains.

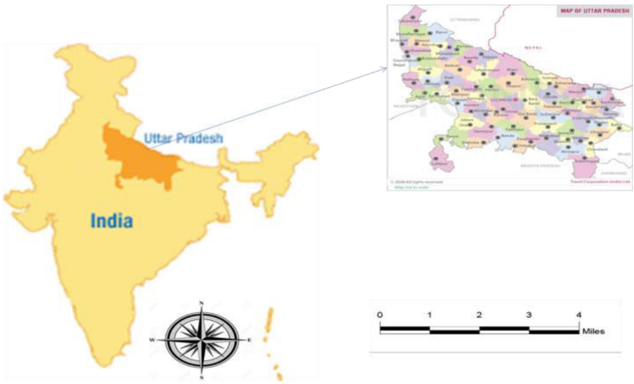


**Figure-1.** Location of the study area.

Data is collected from the Indian Meteorological Department (IMD). The meteorological data of Uttar Pradesh is taken for rainfall prediction for over a period of four years from 09-08-2011 to 19-10-2016. Where as the table 1 below shows only the partial/sample data set used. This data consists of parameters like station, latitude, longitude, altitude, time (IST), date (IST), air temperature, wind speed, wind direction, humidity, and atmospheric pressure.

The total data set is partitioned into two categories, namely, training Data and testing Data. 70 percent of the total data is for training algorithm and 30 percent of the total data for the testing.

**Table-1.** Sample data set used for rainfall prediction.

| Date(IST) | Temperature in °C | Wind Speed in m/s | Wind Direction deg | Atmospheric Pressure (hector Pascal) | Humidity | Rainfall(mm) (Output) |
|---|---|---|---|---|---|---|
| 09-08-2011 (5.30) | 32.9 | 0.4 | 93.8 | 928.3 | 88 | 0 |
| 10-08-2011 (2.30) | 32.4 | 0.4 | 71.8 | 940.2 | 0 | 20 |
| 04-12-2011 (10.30) | 30.7 | 0.9 | 229.2 | 951.5 | 75 | 0 |
| 27-06-2011 (13.30) | 31.7 | 1.2 | 294.2 | 949 | 99 | 46 |
| 04-04-2013 (9.30) | 34.6 | 2.5 | 286.9 | 946.7 | 36 | 0 |

## METHODOLOGY

Figure-2 shows the architecture for the proposed methodology using Neural Network Backpropagation. In the pre-processing phase, input data is processed by applying filtering to evacuate the anomaly data which influences prediction rate, then the scaling conversion is done to frame consistency in data and then rectification of semantic errors is done to rule out values which are not at all insist in prediction and convincible. After preprocessing outliers are removed by applying K-Means algorithm. Large amount of inconsistent data is removed by applying the Bench mark technique (72.49583+1.5*IQR (column attribute)) is used. Now, whole the data is preprocessed.

SVM generates different support vectors based on the preprocessed training data by considering the day, month and year as independent attributes and temperature as dependent attribute fed to SVM. These support vectors are

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ARPN Journal of Engineering and Applied Sciences



applied to the test data to predict the temperature for a specific date.

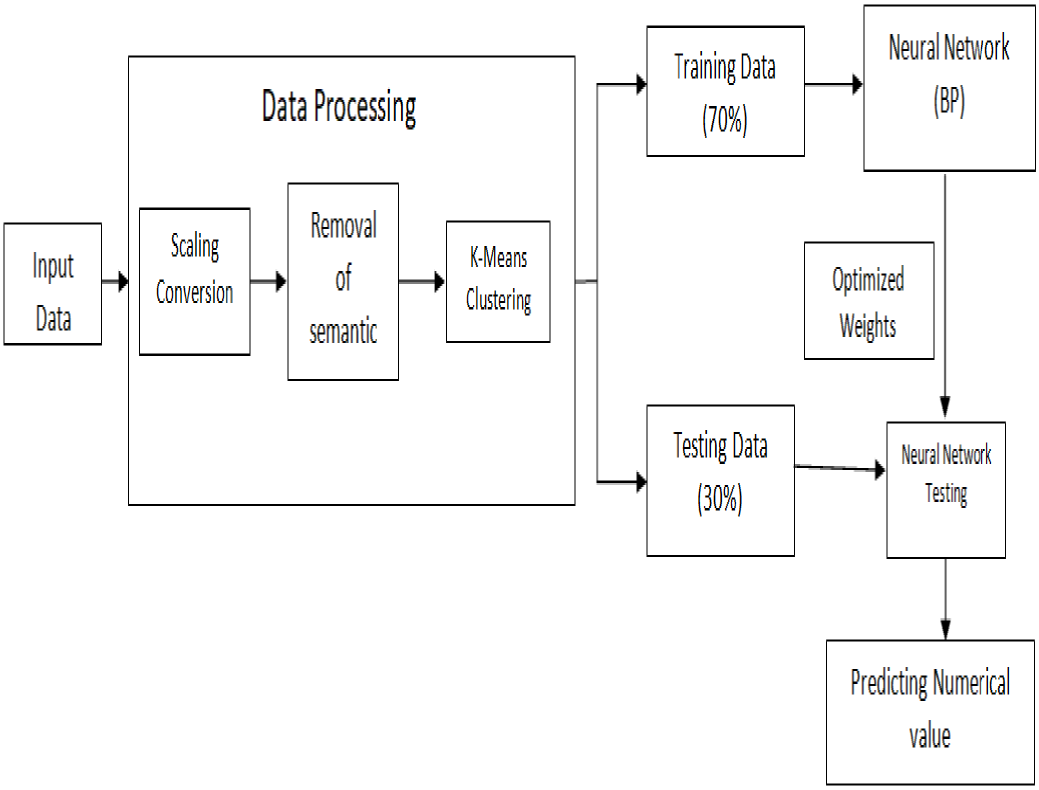


**Figure-2.** Architecture of the propped methodology.

Then the SVM algorithm is trained by applying Day, Month, Year, and Temperature as independent attributes and wind speed as the dependent attribute, which generates related support vectors based on the given data. Test data is applied to related support vectors formed from above SVM algorithm and wind speed is predicted. The same process is used for predicting wind direction. In this case, wind direction is the dependent variable and the independent variables remain the same.

For predicting humidity, attributes are month, year, temperature and wind speeds are used as independent variables. Similarly, for predicting atmospheric pressure, attributes, day, month, year, temperature, wind speed and wind direction are used as independent variables.

Different Support Vector Machines are developed to form different support vectors based on different independent and dependent attribute sets. These procreated support vectors are able to predict the numerical values of dependent attribute sets. Data obtained from various SVM algorithms are used for test model.

After pre-processing phase, Neural Network Backpropagation is trained using training data. In proposed methodology of Neural Network Backpropagation consists of three hidden layers with 4, 3 and 2 number of perceptrons respectively, in each of the first, second and third hidden layers. Output for each perceptron in a hidden layer is obtained by calculating summation of product of previous layer perceptrons connected and it's corresponding weights plus corresponding current weight coefficient. Finally, it generates a relation between the independent attributes and rainfall present as output layer with minimal error using back Propagation technique. This relation makes system capable of predicting the numerical value of dependent attribute (rainfall).

Backpropagation technique is performed based on the error obtained by final layer in neural network. If the error is high, it will adjust the weights and the same operation is repeated until the error rate isminimized and an optimal relation is generated.

Neural Network is calculated by the relation,

$$a_j^l = \sigma\left(\sum_k w_{jk}^l a_k^{l-1} + b_j^l\right)$$

Where,

| | | |
|---|---|---|
| $a^l_j$ | → | Independent attribute (rainfall) |
| $w^l_j$ | → | $j^{th}$ Minimized weights in layer l |
| $a^{l-1}_K$ | → | $k^{th}$ activation function in layer l |
| $b^l_j$ | → | coefficient of corresponding $a^{l-1}_K$ value |

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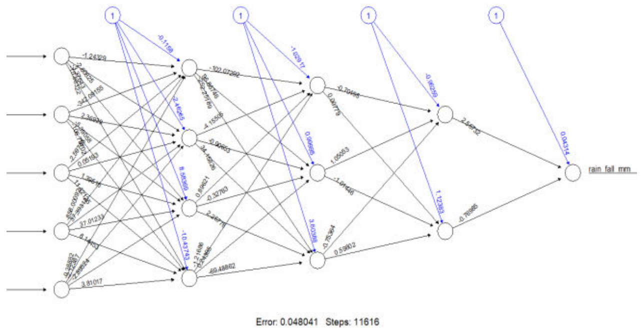


**Figure-3.** Network between dependent and independent attribute.

Neural Network with above equation formation is shown in the above Figure-3.Then this obtained relation is used to apply on data obtained from various support vector machines to calculate dependent attribute, quantitative rainfall. Then predicted rainfall data is compared with actual rainfall data i.e., test data set and marginal error is esteemed.

## RESULTS AND DISCUSSIONS

### Temperature prediction

Figure-4 describes the projected data of actual temperature and predicted temperature data in degree Celsius which are determined by using SVM. Actual values in each graph are obtained from test data set and predicted values are outcomes of the trained algorithm.

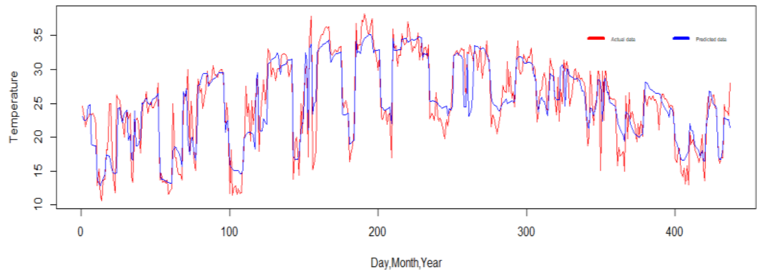


**Figure-4.** Comparision between actual temperature and predicted temperature data.

### Wind Speed prediction

Support Vector Machine is used to predict wind speed by applying related support vectors obtained from algorithm. Figure-5 describes the actual wind speed and predicted wind speed data in meters per second.

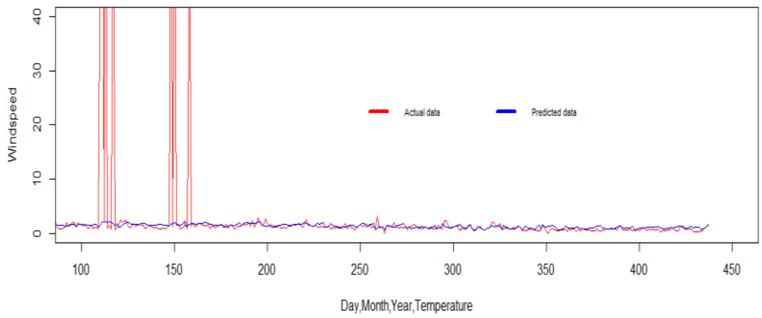


**Figure-5.** Comparision between actual and predicted wind speed data.

### Wind direction prediction

Figure-6 describes the projected values of actual wind direction and predicted wind direction data in degrees.

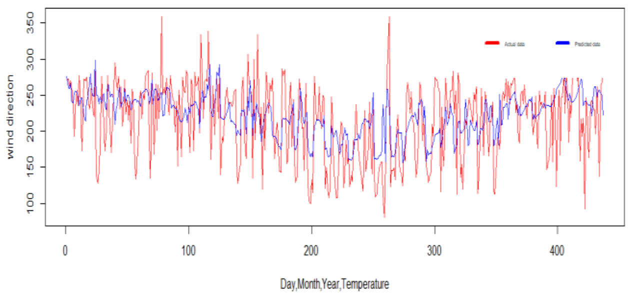


**Figure-6.** Comparision between actual and predicted wind direction data.

**Atmospheric pressure prediction**

Atmospheric pressure is predicted by applying related support vectors mentioned in methodology. Figure-7 describes of actual atmospheric pressure and predicted atmospheric pressure numerical data in hpa.

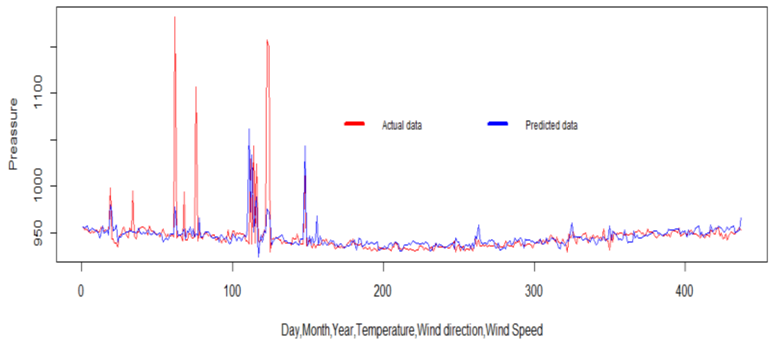


**Figure-7.** Comparision between actual and predicted atmospheric pressure data.

**Humidity Prediction**

Figure-8 projected actual humidity data and predicted humidity numerical data in mm. actual values are obtained from test data sets and predicted values are outcomes of the trained algorithm.

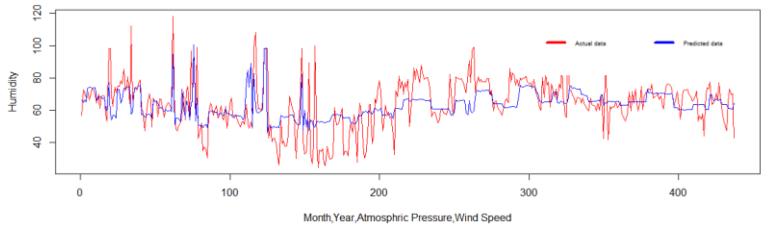


**Figure-8.** Comparision between actual and predicted Humidity data.

**Finally Rainfall Prediction**

Figure-9 describes the projected values of actual rainfall data and predicted rainfall numerical data in mm. Actual values are obtained from test data sets and predicted values are outcomes of the trained algorithm and the error rate is 22.24

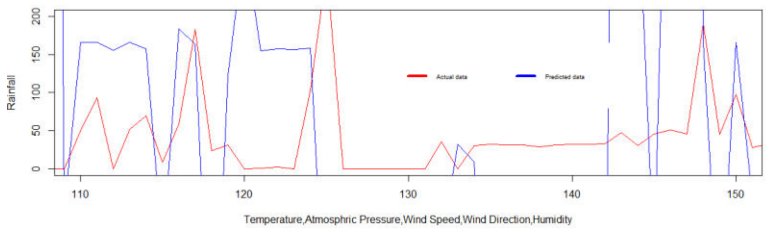


**Figure-9.** Comparision between actual and predicted Humidity data.

**CONCLUSIONS**

The existing frameworks are executed utilizing statistical methodologies, whereas the proposed module is implemented by utilizing K-Means calculation and Neural Network backpropagation, made the framework more exact than past prediction techniques. The issue with the current strategies lies in their failure to consider the effect of every value of each parameter, on the relation. At the end of the day, the impact of each and every esteem isn't viewed as and a more summed up condition is delivered instead of a one of a kind connection. For instance, in the SVM methodology, a plane that contains the information is produced and the condition of this plane is utilized as a connection for the forecast. This represents an issue as information focuses that are far separated from each other as far as extent wind up on a similar plane and their individual impact gets disregarded. The use of Neural Network Backpropagation deals with this problem and optimizes the results by applying backPropagation technique. Historical data used for the proposed module has day, month and year are used to predict independent attributes like temperature, wind speed, wind direction, humidity, and atmosphere pressure and are used to calculate the amount of rainfall. From the findings, it is clear that the proposed method gives better results for rainfall prediction compared to the existing techniques.

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