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Survey on Rainfall Prediction using Artificial Neural Network

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Abstract: ***One of the most significant and difficult tasks in the modern world is rainfall forecasting. Generally speaking, climate and rainfall are extremely complex and non-linear phenomena those that demand sophisticated computer modelling and simulation for making an accurate forecast. Asynthetic neural network (ANN) can be used to forecast how such nonlinear systems will behave. Most of the industries have adopted ANN with success in this subject for the past 25 years as researchers. This paper offers a review of the literature on some study methods used by many scholars to use ANN for predicting rainfall. Additionally, the study notes that The ANN approach is more suitable for predicting rain than standard numerical and statistical techniques.***

Keywords: Rainfall forecasting, machine learning, Artificial Neural Network (ANN), Back Propagation Network (BPN), Numerical Weather Prediction(NWP) , Autoregression(AR) , Autoregression Moving average(ARMA)

I. INTRODUCTION

Rainfall forecasting aids in the management of water resources. Rainfall data from the previous year is useful. Farmers to better manage their crops, resulting in increased production the economy of the country Rainfall timing fluctuations and their effects. Rainfall forecasting is difficult due to the large amount of data available.All of the services supplied by the meteorological department are free of charge. For all countries, weather forecasting is at the top. Around the world the task is difficult since it necessitates. All specialist calls, as well as all other calls, are made without any interruptions certainty. The second section delves into the various rainfall approache. The main concerns in the Kedarnath. In the month of july and august there are occasional rains and the temperature drops till 12 degree celcius in Kedarnath. Due to heavy rainfall, landslides are common during this time. On the other hand, Kedarnath receives very high number of pilgrims from all around the world which makes it very hard to do darshan without avoiding long queues. As we all have know that between June 13 and 17 in the year of 2013, the state of Uttarakhand had received an unusual amount of rainfall. This constitute a serious issue that has led to the loss of human lives as well as economic loss in sectors such as tourism, agriculture, and communications infrastructure. Statistical approaches and the Numerical Weather Prediction (NWP) model are two extensively utilised methods for rainfall forecasting. Rainfall data is non-linear in nature. Frequency, The essential properties of time series are intensity and amount rainstorm. From one point of the earth to another, and from one time to another. a mixture of When AR(autoregression) and MA(moving average)are combined, they provide a useful and generic class of The ARMA model is a time series model. The ARMA model is aonly useful for predicting and stagnant time-series data. Rainfall is expected in the near future. The statistical approaches aren't as effective as they could beability to spot irregular trends and nonlinear patterns in dataseries of events.

II. CONCEPT OF ARTIFICIAL NEURAL NETWORK

Soft computing works with approximate models that yield results or answers that are approximations. Three fundamental parts make up soft computing: Artificial Neural Networks, Genetic algorithm, fuzzy logic, and network (ANN). ANN is routinely employed by scientists studying rainfall prediction. The human brain is a very complicated, parallel, nonlinear system. computer (information-processing system). Cognitive Networks are distilled representations of the biological neuron system. the neural A massively parallel distributed processor called a network consists of basic processing units, which naturally has a tendency towards preserving practical experience and making it usable [1]. An ANN's primary processing component is an synthetic neurons similar to the natural neuron found in the human brain It can take in inputs, process them, and output pertinent data.When neurons connect with one another via synapses, which can be single- or multi-layered, a network of neurons is created. An input layer of neurons makes up a multilayer ANN.A hidden layer of neurons, an output layer of neurons, and neurons.

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The concealed layer facilitates useful computations in between before sending the input to the final layer. Once a network had been created for a certain Using an application, inputs, and the related targets train a network until it understands how to link a specific input with a decent result. The optimal time to train a network is when A training cycle's minimum amount of weight change is achieved. value. It is necessary to assess the network's capacity to generate accurate outputs after it has been properly trained. Numerous nodes in each layer of large multi layered networks with multiple layers can due to the enormous amount of synaptic weights, memory accessible on a network like that. as a result, producing accurate results when it comes to input vectors used throughout the training process, not support a network's capacity to produce precise outputs.

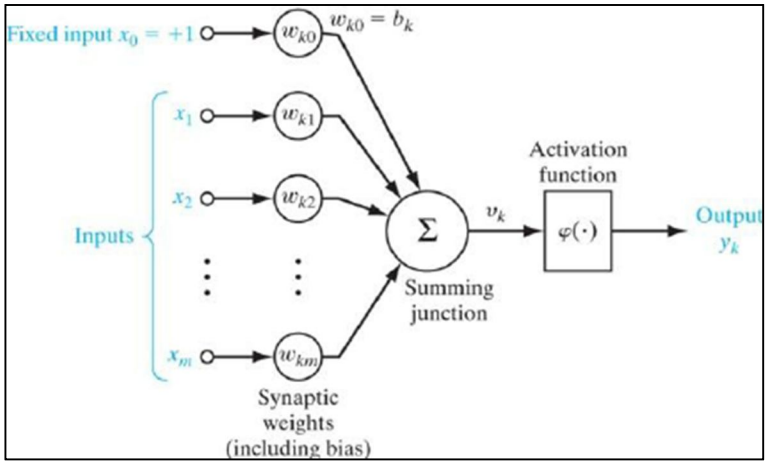

Fig 1: Nonlinear model of a neuron

The net input at the summing junction can be written as:

$$u_k = \sum_{j=1}^{m} w_{kj} x_j$$

and

$$v_k = u_k + b_k$$

The net input is then applied to an activation function, whose main objective is to limit the amplitude of the neuron to some finite value, and helps in achieving exact output. The output

III. METHODOLOGY

The followings are the common types of neural networks used by different researchers for rainfall predictions.

A. Back Propagation Network (BPN)

One of the most significant advancements in neural networks has been the back-propagation learning method[2]. This network is the most widely used and successful model for complicated networks with several layers. This algorithm for learning is utilised with respect to multilayer feed-forward networks made from of processing components that activate differently continuously functions. the back-propagation-related networks. Additionally known as back-propagation networks, learning algorithms (BPNs). It is a method of supervised learning. To a specific set of Using an input-output pair as a training set, this algorithm offers a method. for modifying the weights in a BPN to categorise the input given properly patterned. This algorithm's fundamental idea is that it comprises of two travels through the network's various layers: a front backward pass and a pass.Layer by layer, an input vector is applied to the network's sensory nodes, with subsequent effects propagating across the network. A collection of outputs generated as the network's actual reaction. The synaptic weights of the networks' forward passes all fixed, now. On the other hand, during the backward pass, the Each synaptic weight is altered in response to a mistake rule of rectification. Specifically, the way in which the the desired (target) response to the network is deducted from provide a signal for errors.

The term "error backpropagation" refers to the process by which an error signal is transmitted through the network backward, against the direction of synaptic connections. In order to make the synaptic weights more realistic, actual network responsiveness moves closer to the desired statistical analysis of the response [1] . There is often an input layer in a back-propagation network. a hidden layer, an output layer, and a layer. The quantity of the number of hidden levels and the neurons at each layer Identify the networks' propensity for giving correct results. for a certain set of data. the majority of researchers have used this network to forecast rain.

B. Support Vector Machine (SVM)

One of the significant subcategories of a multi-layer feed-forward network is the support vector machine. Similar to radial basis function networks and multi-layer perceptrons, support vector. Machines can be utilised for nonlinear pattern recognition and categorization regression. created by Support Vector Machines (SVMs).Vapnik and his coworkers have been utilised for learning as a result of I Better generalisation abilities than other NN models (ii) SVM's solution is distinct, ideal, and as it employs linearly constrained assumptions, local minima are missing. Application to nonvectorial data (Strings and Graphs) and (iv) Few parameters are two characteristics of the quadratic programming problem are essential for tweaking the learning m/c.

C. Radial Basis Function Networks (RBFN)

The nonlinear layered feed forward network category includes RBF Networks. The design of neural networks is seen through a different lens, one that treats it as a high-dimensional curve fitting problem space with dimensions. The covert units deliver a series of 'functions' that provide an unrestricted 'basis' for the inputwhen patterns (vectors) are enlarged to the hidden. These are referred to as radial-basis functions. The Three layers are necessary to build an RBF network. many roles: the input layer, the single concealed layer, include the output layer ([3], [4]). When an RBF network executes a complicated pattern categorization challenge, the issue was resolved by turning it become nonlinearly in high dimensional space Nonlinear layered feed forward networks include RBF networks and MLPs (Multi Layer Perceptrons). Both of them unbiased approximators. These two networks, however, are different between them. A single hidden layer exists in an RBF network. An MLP cannot have hidden layers, but can have one or more. The An RBF network's hidden layer is nonlinear, and the output layer is linear, but an output layer's hidden and the majority of MLPs are nonlinear [1]. Numerous academics have utilised this network for precise rainfall forecasting and received beneficial outcomes.

IV. LITERATURE SURVEY

Hu (1964) pioneered the use of ANN in weather prediction. For pattern classification, he employed an adaptive system with the name of Adaline. When this system is trained using 200 Sea level pressure during the winter and 24-hour pressure change patterns between 25 and 65 degrees north and 110 to 170 degrees west, was ability to predict if it will rain or not in San Francisco Bay area on 100 distinct situations that were favourably compared with the same official forecasts from the U.S. Weather Bureau periods. Following this investigation, he proposed that adaptive Systems are capable of producing accurate forecasts, meteorological conditions without a full knowledge of the dynamics[8]. A neural network to forecast average air temperatures was first presented by Cook and Wolfe in 1991. They achieved their goals by using the back-propagation learning technique, and the results were good[9]. A model of an artificial neural network has been created by To provide a 3–7-hour forecast of significant based lifted index and surface-based thunderstorms convergence of surface moisture. A pair of neural networks they produced were operationally merged at National Kansas City, Missouri's Severe Storms Forecast Center, to a single hourly product and was discovered to improve the aptitude for pattern recognition [10]. French et al. (1992) conducted significant research on using ANN for rainfall forecasting, using a neural network to anticipate two-dimensional rainfall. 1 hour prior to rain, rain. their current ANN model rainfall data produced by a mathematical simulation of rainfall a model's input data However, such work was constrained in a variety of factors. For instance, there was a compromise.The training period and the interaction, which could not be simple to balance. The quantity of secret layers and secret the number of nodes appeared insufficient in compared to input and output nodes, with the higher order reserved Relationship required for process abstraction to be effective. However, it has been recognised as the pioneering contribution to the application of ANN and launched a new movement in the comprehension and assessment of ANN's functions in complicated problem solving. processes in geophysics [11] . A feature-based neural network was proposed by Chen and Takagi in 1993.Network technique for predicting rainfall in the region of open water close to Japan's Shikoku. a neural network with four layers to intuitively understand the internal relationship GMS data from geostationary weather satellites and spread of rainfall intensity. Back was utilised by them. IR and training propagation learning algorithm provides the input data to the GMS image's viewable imagery internet [12].

Zhang and Scofield introduced an artificial neural network (ANN) method in 1994 for estimating strong convective rainfall and recognising cloud mergers from satellite data. They have created a specialist in artificial neural networks. System for Satellite-derived Rainfall Estimation (ANSER) in the Laboratory for Satellite Applications of the NOAA/NESDIS and discovered that employing group approaches for artificial neural networks, The following results are possible: automatic cloud recognition mergers, calculation of ten-fold rainfall amounts average errors of the predicted rainfall forecasts for the overall amount of precipitation will be less than 10 [13] Percent. In order to estimate missing rainfall data across Cyprus, Michaelides et al. (1995) compared the effectiveness of ANN with multiple linear regressions. They have suggested a method that can put forth to create a time series that is lengthy enough of rainfall data for those areas where the current When time series are either stopped (ahead extension) or the beginning of the archives is rather recent (backward extension). Artificial neural networks are used in the technique to estimate of daily precipitation at specific observation locations in Cyprus (referred to as the target stations) utilising daily rainfall as input observations from nearby stations with a strong enough long and comprehensive data archive (termed control stations). In this way, the method can be used to check for errors as well as to fill in missing data from the rainfall observation network. using the data from nearby stations' records to identify possible data. The use of neural networks in this method contrasts with the conventional method of multivariate linear regression. Here, the goal the dependent variable was station, and the As the independent variables, control stations [14]. ANN was used by Kalogirou et al. (1997) to recreate the rainfall in Cyprus across the time series. They fed people. utilising forward multilayer neural networks to estimate precipitation at a few Cyprus rainfall collection locations. An appropriate artificial neural network was trained using archived data gathered over a nine-year period and six control stations positioned around a target station. various neural networks Architectures and learning rates were examined with the goal of constructing a network that allows for the most accurate reconstruction of records of missing rainfall. Then they picked numerous concealed For this, a layer neural network design is used. This kind of architecture used to address issues with comparable requirements. The variables employed in training the were gathered at each control station from the network. That was the Julian time, height, and separation between the target and the control stations, as well as the rainfall. The rate of correlation the training data set was obtained was 0.933 Utilizing unknown data for the target station allowed for network verification. Data from that year were not used in this. of the practise set. The correlation value between the Case unknown was 0.961. The forecasting inaccuracy was minimal. to 17.1mm or less of precipitation, which is regarded as satisfactory [15]. Venkatesan et al. in another study.(1997) used an ANN to forecast the whole Indian Rainfall during the summer monsoon with various meteorological parameter inputs for models They employed multilayered feed forward neural networks that have been error-backpropagation (EBP) trained. Three network models that utilised 2, 3, and 10 different input parameters, respectively, are recognised as having a substantial impact on the Indian summer monsoon The ISMR for rainfall was built and optimised. Next they extensively compared their results to the statistical models. Network models' projections showed that they can be an effective method for predicting ISMR [16] .In order to predict rainfall, Lee et al. (1998) divided the available data into homogeneous subpopulations. They suggested a divide-and-conquer strategy in which the four sub-areas make up the entire region, and each is modelled utilising a different approach. They did so for two larger areas. have carried out using radial basis function (RBF) networks Rainfall forecast. They have two further smaller sub-areas. utilised a straightforward linear regression model to forecast the rain. They have then drawn comparisons between these two. approaches and discovered that RBF networks generated good results inferior predictions compared to the linear models .The authors thought their approach was appropriate for both long-term management of polluted sites and emergency situations. areas [17].Koizumi suggested a radar-based ANN model in 1999. combined with numerical data from weather stations and satellites Japanese Meteorological Agency-produced goods Asian Spectral Model (JMA) was used to train the model. 1 year of data. It was discovered that ANN skills were superior than the linear regression, the persistence forecast (after three hours), and predictions and precipitation prediction from a computer model. The ANN model was only trained using data from a single year, so There were few results. The author was adamant that the The neural network's efficiency would rise when There were more training data available. There were more training data available. It is yet unknown how much each predictor affected the forecast and how much new observations might have an impact on it [18].Toth et al. compared forecasts for short-term rainfall in 2000. models for forecasting floods in real time. Three were used. Auto-regressive moving averages for time series (ARMA), Forecasting using ANN and the k-nearest-neighbors (KNN) approach stormy weather causing heavy rainfall in the Sieve River basin, Italy, during with lead times ranging from 1 to 6 hours, from 1992 to 1996. The Results indicated that the ANN had the best performance in the an increase in the runoff forecasting's precision when the The rainy run-off was fed with inputs from the anticipated precipitation. model [19].Three ANNs that are suitable for predicting rainfall have been created and compared by Luk et al. (2001): the multilayer feed forward neural network (MLFN), the Elman partial recurrent neural network, and time delay neural network and neural network (Elman) (TDNN) [20] .

V. CONCLUSION

This research presents a thorough analysis of rainfall forecasts made over a period of 25 years using various neural network designs. According to the study, the majority of the For rainfall, researchers employed a back propagation network. prediction and obtained meaningful outcomes. The poll provides a result that the MLP-based forecasting algorithms, For predicting rainfall, BPN, RBFN, SOM, and SVM are appropriate. compared to other forecasting methods like statistics and numerical approaches. However, those have some limitations. ways have been discovered. The numerous citations that support of the various ANN research advancements presented with The study should be very beneficial to ANN researchers in order to correctly forecast future rains.

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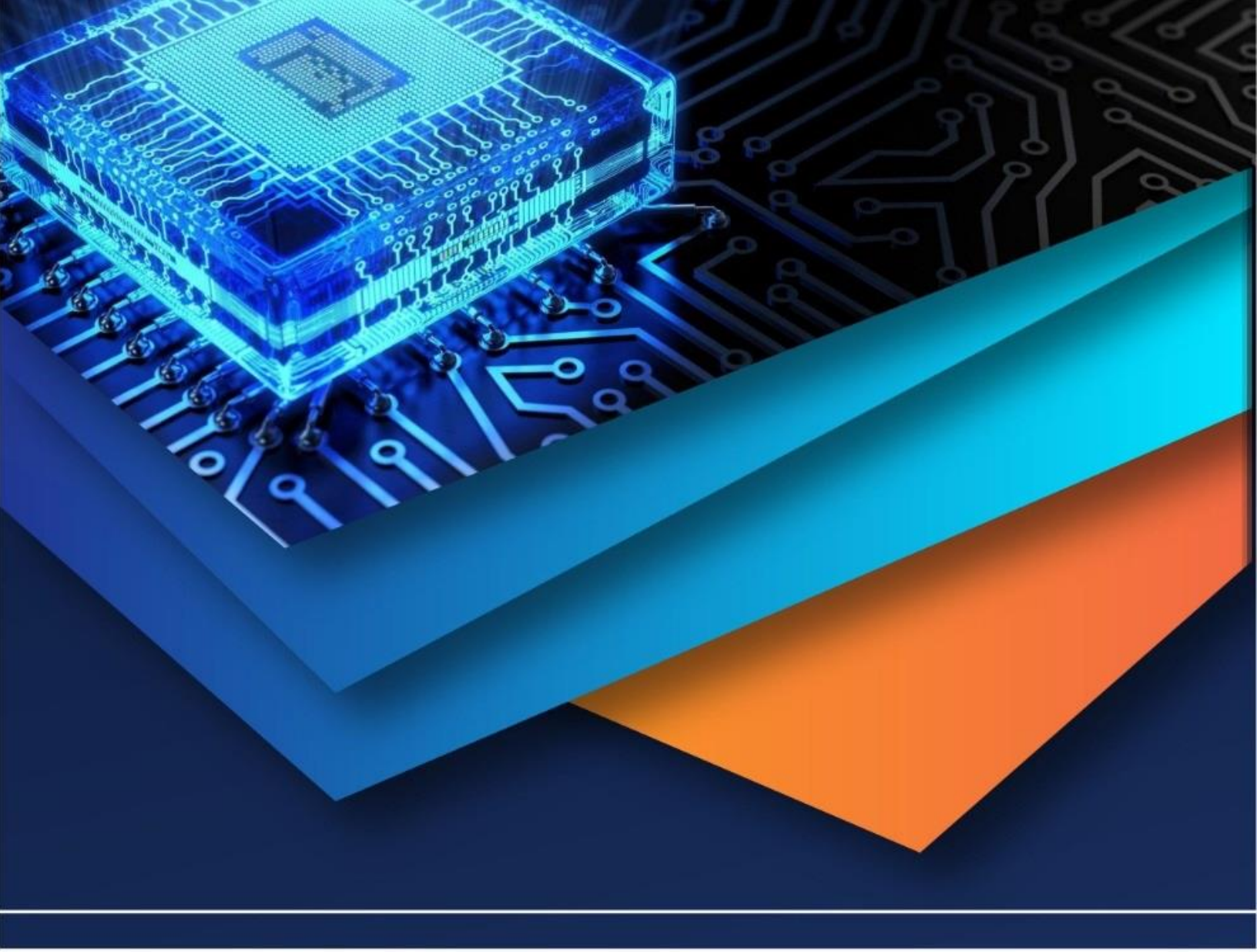

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