



# BPN Based Rainfall Forecasting: A Review

Biju M J<sup>1</sup>, Aneesha N<sup>2</sup>

1. Head Of Section Department of Computer Engineering, GWPC Thrissur, Kerala, India.
2. Lecturer, Department of Computer Engineering, GWPC Thrissur, Kerala, India.

**Abstract:** Rainfall is a natural climatic phenomenon. Since the economy of India is highly dependent on agriculture, accuracy of rainfall forecasting is important. Accurate rainfall information is critical for the planning and management of water resources. Fluctuation in rainfall timing makes the rainfall prediction a challenging task. Climate and rainfall are highly nonlinear and complicated process. They required advanced computer modelling and simulation for their accurate prediction. ANN can be used to predict the behaviour of such nonlinear systems. Back propagation networks (BPN) are one of the most popular and effective model for complex and multi layered networks. This paper aims to provide a review of some methodologists employed by researchers to utilize Back Propagation based ANN for rainfall prediction.

**Keywords:** forecasting, simulation, ANN, BPN, multilayered network.

## I. INTRODUCTION

Rain is one of nature's greatest gifts and in countries like India, the entire agriculture depends upon rain. Rainfall prediction is important and demand full. It will help to avoid flood and which saves lives and human properties. Accurate information on rainfall is essential for the planning and management of water resources. Two techniques for rainfall forecasting are the numerical and statistical methods. The dynamic models are based on the system of nonlinear operator equations governing the atmospheric system. The chaotic behaviour of the nonlinear equations are sensitive to the initial conditions which makes it more difficult to solve these equations. Hence these systems give poor results for long range predictions of monsoon rainfall. In statistical methods, rainfall time series are treated as stochastic. It is commonly used for monsoon rainfall. But this model is not useful to study the nonlinear relationship rainfall and its predictions. The Neural Network (NN) technique is able to get rid of drawbacks of statistical methods. Elsner et al. [1] have shown that NN can be used to predict the chaotic series. NN technique is useful for both statistic and deterministic forecast methods. In deterministic forecast methods, rainfall time series is treated as deterministic and even chaotic. It uses rainfall data of past years to forecast future rainfall. The paper has been constructed with the sections. Section II discussed the concept of Artificial neural network and Different methodologies used by researchers to predict rainfall. Section III discusses the literature survey of rainfall prediction based on Back Propagation Network all over India. At last a conclusion is discussed in the section IV.

## II. ARTIFICIAL NEURAL NETWORK (ANN)

Human brain is a highly complex, nonlinear information processing system. Neural networks are simplified models of biological neuron system. NN is a network of simple elements called neurons which receives input, change their internal state according to input and activation function and producing output depending on input and activation function. ANN is an information processing paradigm that is inspired by the way the biological nervous system process information. The fundamental or key processing element of an ANN is an artificial neuron. Like biological neuron, it can receive inputs, process them and produce the relevant output. An artificial neuron is a device with many inputs and one output. A simple mathematical model in fig.1 can be used to explain neurons quantitatively [2]. Three basic elements of the neuronal model are a set of synapses or connecting links, an adder and an activation function. The weight of an input is a number which when multiplied with input gives weighted input. these weighted inputs are then added together and if they exceed a pre-set threshold value, the neuron fires. In any other cases, the neuron does not fire. The net input at the summing junction can be written as

$$U_k = \sum_{j=0}^n w_{kj} x_j \quad \text{and} \quad b_k = u_k + v_k$$

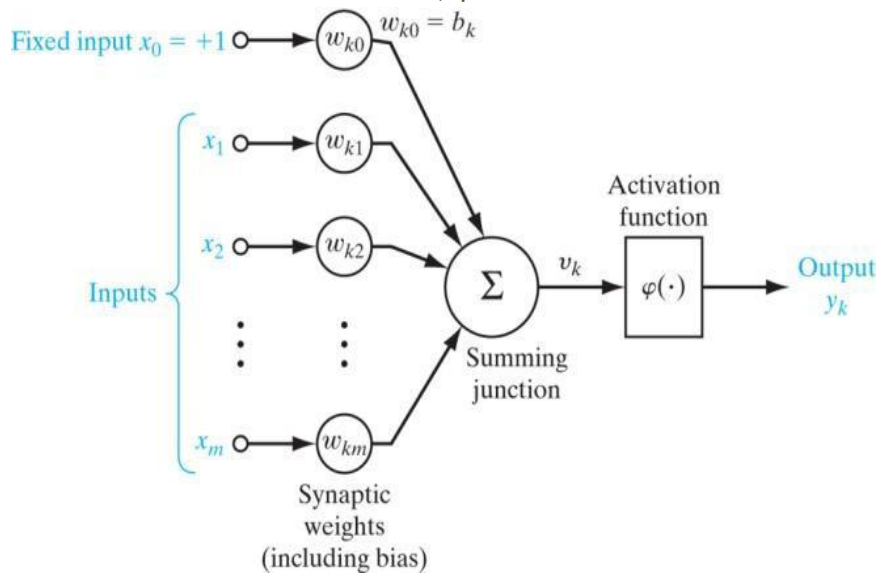


Fig.1. Nonlinear model of a neuron

where  $b_k$  is an externally applied bias. The net input is then applied to an activation function whose main objective is to limit the amplitude of neuron to some finite value and helps in achieving exact output. Therefore output of the  $k$ th neuron is

$$y_k = \phi(u_k + b_k)$$

A network of neuron is formed when a neuron is linked with others via synapses which can be single or multi layered. A multi layered ANN contains one input layer, one output layer and one or more hidden layer of neurons.

When a network had constructed for a specific application, inputs and the corresponding targets are used to train a network until it learns to associate a particular input with a reasonable output. A network is trained until the change in weight in a training cycle reaches a minimum value. After the network is properly trained, it has to be tested for its ability to produce accurate output. A neural network's knowledge is stored with in inter neuron connection strength known as synaptic weights. In multi layered networks, multiple nodes in each layer is capable of memorising data due to the vast number of synaptic weights available. ANN has the capability to extract the relationship between input and output of a process without the Physics being explicitly provided. Thus the properties of ANN are well suited to the problems of weather forecasting especially rainfall forecasting. The following are the common types of neural networks used for rainfall prediction.

#### A. Back Propagation Network (BPN)

BPN is still the most popular and most effective model for complex, multi-layered networks[3]. Back Propagation algorithm is a supervised learning method. This learning algorithm is applied to multilayer feed forward network. The network associated with back propagation learning algorithm is BPN. A typical BPN consists of an input layer, an output layer and at least one hidden layer. Number of neurons at each layer and number of hidden layers determine the network's ability on predicting accurate output for a given data set. Back propagation algorithm consists of two passes through different layers of the network: a forward pass and a backward pass.

#### B. Radial Basis Function Network(RBFN)

RBFN is a feed forward neural network and has both supervised and unsupervised phases. RBFN uses radial basis function as activation function. These network has three layers: an input layer, a hidden layer with a nonlinear RBF activation function and a linear output layer[4][5]. Hidden units are known as radial centres and are represented by the vectors  $c_1, c_2, \dots, c_n$ . Transformation from input space to hidden unit space is nonlinear and that from hidden space to output space is linear. Each hidden unit has its own receptive field in input space. An input vector  $x_i$  which lies in the receptive field for centre  $g$  would activate  $c_j$  and by proper choice of weight the target output is obtained.

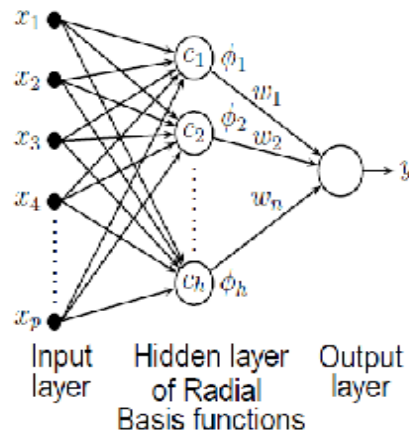


Fig. 2. Radial Basis Function Network

### C. Support Vector Machines (SVM)

SVM is a supervised learning method. It is a multilayer feed forward network. It can be used for pattern classification and nonlinear regression. Kernel methods are a set of algorithms which includes sum for classification and regression. Very few researchers used this technique for rainfall prediction. SVM is found to be a significant technique to solve many classification problems in the last couple of years. Very few researchers of this field used this technique for rainfall prediction and got satisfactory results [2].

### D. Self-Organising Map (SOM)

SOM is one of the most popular neural network models. It is a competitive learning network. It is based on unsupervised learning which means that no interventions are needed during learning and it can be used to detect features inherent to the problem and thus it is also called Self Organising Feature Map (SOFM) [7], [8]. SOM consists of components called nodes or neurons. Associated with each node is a weight vector of the same dimensions as the input data vector and a position in map space. The usual arrangements of nodes are a 2D regular spacing in a hexagonal or rectangular grid. The output neurons of the network compete among themselves to be activated or fired; with the result that only one output neuron is on at any time. This neuron is the winning neuron. The weight vector associated with winning neurons is updated only on the basis of winner-takes-all. Researchers have applied different networks for prediction of rainfalls for various regions. There is no general agreement in applying particular networks for rainfall prediction for a region. The significance of the Back Propagation algorithm is that it can minimize the error in the network by adjusting the weights through which the neurons are connected to each other.

## III. RAINFALL PREDICTION METHODS BASED ON BPN

Guhathakurtha developed an ANN model for long range monsoon rainfall prediction for the districts and subdivisions of Kerala based on the area weighted value of all district forecasts [6]. They used a feed forward neural network with Back Propagation learning algorithm. They used a three layer network with one input layer, one hidden layer and one output layer to develop the model. The hidden layer contained three neurons and the sigmoidal function is used as the transfer function. Training of the network is continued till the mean square error becomes less than a pre-assigned value.

Fourteen separate deterministic neural network models were developed for each of the 14 districts of Kerala. Performance of all these models is exceptionally good for all years up to 2003. They found that deterministic neural network models perform well for smaller spatial scales i.e. district monsoon rainfall forecasts.

Prashanth Goswami and Srividya presented a work to describe the construction and performance of a novel generalised neural network which provides a long range prediction of annual rainfall [9]. The training algorithm used is a straight forward extension of the back propagation algorithm. The major idea was the introduction of a structured neuron in place of a conventional point neuron and the resultant composite network is much more efficient than a conventional neural network.

Composite neuron networks (CN) are structurally strong and their performance does not critically depend on parameters of the transfer function. CN can predict the direction of departure from the mean accurately and consistently for long periods, making them potentially useful tools for designing long term policy for crisis preparedness.



Surajit Chattopadhyay developed a ANN model to predict the average rain fall over India during summer monsoon. [10] ANN based predictive model is developed using back propagation learning through the method of conjugate gradient descent. ie. The weight adjustment is proportional to the gradient of the error with respect to the weight of ANN. With conjugate gradient descent , back propagation algorithm yielded a high monsoon rainfall prediction. Here the activation function used is sigmoid function.

A R Naick and S K Pathan proposed a model for rainfall classification and prediction using an ANN [11]. This model proposed a new neural modified back propagation algorithm which is more robust than that of a simple back propagation algorithm. The proposed network consists of three layers and each layer has several processing elements called neurons. Activation function used is sigmoid. The learning methodology used is supervisory. Input data was collected using wireless sensors or any meteorological sites and normalised. This normalised data is given as input to the network.

Priya et al. proposed a model to evaluate the applicability of ANN for the prediction of Indian rainfall. Here the normalised input data is trained using back propagation algorithm [12] . Their proposed model is three layer ANN back propagation learning. Model contains one neuron for input and on neuron for output and four neurons for hidden layer with a learning rate of 0.2. rain fall prediction is made on the basis of previous data. The criteria for the prediction in the model are correlation, RMSE and standard deviation.

Vamsidhar et al presented a back propagation neural network model for predicting the rainfall based on humidity, dew point and pressure in the country [13]. Here a three layer feed forward NN architecture was created by initializing the weight of NN by random values. The presented back propagation neural network established an accuracy of 99.79% All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

#### IV. CONCLUSION

ANN has been successfully used by most of the researchers in this field for the last twenty-five years. Back propagation, is a common method of teaching artificial neural networks how to perform a given task. It is a supervised learning method, and is an implementation of the Delta rule. The significance of Back Propagation algorithm is that it can minimise the error in network by adjusting the weight through which the neurons are connected to each other. This paper reports a survey on rainfall predictions using BPN based neural network architectures. From the survey it has been found that most of the researchers used back propagation network for rainfall prediction and got significant results. The main advantage of the BPN neural network method is that it can fairly approximate a large class of functions.

#### ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to Smt. A S Chandrakanta, The Head of the Institution, for providing the necessary motivation and guidance for the completion of this paper. Also would like to thank their colleagues, family members and the anonymous reviewers and editors for their helpful comments, suggestions and constructive criticism, which will help to improve the presentation of the paper.

#### REFERENCES

- [1] Elsner, J. B. and Tsonis, A. A., Bull. Am. Meteorol. Soc., 73, 49–60, 1.992..
- [2] Deepak Ranjan Nayak, Amitav Mahapatra and Pranati Mishra, A Survey on Rainfall Prediction using Artificial Neural Network, International Journal of Computer Applications (0975 – 8887) Volume 72– No.16, June 2013.
- [3] Simon Haykin, neural Network : A comprehensive Foundation, 2<sup>nd</sup> edition.
- [4] M. J. D. Powell, Radial basis functions for multivariable interpolation: a review. In J.C. Mason, and M.G. Cox (Eds.), Algorithms for Approximation, pp. 143-167, 1987.
- [5] J Park, and I Sandberg, Universal approximation using radial basis function networks. Neural Computation, 3 (2), 246-257, 1991.
- [6] P. Guhathakurta, Long-Range Monsoon Rainfall Prediction of 2005 for the Districts and Sub-Division Kerala with Artificial Neural Network , Current Science, 90 (6), pp-773-779., 2006.
- [7] T. Kohonen, The self organizing Map, Proceedings of IEEE, 78(9), 1464-1478 ,1990.
- [8] W. Patterson Dan, Artificial Neural Networks: Theory and Applications, Prentice Hall, 1996.
- [9] Prasanth Goswami and Srividya, A novel neural network design for long range prediction of rainfall pattern, current science vol 70 ,No 6, 1996.
- [10] Surajit Chattopadhyay, Anticipation of summer monsoon rainfall over India by Artificial Neural Network with Conjugate Gradient Descent Learning, . Subject Classifications: 82C32, 37M10, 2000.
- [11] A R Naick and S K pathan M Indian Monsoon Rainfall Classification And Prediction Using Robust Back Propagation Artificial Neural Network, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 11, November 2013.
- [12] Priya, Shilpi, Vashistha, Vinay Singh Time Series Analysis of Forecasting Indian Rainfall , International Journal of Innovations & Advancement in Computer Science IJIACS ISSN 2347 – 8616 Volume 3, Issue 1 .2014.



- [13] Vamsidhar K.V.S.R.P.Varma P.Sankara Rao Ravikanth satapati, Prediction of Rainfall using Backpropgion Neurl Network International Journal on Computer Science and Engineering Vol. 02, No. 04, 2010.

#### BIOGRAPHY



**Mr. Biju M J**, is now working as HOD in Govt Women's Polytechnic College, Nedupuzha. He secured B.Tech in Computer Science & Engineering from Govt Engg College Thrissur in 2003. He secured his M.Tech in Information Technology from MS University, Tirunelveli in 2012. His area of project was "**Segment based binary coding character recognition algorithm for Indian number plates**". He is empowered with CMI Level 5 certification by Chartered Management Institute, UK. He was honoured with best polytechnic teacher of Kerala State during 2016 by Indian Society for Technical Education (ISTE). He worked as Demonstrator, Lecturer and HOD in Various Govt Polytechnic Colleges in Kerala during 1997-2017. He had handled the subjects such as System Programming, Programming Languages, and Operating Systems. His area of interest is Image Processing.



**Mrs. Aneesha N**, Now Lecturer in Govt Women's Polytechnic college, Nedupuzha. She completed BTech in Computer Science & Engineering from College of Engineering Thalassery in 2005. She completed her M.Tech in Computer Science & Engineering from MES college of Engineering. From 2012-2015 she worked as a Lecturer in UKF college of Engineering and Technology. She handled the subject areas such as compilers, System Programming. Her area of interest is Code Optimisation in Compilers.