# Weather Prediction Using Artificial Intelligence

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## ABSTRACT

Weather forecasting has become an important field of research in the last few decades. Daily Weather forecasting is used for multiple reasons in multiple areas likeagriculture, energy supply, transportations, etc. In this project, a neural network- based algorithm for predicting the temperature will be implemented. The Neural Networks package supports different types of training or learning algorithms. One such algorithm is the Back Propagation Neural Network (BPN) technique. The mainadvantage of the BPN neural network method is that it can fairly approximate a largeclass of functions. The proposed idea is tested using a real-time dataset. Backpropagation is a method used in artificial neural networks to calculate a gradientthat is needed in the calculation of the weights to be used in the network. Backpropagation is shorthand for "the backward propagation of errors " since an error is computed at the output and distributed backward throughout the network's layers. It is commonly used to train deep neural networks a term referring to neural networks with more than one hidden layer.

## OBJECTIVES

- To predict the various weather parameters – temperature, humidity, precipitation, dew point, and wind speed and classify weather as hot, cold,rainy, windy, sunny, cloudy, or humid.

## INTRODUCTION

The chaotic nature of the atmosphere implies the need of massive computational power required to solve the equations that describe the atmospheric conditions. This is resulted from incomplete understanding of atmospheric processes mean that forecasts become less accurate as the difference in time between the present momentand the time for which the forecast is being made increases. Weather is a continuous,data-intensive, multidimensional, dynamic and chaotic process and these properties make weather prediction a big challenge. Generally, two methods are used for weather forecasting

(a) the empirical approach

(b) the dynamical approach

## BACKGROUND

Weather forecasting is a vital application in meteorology and hasbeen one of the most scientifically and technologically challenging problems around the world. Primary users for the system are generalpublic aviation, fire, and marine. Aviation forecasters use them to keep an eye on surface observation for wind shear, restrictions to visibility tat could affect takeoffs and landings.

## MOTIVATION

Weather warnings are important forecasts because they are used to protect life and property. Forecasts based on temperature and precipitation are important to agriculture, and therefore to traders within commodity markets.

From a programmer point of view, the project helps understand a wide array of topics like Back Propagation, predictive analysis, andPython libraries such as NumPy, etc.

## METHODOLOGY

## ALGORITHM:

The algorithm used to do the predictive analysis is

4. **Back Propagation.**
5. **Fletcher-Reeves Model (Updating to Backpropagation Algorithm)**
6. **Artificial Neural Network (ANN) Approach**

**Back Propagation:**

Backpropagation is a method used in artificial neural networks to calculate a gradient that is needed in the calculation of the weights to be used in the network.

Backpropagation is shorthand for "the backward propagation of errors," since an error is computed at the output and distributed backwardsthroughout the network’s layers.

It is commonly used to train deep neural networks a term referring to neural networks with more than one hidden layer.

Backpropagation is a special case of a more general technique called automatic differentiation. In the context of learning, backpropagation is commonly used by the gradient descent optimization algorithm to adjust the weight of neurons by calculating the gradient of the loss function.

This technique is also sometimes called backward propagation of errors, because the error is calculated at the output and distributed back throughthe network layers.

Backpropagation requires the derivative of the loss function with respectto the network output to be known, which typically (but not necessarily) means that a desired target value is known. For this reason, it is consideredto be a supervised learning method, although it is used in some unsupervised networks such as autoencoders.

Backpropagation is also a generalization of the delta rule to multi-layered feedforward networks, made possible by using the chain rule to iterativelycompute gradients for each layer. It is closely related to the Gauss– Newton algorithm, and is part of continuing research in neural backpropagation. Backpropagation can be used with any gradient- based optimizer.

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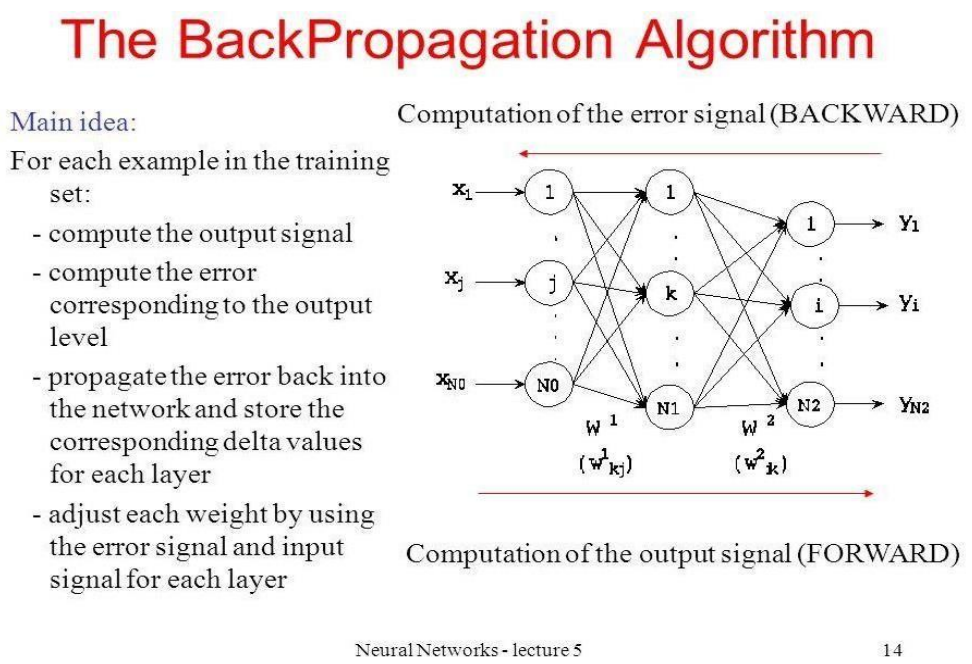
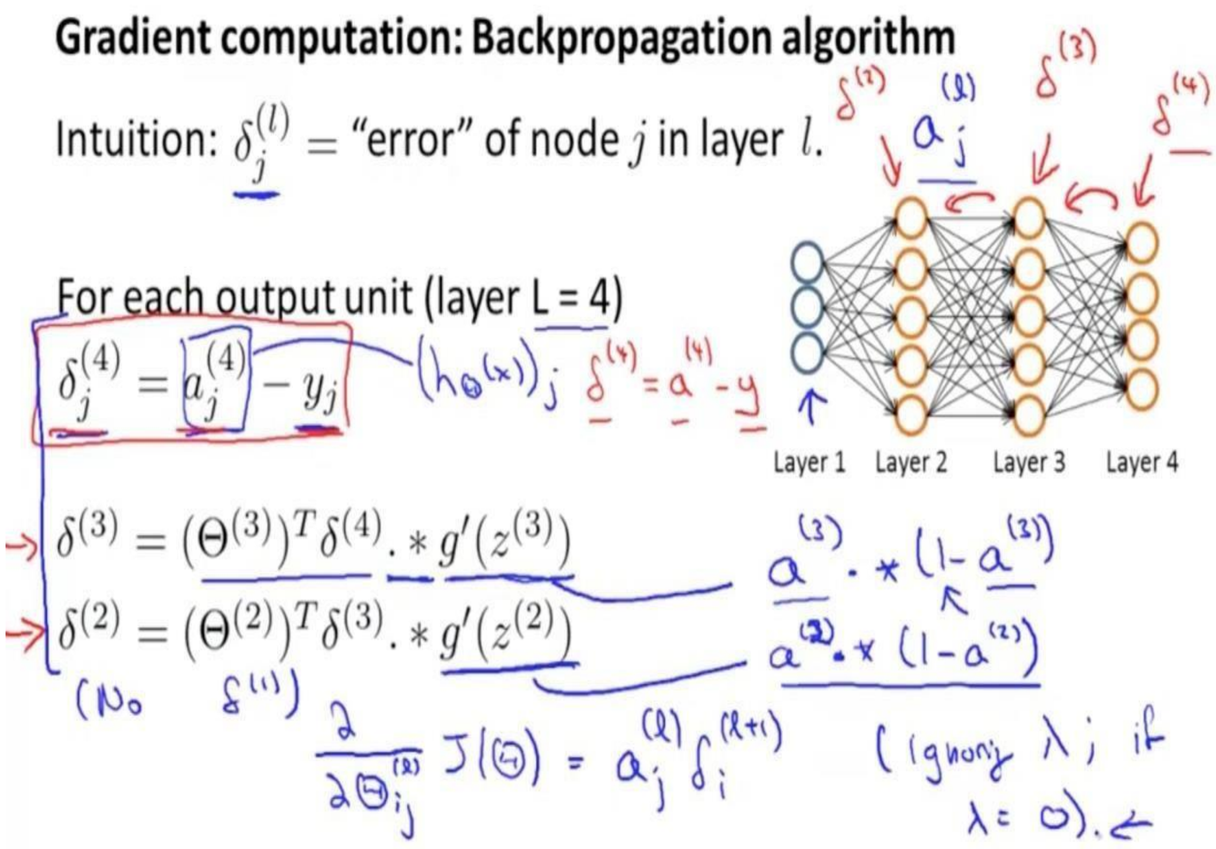



**Equations for Gradient Computations in Back Propogation Algorithm**



**BACK PROPOGATION STEPS**

**Phase 1: propagation**

Each propagation involves the following steps:

1. Propagation forward through the network to generate the output value(s)
2. Calculation of the cost (error term)
3. Propagation of the output activations back through the network using the training pattern target to generate the deltas (the difference between the targeted and actual output values) of all output and hidden neurons.

**4. Phase 2: weight update**

5. For each weight, the following steps must be followed:
6. The weight's output delta and input activation are multiplied to find the gradient of the weight.
7. A ratio (percentage) of the weight's gradient is subtracted from the weight. This ratio (percentage) influences the speed and quality of learning; it is called the learning rate. The greater the ratio, the fasterthe neuron trains, but the lower the ratio, the more accurate the training is. The sign of the gradient of a weight indicates whether theerror varies directly with, or inversely to, the weight. Therefore, the weight must be updated in the opposite direction, "descending" the gradient.

**8. Disadvantages of Back Propagation Algorithm**

9. The actual performance of BackPropagation on particular datais completely dependent on its inputs.

10. Backpropagation can be sensitive to noisy data and outliers.

11. Fully matrix-based approach to backpropagation over a mini-batch.

**Fletcher-Reeves Model (Updation to BackpropagationAlgorithm)**

Despite the general success of back-propagation method in the learning process, several major deficiencies are still needed to be solved. The convergence rate of back -propagation is very low and hence it becomes unsuitable for large problems. Furthermore, the convergence behavior of theback-propagation algorithm depends on the choice of initial values of connection weights and other parameters used in the algorithm such as the learning rate and the momentum term.

Improving the training efficiency of neural network based algorithms is an active area of research and numerous papers have been proposed in the literature. Among these Fletcher and Reeves algorithm was turn out to be more efficient than Backpropagation Algorithm.

The following iterative algorithm is proposed for changing the gradient basedsearch direction using a gain value. The gradient based search direction is a function of gradient of error with respect to weights.

**Steps:**

Step 1 Initialize the weight vector with random values and the vector of gainvalues with one.

Step 2 Calculate the gradient of error w.r.t. to weights usingEquation, and gradient of error w.r.t. to gain using Equation.

Step 3 Use the gradient weight vector and gradient of gain calculated in step2 to calculate the new weight vector using equation and vector of new gainvalues using equation for use in the next epoch.

Step 4 Repeat the following steps 2 and 3 on an epoch-byepoch basis untilthe selected error minimization criteria is satisfied.

**Artificial Neural Network (ANN) Approach**

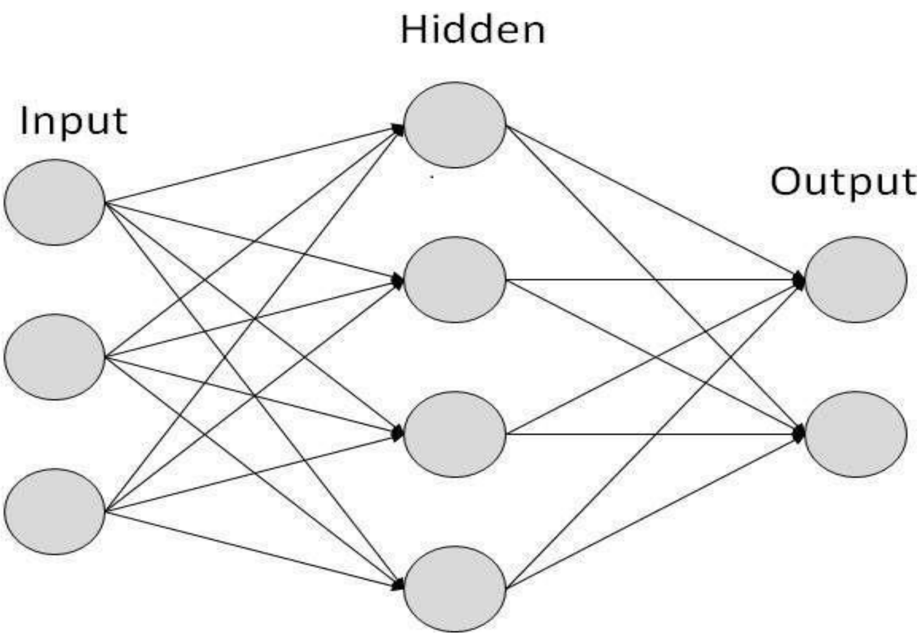
An Artificial Neural Network (ANN) is an information processing paradigmthat is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the new structure of the information processing system. It is composed of a huge number of highly interconnected processing elements (neurons) working together to solve specific problems.

ANNs, like people, learn by example. An ANN is configured for a particularapplication, such as pattern recognition or data classification, through a learning process. Learning in biological systems adds adjustments to the synaptic connections that exist between the neurons.

The ANN has capability to extract the relationship between the inputs and outputs of a process, without the physics being explicitly provided. Thus, these properties of ANN are well suited to the problem of weather forecasting.The main purpose is to develop the most suitable ANN architecture and its associatedtraining technique for weather prediction.

This development will be based on using two different neural network architecture to demonstrate the suitable one for this application. Back Propagation (BPN) feed forward network and radial basis function network which were trained by differential evolution algorithm are the selected architectures in this study.

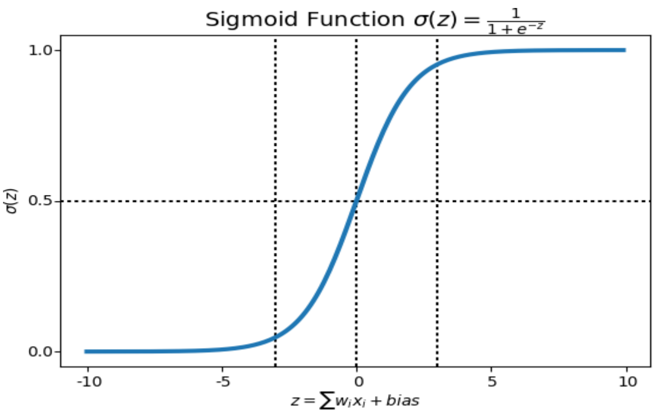
The basic architecture of the both Radial Basis Functions (RBF) neural network and multilayer feed forward neural networks are given. Componentsof a modern weather forecasting system include the following modules: datacollection, data assimilation and numerical weather prediction.




**Basic Diagram for ANN**

**Sigmoid Function and their Usage in Neural Network**

It is used in neural networks to give logistic neurons real-valued output thatis a smooth and bounded function of their total input. It also has the added benefit of having nice derivatives which make learning the weights of a neural network easier.A neural network element computes a linear combination of its input signals, and applies a sigmoid function to the result.A reason for its popularity in neural networks is because the sigmoid function satisfies a property between the derivative and itself such that it is computationally easy to perform.




Steps involved in ANN approach

**A. Data collection:**

Observations of atmospheric pressure, temperature, wind speed, wind direction, humidity and precipitation are made near the earth's surface by trained observers, automatic weather stations.
The World Meteorological Organization acts to standardize the instrumentation, observing practices and timing of these observations worldwide.

**B. Data assimilation:**

During the data assimilation process, information gained from the observations is used in conjunction with a numerical model most recent forecast for the time that observations were made to produce the meteorological analysis. This is the best estimate of the current state of the atmosphere. It is a three-dimensional representation of the distribution of temperature, moisture and wind.

The features considered in this study are bar temperature, bar reading, sea level pressure, mean sea level pressure, dry bulb temperature, wet bulbtemperature, duw point temperature, vapor pressure, wind speed, humidity, cloudiness, precipitation, wind direction, wind speed and for prediction of rain. It is easy to implement and produces desirable forecasting result by training the given data set.

### C. Numerical weather prediction:

Numerical Weather Prediction (NWP) uses the power of computers to makea 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.

## RESULT

### TEST CASE 1

**INPUT:** 1 37 25 13 6 44 15 1009 1003 8 1 13

| Data labels | Max Temperature | Min Temperature | Max DewPoint | Min DewPoint | Max Humidity | Min Humidity | Max Pressure | Min Pressure | Max Visibility | Min Visibility | Mean Wind Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 37 | 25 | 13 | 6 | 44 | 15 | 1009 | 1003 | 8 | 1 | 13 |

**OUTPUT:**

'

```
Epoch 143/150
 - 1s - loss: 0.2455 - accuracy: 0.8943 - val_loss: 0.2966 - val_accuracy: 0.8756
Epoch 144/150
 - 1s - loss: 0.2500 - accuracy: 0.8914 - val_loss: 0.3252 - val_accuracy: 0.8649
Epoch 145/150
 - 1s - loss: 0.2466 - accuracy: 0.8953 - val_loss: 0.3144 - val_accuracy: 0.8729
Epoch 146/150
 - 1s - loss: 0.2448 - accuracy: 0.8981 - val_loss: 0.3127 - val_accuracy: 0.8648
Epoch 147/150
 - 1s - loss: 0.2477 - accuracy: 0.8943 - val_loss: 0.3243 - val_accuracy: 0.8677
Epoch 148/150
 - 1s - loss: 0.2472 - accuracy: 0.8959 - val_loss: 0.2961 - val_accuracy: 0.8744
Epoch 149/150
 - 1s - loss: 0.2480 - accuracy: 0.8945 - val_loss: 0.3075 - val_accuracy: 0.8637
Epoch 150/150
 - 1s - loss: 0.2507 - accuracy: 0.8951 - val_loss: 0.3408 - val_accuracy: 0.8663


accuracy: 86.63%
```

We took the following values as in dataset and it predicts that the weather for the aboveattribute of data is **fog.**

```
[[   1   37   25   13    6   44   15 1009 1003    8    1   13]]

 [[1.9721438e-04 4.6589645e-05 2.2068853e-08 9.9975616e-01]]
Foggy

In [ ]:
```

**TEST CASE 2**

**INPUT:** 0 22 10 13 9 101 47 1021 1017 3 1 15

| Data labels | Max Temperature | Min Temperature | Max DewPoint | Min DewPoint | Max Humidity | Min Humidity | Max Pressure | Min Pressure | Max Visibility | Min Visibility | Mean Wind Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 22 | 10 | 13 | 9 | 101 | 47 | 1021 | 1017 | 3 | 1 | 15 |

**OUTPUT:**

```
Epoch 143/150
 - 1s - loss: 0.2455 - accuracy: 0.8943 - val_loss: 0.2966 - val_accuracy: 0.8756
Epoch 144/150
 - 1s - loss: 0.2500 - accuracy: 0.8914 - val_loss: 0.3252 - val_accuracy: 0.8649
Epoch 145/150
 - 1s - loss: 0.2466 - accuracy: 0.8953 - val_loss: 0.3144 - val_accuracy: 0.8729
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Epoch 150/150
 - 1s - loss: 0.2507 - accuracy: 0.8951 - val_loss: 0.3408 - val_accuracy: 0.8663


accuracy: 86.63%
```

We take the following values as in dataset and it predicts that the weatherfor the above attribute of data is **rain**

```
[[   0   22   10   13    9  101   47 1021 1017    3    1   15]]

 [[0.01839338 0.03186956 0.7977994  0.1519376 ]]
Rainy

In [ ]:
```

## DISCUSSION

Artificial Neural Network the Back-Propagation Algorithm is implemented and the variations in parameters are observed. According to these variations the logic in BackPropagation will be developed and the change in other parameters with respect to oneparameter will be predicted. All the information of parameters which changed and predicted is collected together and the new classification of weather will be drawn, whether the future day will be rainy day, sunny day or windy day and whether on thatparticular day the probability of experiencing a thunderstorm is high or not.

## CONCLUSION AND FUTURE SCOPE

It concludes that there can be a new method to predict the future weather with the help of back propagation training algorithm. It was found that the network learns very fast with back propagation algorithm. The results are more accurate for predicting the future weather. Back propagation is a gradient descent algorithm which learns by minimizing the error in the output by adjusting the weights in the network. Our model has potential to capture the complex relationships between many factors that contribute to certain weather condition.

The accuracy from weather forecasting model using ANN and Back Propagation Algorithm is more than other Statistical Model. An extension to this technology canbe done using any of the other technique instead of Data mining and Different

Algorithm. Furthermore, in order to improve the efficiency of the neural network algorithms other statistical based feature selection techniques, statistical indicatorscan be integrated. In another perspective fuzzy techniques can be incorporated, which an inferential, probality based approach to data comparisons is allowing to infer, based on probabilities, the strength of the relationships between attributes in the data sets and to achieve better predictability rate.

## REFERENCES

[1] Ch.Jyosthna Devi, B.Syam Prasad Reddy, K.Vagdhan Kumar, B.Musala Reddy, and N.Raja Nayak (2012). ANN Approach for Weather Prediction using Back Propagation. *International Journal of Engineering Trends and Technology*, 3(1), 19-23.

[2] Sanjay D. Sawaitul, Prof. K. P. Wagh, and Dr. P. N. Chatur (2012). Classification andPrediction of Future Weather by using Back Propagation Algorithm. *International Journalof Emerging Technology and Advanced Engineering*, 2(1), 110-113.

[3] Pooja Malik, Prof. Saranjeet Singh, and Binni Arora (2014). An Effective Weather Forecasting Using Neural Network. *International Journal of Emerging Engineering Research and Technology*, *2*(2), 209-212.

[4] Saboor Ahmad Kakar, Naveed Sheikh, Saleem Iqbal, Abdul Rehman, and Aziz Ullah Kakar (2018). Artificial Neural Network based Weather Prediction using Back Propagation Technique. *International Journal of Advanced Computer Science and Applications,* 9(8), 462.

[5] M. Zhang, and A. R. Scofield (1994). Artificial Neural Network techniques for estimating rainfall and recognizing cloud merger from satellite data. *International Journalof Remote Sensing*,15(16),3241-3261.

[6] Siou, Line Kong A., Anne Johannet, Valérie Borrell, and Séverin Pistre (2011). Complexity selection of a neural network model for karst flood forecasting: The case of the Lez Basin (southern France). *Journal of Hydrology*, *403*(3-4), 367-380.

[7] Jitcha Shivang, S.S Sridhar (2018). Weather prediction for Indian location using Machine learning. *International Journal of Pure and Applied Mathematics*, 118, 1945- 1949.

[8] P. Kuppusamy, K. Jayalakshmi, C. Himavathi (2019). Application of Machine Learningfor Weather Forecasting Using Artificial Neural Networks. *International Journal of Computer Sciences and Engineering*, 1(4), 321.

[9] S. Bhatkande, Roopa G. Hubballi (2016). Weather Prediction Based on Decision TreeAlgorithm Using Data Mining Techniques. *International Journal of Advanced Research in Computer and Communication Engineering*, 5(5), 483-487.

[10] Sanyam Gupta, Indumathy K, and Govind Singhal (2016). Weather Prediction Using Normal Equation Method and Linear regression Techniques. International Journal of Computer Science and Information Technologies (IJCSIT), 7(3), 1490-1493.

[11] El-Shafie, A., Jaafer, O. and Akrami, S.A. (2011). Adaptive neuro-fuzzy inference system-based model for rainfall forecasting in Klang River, Malaysia. *International Journal of Physical Sciences*, *6*(12), 2875-2888.

[12] Arti R. Naik, and Prof S. K. Pathan (2012). Weather Classification and Forecasting using Back Propagation Feed-Forward Neural Network. *International Journal of Scientificand Research Publications*, 2(12), 1-3.

[13] Ch. Jyosthna Devi, B. Syam Prasad Reddy, K.Vagdhan Kumar, B. Musala Reddy, andN.RajaNayak (2012). ANN Approach for Weather Prediction Using Back Propagation. *International Journal of Engineering Trends and Technology*, 3(1), 19-23.

[14] Mahesh Anad, Ansupa Dash, M.S.Jagadeesh Kumar, and Amit Kesarkar (2011). Prediction and Classification of Thunderstorms Using Artificial Neural Network. *International Journal of Engineering Trends and Technology*3(5), 4031-4035.

[15] Vesna Rankovic, Aleksandar Novakovic, Nenad Grujovic, Dejan Divac, Nikola, andMilivojevic (2014). Predicting piezometric water level in dams via artificial neural networks. *Springer-Verlag London 2013*, *Neural Computing & Applications*, 24(5), 1115-1121.

[16] D.W. McCann (1992). A Neural Network Short-Term Forecast of Significant Thunderstorms. *Weather and Forecasting*, *7*(3), 525-534.

[17] M. N. French, W. F. Krajewski, and R. R. Cuykendall (1992). Rainfall forecasting inspace and time using a neural network. *J. Hydrol*., 137(1-4), 1–31.

[18] Tao Chen, M Takagi (1993). Rainfall prediction of geostationary meteorological satellite images using artificial neural networks. *IGARSS*, 3, 1247 – 1249.

[19] M. Zhang, and A. R. Scofield (1994). Artificial Neural Network techniques for estimating rainfall and recognizing cloud merger from satellite data. *International Journalof Remote Sensing*, 15(16),3241-3262

[20] K.W. Wong, P.M. Wong, T. D. Gedeon & C. C. Fung (2003). Rainfall Prediction Using Soft Computing Technique. *Soft Computing*, 7(6),434 – 438.

[21] Muthulakshmi A, ME (SE), and Dr.S.Baghavathi Priya (2015). A survey on weather forecasting to predict rainfall using big data analytics. *IJISET - International Journal of Innovative Science, Engineering & Technology*, 2(10), 201-210.

[22] Dawson, Christian W., and Robert Wilby. (1998). An artificial neural network approach to rainfall-runoff modelling. *Hydrological Sciences Journal*, *43*(1), 47-66.

[23] S. Lee, S. Cho & P.M. Wong (1998). Rainfall prediction using artificial neural networks. *J. Geog. Inf. Decision Anal*, 2(3), 233–242.

[24] Guhathakurta, P., Rajeevan, M., & Thapliyal, V. (1999). Long range forecasting Indian summer monsoon rainfallby a hybrid principal component neural network model. *Meteorology and atmospheric physics*, 71(3-4), 255-266.

[25] Afshin Sarah, Fahmi Hedayat, Alizadeh Amin, Sedghi Hussein, and Kaveh Fereidoon(2011). Long term rainfall forecasting by the integrated artificial neural network-fuzzy logic-wavelet model in Karoon basin. *Scientific Research and Essays*, 6(6), 1200-1208.

[26] C.L. Wu, K.W. Chau (2013). Prediction of rainfall time series using a modular soft computing method. *Engineering Application of Artificial Intelligence* 26(3), 997- 1007.

[27] Rohit R. Deshpande (2012). On the Rainfall Time Series Prediction Using MultilayerPerceptron Artificial Neural Network. *IJETAE*, *2*(1), 2250-2459.

[28] Paras, Sanjay Mathur, Avinash Kumar, and Mahesh Chandra (2007). A feature-basedon weather prediction using ANN. *World Academy of Science, Engineering, and Technology* 34, 700-705.

[29] S Chattopadhyay (2007). Feed Forward Artificial Neural Network model to predict the average summer monsoon rainfall in India. *Acta Geophysica* 55 (3), 369-382.

[30] Dr. S. Santosh Baboo and I. Khadar Shareef (2010). An efficient Weather ForecastingModel using Artificial Neural Network. *International Journal of Environmental Science and Development*, 1(4), 321.

[31] M. M. Ali, P. S. V. Jagadeesh, I.-I. Lin, and Je-Yuan Hsu (2012). A Neural Network Approach to Estimate Tropical Cyclone Heat Potential in the Indian Ocean. *IEEE Geosciences and Remote Sensing Letters*, *9*(6), 1114-1117.

[32] Diganta Kumar Sarma, Mahen Konwar, Jyotirmoy Das, Srimanta Pal, and Sanjay Sharma (2005). A Soft Computing Approach for Rainfall Retrieval from the TRMM Microwave Imager. *IEEE Transactions on Geosciences and Remote Sensing*, *43*(12), 2879-2885.

[33] Sutapa Chaudhuri, Surajit Chattopadhyay (2015). Neuro- computing-based short- range prediction of some meteorological parameters during the pre-monsoon season. *Springer-Verlag, Journal of Soft Computing*, *9*(5), 349-354.

[34] F. Mekanik and M. A. Imteaz (2012). A Multivariate Artificial Neural Network Approach for Rainfall Forecasting: Case Study of Victoria. *Australia, Proceedings of the World Congress on Engineering and Computer Science*, 1, 557-561.

[35] Kin C. Luk, J. E. Ball, and A. Sharma (2001). An Application of Artificial Neural Networks for Rainfall Forecasting. *Mathematical and Computer Modeling*, *33*(6-7), 683- 693.

[36] A. C. Subhajini and V. Joseph Raj (2010). Computational Analysis of Optical Neural Network Models to Weather Forecasting. *International Journal of Computer Science IssueISSN*, *7*(5), 327.

[37] Mohsen Hayati and Zahra Mohebi (2007). Temperature Forecasting Based on Neural Network Approach. *World Applied Sciences Journal*, *2*(6), 613-620.

[38] Amanpreet Kaur, Harpreet Singh (2011). Artificial Neural Networks in Forecasting Minimum Temperature. *International Journal of Electronics and Communication Technology*, *2*(3), 101-105.

[39] Deepak Ranjan Nayak, Amitav Mahapatra, Pranati Mishra (2013). A Survey on Rainfall Prediction using Artificial Neural Network. *International Journal of Computer Applications*, *72*(16), 546-552.

[40] Enireddy.Vamsidhar, K.V.S.R.P.Varma P.Sankara Rao, Ravikanth satapati (2010). Prediction of Rainfall Using Backpropagation Neural Network Model. *International Journal on Computer Science and Engineering*, *2*(4), 1119-1121.