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Survey of Neural Network Models and Algorithms Used For Rainfall Forecasting

P. Dhandapani[1], Dr. T. Anuradha[2]
[1]*Assoc. Professor S.V. College of Computer Sciences, R.V.S Nagar, Tirupati Road, Chittoor (A.P).*
[2]*Assoc. Professor, Dept. of Computer Sciences, Dravidian University, Kuppam (A.P).*

ABSTRACT
Rainfall forecasting takes an important role in India not only for agriculture but also for minimising damages from floods, to reduce water scarcity and for efficient water resource management.There are various machine learning techniques used for Rainfall Forecasting. Among these techniques, Artificial Neural Networks (ANN) is the most widely used Machine Learning Technique for Rainfall Forecasting. Purpose of this paper is to identify and analyse the trends of Neural Network Techniques in Rainfall Forecasting.
Keywords: Rainfall, Forecasting, Machine Learning Techniques, Artificial Neural Networks (ANN)

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I. INTRODUCTION

Rainfall Forecasting plays an important role in crop production, Water Resource Management and in prior detection of floods. The variations in timing and quantity of rainfall have the potential impact on the agriculture and human life. Early prediction of rainfall helps human beings to protect from disaster, to make effective utilisation of water and make farmers to minimise crop damages. Hence, there is a need for effective technique for Rainfall Forecasting.Artificial Neural Networks became as one of the choices for making such type of processing.

Neural Networks are being applied to an increasing large number of real-world problems. Their primary advantage is that they can solve problems that are too complex for conventional techniques i.e., problems that do not have an algorithmic solution or for which an algorithmic solution is too complex to be defined. In algorithmic solution, the computer follows a set of instructions to solve a problem unless the specific steps that the computer needs to follow areknown the computer can't solve the problems. That restricts the problem solving capability of conventional programs, which can be solved by the data. By considering the successful applicability of Neural Networks in many areas, an endeavour to assess their performance for dataretrieval forms the basis for this research work.

Present paper is divided into four sections. Section two describes Rainfall Forecasting and its importance, in section three, about Artificial Neural Networks are discussed. Section four describe the various research work carried out on Rainfall Forecasting using Artificial Neural Networks and finally conclusions are given in section five.

II. RAINFALL FORECASTING

Rainfall is the crucial source of water supply necessary for agriculture, industry and households in the country.Agriculture is the backbone of India and is having the major GDP contribution towards the Indian economy. India gets around 70% of its annual rainfall during the monsoon season. Around50% of India's total food output comes in the form of kharif crops. A seasonal rainfall may help in crop production and water resource management. There could be unseasonal rainfall which may cause for crop damages and damages from flood. India is now experiencing the tail end of a monsoon that has seen both severe water scarcity and massive floods. While the fluctuation in rainfall brought on by climate change has been an issue for some years now.

The Indian Meteorological Department (IMD) is an agency of the Ministry of Earth Sciences of theGovernment of India. It is the principal agency responsible for meteorological observations, weather forecasting and seismology. IMD is headquartered in Delhi and operates in hundreds of observation stations across India. Its regional offices are at Pune, Chennai, Guwahati, Kolkata, Mumbai, Nagpur and New Delhi. Though IMD predicts the rainfall using statistical approach it does not give more accurate results.

Therefore, there is a need for advanced rainfall prediction system that helps human beings to improve crop production, to effective utilisation

of water and to protect from disasters, and farmers to minimise from crop damages.

III. ARTIFICIAL NEURAL NETWORKS

Artificial Neural Network is an information processing paradigm that is inspired by the biological nervous system. An Artificial Neural Network consists of artificial neurons or processing elements and is organised in three interconnected layers: Input player, hidden layerand output layer.The input layer contains input neurons that send information to the hidden layer. The hidden layer sends data to the output layer. Every neuron has waited inputs, an activation function (defines the output given an input) and one output.

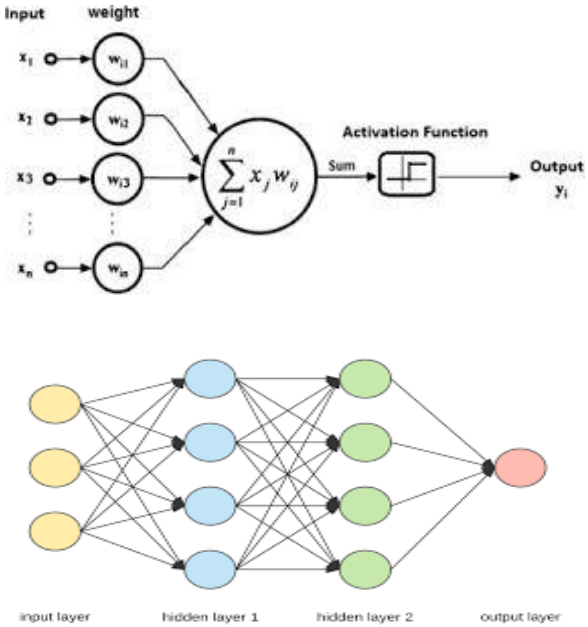

Fig: 1 Model of Artificial Neural Network

Artificial Neural Networks allow the systems to recognise the input patterns by learning from past experiences or examples. Moreover ANNs does not require separate memory locations to store the outcome data with its associated probabilities. Neural Networks are used for solving different types of problems in many areas including Agriculture, Finance, Medical, in Geographical information etc. The major tasks of Artificial Neural Networks are Function Approximation, Classification, Clustering, Decision Support Systems etc.

History: *Mc-Culloch-Pitts* (1943) proposed a model of computing elements called Mc-Culloch—Pits neuron,which performs waited sum of inputs to these elements followed by a threshold logic operation. Combinations of these computing elements are used to realize several logical computations. The main drawback of this model of computation is that the weights are fixed and hence the models could not learn from examples, which is the main characteristic of the ANN technique evolved later. *Hebb (1949)* proposed a learning scheme for adjusting a connection weight based on preand post synaptic values of the variables. Hebb's law became a fundamental learning rule in neuron–network literature. *Rosenblatt (1958)* proposed the perceptron models, which has weight adjustable by the Perceptron Laws. *Widrow and Hoff (1960)* and their group proposed an *ADALINE* (*Adaptive Linear Element*) model for computingElements and LMS (*Least Mean Square*) learning algorithm to adjust the weights of ADALINE model. *Hopfield* (1982) gave energy analysis of *Feedback Neural Networks*. The analysis showed the existence of stable equilibrium states in a Feedback Network, the provided network has symmetrical weights. *Rumelhart el at* (1986) showed that it is possible to adjust weight of a *Multi-Layer FeedForward Neural Network* in a systematic way to learn the implicit mapping in the set of input–output pattern pairs.The learning law is called *Generalised Delta*rule or *Error Backpropagation*.

Activation(Transfer) Functions: To acquire a stable and robust output from an ANN within input-output span, an activation or transfer function is used. The net input y_{in} ($\sum x_i w_i b + \sum x_i w_i$ in case of bias) is further processed through this activation or transfer function. The most commonly used activation or transfer functions are (a) *Binary Step Function* (b) *Bipolar Step Function* (c) *Binary Sigmoid Function* (d) *Bipolar Sigmoid Function* (e) *Ramp Function*.

***Learning Laws(Rules)*:**The internal process that carried out for weight modification during the training process is called as Learning. Learning Laws are the rules that are applied to modify the weights. Some of the most commonly applied learning rules are: *HebbianLearning Rule,Perceptron Learning Rule, Delta Learning Rule, Competitive Learning Rule, OutstarLearning Rule, BoltzmanLearning Rule*, etc.

Supervised and Unsupervised Training: The method of setting the value for the weight enables the process of training or learning.The process of modifying the weights in the connections between the network layers with the objective of achieving the expected output is called as *training a network*. The internal process that takes place, when a network is trained is called as *learning*. The most commonly used training processes are (a) Supervised Training and (b) Unsupervised Training.

Supervised Training requires a pair of training data i.e., Input and target data set. The provided output is referred to as target data. In this training process, internal connections such as neuron weights and bias are adjusted based on the results of the comparison between target and output values from ANN to generate a response close to the target value. This method is known as effective and commonly used training method. Some of the supervised training includes Hebb net, Pattern Association Memory net,Back propagation net, Counter Propagation net, etc.

In contrast to the supervised training, *unsupervised training* requires only input data (without target) as training data.This process uses the previously generated output data as new input data and modifies the neuron weights until ANN produces consistent output. Some of the unsupervised training networks are Feedback nets, Binary Adaptive Resonance Theory (ART1), Analog Adaptive Resonance Theory (ART2, ART2A),Discrete Hopfield (DH), Continuous Hopfield (CH), Discrete Bi-directional Associative Memory (BAM), etc.

IV. RELATED WORK

Many researchers developed and implemented the different types of models and algorithms for rainfall forecasting using Artificial Neural Network. Some of these are discussed in this paper.

Kumar Abhishek, Abhay Kumar, Rajiv Ranjan, Sarthak Kumar [1],In their study they analysed the possibility of predicting average rainfall over Udupi district of Karnataka using Artificial Neural Network. In their study they used MultilayeredNeural Network model with Backpropagation algorithm to predict the average rainfall. They used Neural Network tool (NNTool) to implement and to test the accuracy of the results. In their paper they presented the accuracy of the results in terms of graphs.

Deepti Gupta, UdayanGhose [2],In their paper a comparative study was made on classification algorithms for forecasting rainfall. They compare Classification and Regression Tree algorithm, NaiveBayes approach, K Nearest Neighbor algorithm and Pattern Recognition Neural Networks for rainfall forecasting. The weather factors like temperature, humidity, wind and pressure are used for rainfall forecasting. They use data set of 2245 samples to test these four techniques and recorded the accuracy percentage as 82.1% by Pattern Recognition Neural Networks, 80.7% by K Nearest Neighbor algorithm, 80.3% by Classification and Regression Tree (CART) and 78.9% by Naive Bayes algorithm. This paper shows that Pattern Recognition Neural Networks has given more accuracy than the other models.

Pallavi, Garima Singh [3],In their study they made a survey on different techniques and algorithms used for rainfall forecasting and presented in the paper. This paper showed the different types of Artificial Neural Networks models used for rainfall forecasting and the accuracy achieved when comparing to the other models.

TomoakiKashiwao, KoichiNakayama, ShinAndocKenjiIkeda, MoonyongLee, AlirezaBahadori [4],In their study they developed a local rainfall prediction system using Artificial Neural Networks to automatically obtain meteorological data from internet and to predict the rainfall automatically in Japan region. They used the data from Japan meteorological Agency (JMA) to test the rainfall prediction. In their study they used a Multilayer Perceptron(MLP) Neural Network with a hybrid algorithm composed of Back Propagation (BP) and Random Optimization (RO) methods, and Radial Basis Function Network (RBFN) with the Least Square Method (LSM) and compared the prediction performance of the two models. The experimental results showed that precipitation in Japan can be predicted by the proposed method, and that the prediction performance of the MLP model was superior to that of the RBFN model for the rainfall prediction problem.

Duong Tran Anh, ThanhDuc Dang and Song Pham Van [5]. In their study they predicted the monthly rainfall in Vietnam. They collected the data from Ca Mau Hydrological station. To predict monthly rainfall, they combined two pre-processing methods (Seasonal Decomposition and Discrete Wavelet Transform)and two feed-forward neural networks (Artificial Neural Network and Seasonal Artificial Neural Network). For accuracy they compared their results with traditional Genetic Algorithm and Simulated Annealing algorithm (GA-SA) supported by Autoregressive Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA). Their results showed that their anticipated methods gave more accuracy than the traditional methods.

V. CONCLUSION

Rainfall forecasting takes an important role in India not only for agriculture but also for minimising damages from floods, to reduce water scarcity and for efficient water resource management. Therefore, there is a need for efficient rainfall forecasting. Since Artificial Neural Network gives more accuracy when comparing to other models, the Multi-Layered Neural Network

Model with Back Propagation Algorithms is supposed for efficient Rainfall Forecasting.

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