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A Relative Analysis of Modern ML Methods for Rainfall Prediction

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Abstract

The aim of this research is to deliver climatic insights to clients from various industries, like agriculturists, scholars, and others, so that they may grasp the motive of changes in the climatic and atmospheric features like precipitation, humidity and temperature. One of the most essential areas of meteorological science is estimating precipitation. A combination of factual processes and ML approaches can be utilized to forecast and evaluate meteorological data, including precipitation. These experiment can incorporate daily observations. In explained studies the accuracy of prediction model testing is checked through ground truth validation. These experiment also reveals that ARIMA and Neural Network work well for forecasting meteorological parameters and have the greatest performance when compared to other machine learning techniques for projecting downpour.

Keywords: *Rainfall prediction, Machine learning, SVM, ANN, ARIMA*

1. Introduction

Rainfall forecasting is helpful in preventing floods, that saves lives and property. In reality, it also helps in management of the water supply (Namitha *et al.*, 2015). Rainfall data from the past has aided farmers in better managing their crops, resulting in increased economic growth in the country. Rainfall prediction is difficult for meteorological scientists because of the variability in rainfall timing and volume. Precision rainfall forecasting has become one of the most pressing topics in hydrology, early warning of extreme weather can help to prevent natural disasters and cause damage if forecasts are made at quick moments and accurately (Shabib *et al.*, 2018). It is one of the most problematic tasks for academics in a variety of domains, with meteorological data mining, environmental ML, and others. Early warning, event frequency prediction for hydraulic design, and long-term projections for developing adaption strategies to future conditions all require daily and seasonal forecasts. Droughts and floods are often treated separately in all three forms of predictions—forecasts, frequency estimates, and projections—despite the fact that both types of extremes can be examined using similar methodologies and pose similar issues. There are two basic ways for forecasting rainfall in India. The most often used computational approaches for weather

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forecasting are Regression, Decision Tree, Fuzzy logic, and team data processing processes. The main goal is to gather intangible and sometimes expensive knowledge by following information rules and relationships. ANN are a potential element of this broad field (Zainudin *et al.*, 2016; Ridwan *et al.*, 2021; Grace and Suganya, 2020; Thirumalai *et al*., 2017; Venkata Ramana *et al*., 2013; and Sivapragasam *et al*.., 2001).

The paper is structured as follows: ML is defined and its relationship to AI are presented in the second section, along with descriptions of the most often used approaches. It gives a taxonomy of the various approaches to rainfall prediction that have been offered. The following part goes over the findings of the study in terms of the techniques utilized and their evaluation. It identifies the obstacles encountered and suggests ways to overcome them. The paper ends with the final conclusion. In Table 1, most of the existing literature is presented in the form of table with their summary of work and used tools and algorithms for different predictions and detections (Cramer *et al.*, 2015).

Table 1: Related Studies and Existing Models for Prediction of Rainfall

Authors	Year of Publication	Summary	Techniques / Tools
Namitha K *et al.*	2015	Introduce an approach to classification of large volume of weather dataset & ANN is used for evaluation of other days rainfall.	ANN (Artificial Neural Network)
Shabib Aftab *et al.*	2018	It explains about the use of different data mining technologies for prediction of rainfall.	Data mining technologies.
Suhaila Zainudin *et al.*	2016	Data mining methods used to compute prediction of rainfall.	Used various Data mining techniques.
Wanic M. Ridwan *et al.*	2021	This study explains about various machine learning models.	Used various Machine Learning (ML) models.
R. Kingsy Grace *et al.*	2020	Describes a tool using (MLR).	(MLR)
Chandrasegar Thirumalai *et al.*	2017	Discusses the rate of rainfall in previous years and predicts the rainfall in future.	Machine Learning techniques (linear regression method)
Dutta *et al.*	2014	weather forecasting is created by the appliance in technology & science. It is created for the aggregation of quantative information concerning present condition of the environment by the meteorological observation posts and interpreted by meteorologist.	Regression
Nkrintra Singhrattna *et al.*	2005	In the post-1980 period, the ENSO–Indian monsoon link has decreased significantly. They propose that this weakening could be caused by changes in ENSO features and global warming. As most of the Indian monsoon's predictors, this is having a significant impact on forecasting attempts.	Linear regression, Nonparametric regression, LOCFIT
M Kannan *et al.*	2010	Group data handling are the most extensively used empirical methodologies for climate prediction. The dynamical approach to forecasting uses physical methods rely on systems comparisons which evaluate the growth of the climatic system to respond to initiating aerial surroundings.	Regression
Aakash Parmar *et al.*	2017	Machine learning was used to anticipate the rainfall pattern. The ANN model has a strong ability to learn by adjusting these parameters to achieve the desired result. They indicated that tiny modifications in the no. of stripes and neurons in the input, beyond making any changes in the output parts, could be used to make the neural network generalize enough.	Back Propagation NN, Layer Recurrent Network, (SVM), (SOM) , Cascade Forward Back Propagation Network
David N. Yates *et al.*	2003	Downscaling procedures, which entail generating statistical connections between past meteorological data and output from regional and climate projections, are used to evaluate the expected consequences of climatic changes for IA analysis.	KNN
Antonio Sarasa-Cabezuelo	2022	Enormous number of variables on which they are reliant, writings on meteorological phenomena generate a enormous of data, making more hard to make forecasts about future events. Probabilistic models, which provide forecasts with a margin of uncertainty, are commonly utilized.	K NN Algorithm, Decision Random Forest Trees, Neural Networks
Hung *et al.*	2009	Predict the plans and manages the water resources, accurate rainfall data is critical.	ANN
Jyoti Upadhyay *et al.*	2012	Calculate the impact of climate variables and changes on Assam's rice productivities. Authors use time & series data from 1970-2010 for the various variables. Conclusion given by authors is that by increasing temperature yield of crop become less and if the temperature is positive productivity of crop become more.	ML

Table 1 (Cont.)

Utpal Misra *et al.*	2018	The prediction of merged rainfall is a recent trending in which precipitation is estimated using a mix of satellite, rain gauge, and NWP model rainfall. The underlying concern of each component's accuracy is currently being investigated. It's also worth noting that finer scales, the rainfall product beats model output.	NN
Venkata Ramana *et al.*	2013	Predict rainfall with the use of wavelet technique with ANN model on rainfall data of Darjeeling rain gauge. Analysis of paper tell that performance of WNN is higher than ANN.	The Wavelet & The ANN model
Nikhil Oswal	2019	Predict seeks to give ML life process, from data pre-processing to model implementation and evaluation. The data pre-processing process includes procedures such as missing value replacement, feature transformation, categorical feature encoding, feature scaling, and feature selection.	Accuracy, Precision, Recall
Sivapragasam Chandrasekaran *et al.*	2001	Purposed a technique on SSA with SVM on Singapore rainfall data. Authors compare results with non-linear prediction (NLP) method and conclude that purposed technique give higher accuracy than NLP.	(SSA) combined (SVM)
Sam Cramer *et al.*	2015	Predict rainfall with the use of Genetic Programming (GP). Authors also compare GP with MCRP amongst 21 data sets of cities in Europe. Paper concludes that GP method is better than MCRP method.	MCRP and GP method.
Minghui Qiu *et al.*	2017	predicted a short-term rainfall with the help of multiple neural network and deep learning techniques and paper conclude that proposed approach is better than other models.	Multitask convolutional neural network and deep learning techniques
Santosh Kumar Nanda *et al.*	2013	Uses ARIMA and different ANN models like MLP, FLANN and LPE to predict the rainfall prediction. series model.	ARIMA models and MLP, FLANN and LPE models.
Maya L. Pai *et al.*	2014	Purposed to predict Southwest Indian Monsoon rainfall using ANN with clustering approach. Author predicted the rainfall for 6 years and model was trained for 36 years,	ANN based on Clustering Approaches
Tomoaki Kashiwaoa *et al.*	2017	Used to develop an accurate prediction with the help of various ANN models like models like MLP and RBFN. Conclusion of this paper is that efficiency of the MLP model is good as compared to RBFN model for the prediction.	Different ANN models (RBFN) and (MLP) with a hybrid algorithm comprising of (BP) and (RO) approaches.
Kyaw Htike *et al.*	2010	Uses an approach of FTDNN) to generate rainfall forecasting models comprising different datasets. Each dataset used by authors contain 29 years data. Paper concludes: yearly rainfall dataset gives better & accuracy as compared to monthly, quarterly dataset.	FTDNN

From the above literature, various common challenges are identified to rainfall prediction. Furthermore, a discussion on potential approaches for tackling these challenges is taken place.

2. Methodology

The artificial intelligence-based methodology for the prediction of rainfall data is illustrated in Figure 1, which shows a step-by-step procedure for predicting rainfall. Because of the greater processing costs and memory requirements, high-dimensional data poses a challenge for classification systems. To correct this, dimensionality deducting techniques like feature reduction and feature selection were applied (Pai *et al.*, 2014).

Feature extraction and selection algorithms are used separately or in combination to increase performance, estimated accuracy, visualization, and information comprehension. The benefit of employing feature selection is that the significance of any small piece of information is not overlooked, however when evaluating a huge pool of data with many different features, certain features may be overlooked (Htike and Khalifa, 2010). The

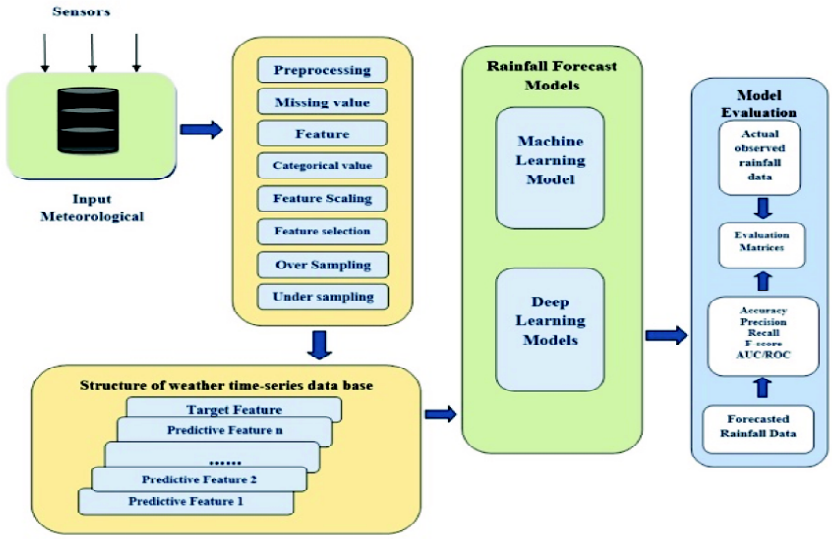

Figure 1: Basic Methodology Used for Rainfall Prediction Using ML and DL.

size of the feature in feature extraction. Choosing between these two techniques is based solely upon the type and domain of the specific task.

The final aim of the prediction models is to estimate the rainfall in future on test data. This can be possible by using simple steps as importing datasets, extracting independent and dependent variable, distributing dataset into training and testing set and feature sorting (Kashiwao *et al.*, 2017).

3. Artificial Intelligence, Machine Learning and Deep Learning for Rainfall Prediction

Classic definition of Artificial Intelligence (AI) is "weak." It becomes capable of recreating human behavior with awareness, sensitivity, and spirit as it becomes stronger. The advent of Machine Learning (ML) provided the means to take a step toward realizing this goal. It works on the premise of recreating a behavior using algorithms that are fed by enormous amounts of data. When confronted with a variety of scenarios, the algorithm learned whichever judgment to be made and builds a model. As a result, computer can automate operations

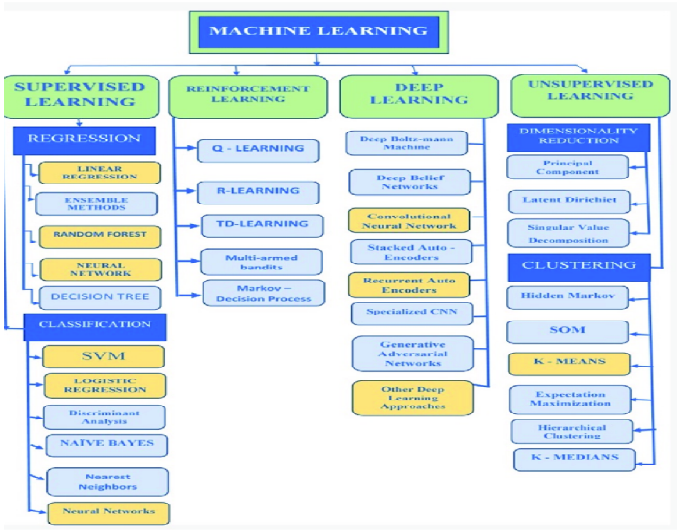

Figure 2: Classifications of Machine Learning Algorithms for Predicting and Analyzing Weather Data

based on the circumstances (Yates *et al.*, 2003; Sarasa-Cabezuelo, 2022; Hung *et al.*, 2009; and Upadhyay, 2012). The general way to do a Machine Learning need a training dataset, a test dataset, and an algorithm to propagate a predictive model as shown in Figure 2. In each category, there are different algorithms. There are various algorithms used for analyzing weather data for predicting rainfall, some of them are discussed as follows.

3.1. Random Forest

In the supervised learning technique, it is a common ML Algo. It used to tackle ML categorization and regression problems, ensemble learning is a method for tackling complicated issue and improving models by integrating multiple classifiers efficiency. "Random Forest is a classifier that consists of a number of decision trees on different subsets of a given dataset and takes the average to enhance the predicted accuracy of that dataset". The random forest predicts the end outcome vote of predictions by summing most projections from each tree, despite of trusting on a single decision tree (Dutta and Tahbilder, 2014). The functioning of the Random Forest algorithm can be understood in Figure 3 and using the following steps**"**.

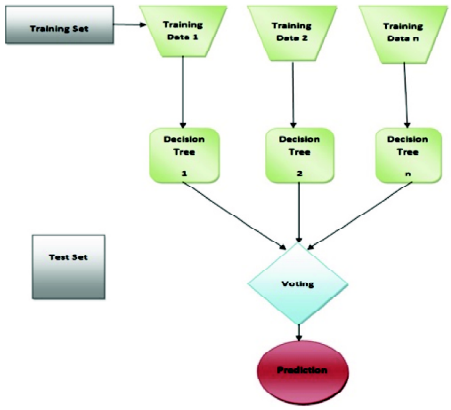

Figure 3: Illustration of Random Forest Algorithm

Step 1: Begin the collection of data from the acquired dataset.

Step 2: For each data collected, the algorithm will build a decision tree. The forecast result will then be obtained by any decision tree.

Step 3: Voting for predicted result will be held at this stage.

Step 4: As the forecast's final result, choose the outcome of the most popular prediction. Random Forest regression from sklearn is utilized for the training model.

3.2. Linear Regression Method

Linear regression can be treated as one of the most conventional machine learning technologies. In L R model, the dataset used as the input that is the pre-processing stage (Htike and Khalifa, 2010). The feature is taken by use of the LR Model as shown in Figure 4.

3.3. Artificial Neural Network

As shown in Figure 5, an ANN is defined by a neuron model: the NN's information processing unit, an architecture: a set of neurons, and linkages connecting neurons. Each link includes a weight, which is used to train the NN by altering the weights to accurately represent a specific learning task on the training samples.

(1) Back-Propagation Neural Network: The MLFF NN that makes up BPNN has one input layer, hidden layers, and one output layer. One hidden layer in a BPNN design. By modifying the weights after each iteration, the aim of BPNN is to reduce the estimated issue obtained from the discrepancy b/w both the computed output and desired of the neural network (Sivapragasam *et al.*, 2001; and Cramer *et al.*, 2015).

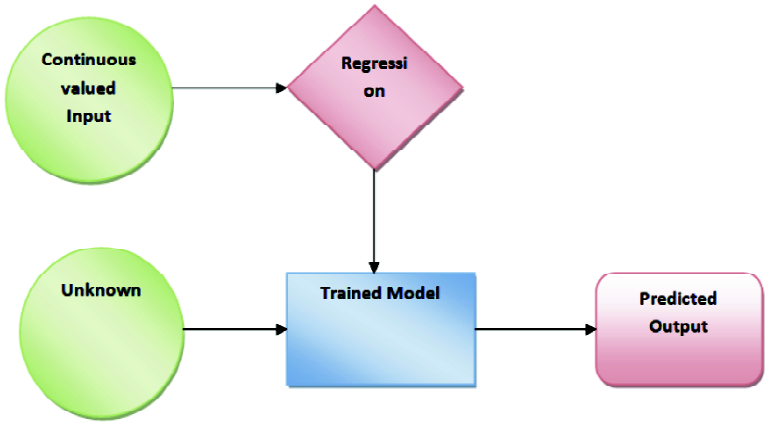

Figure 4: Simple Linear Regression Model

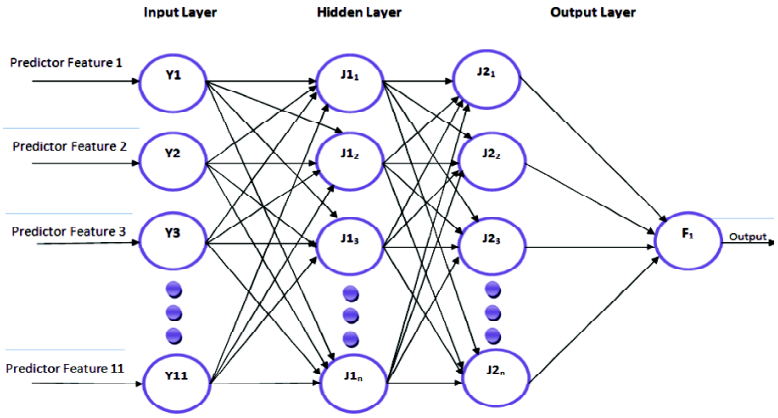

Figure 5: Basic Structure of ANN for Predicting Values

(2) Cascade Forward Back Propagation: CFBP is a type of ANN, used to predict the new output data. All the layers relate to its previous layer and input layers. Each layer in network is provided with different inputs (Pai *et al.*, 2014).

(3) Layer Recurrent Network: In layer recurrent network directed cycle is created by connecting between units. Opposite to feed-forward neural network, it uses internal to compute arbitrary sequence of inputs. They are feedback loop neural network. The processes in the layers that are hidden, and function outputs are delivered to network for input in next process (Kashiwao *et al.*, 2017).

3.4. Support Vector Machine

The SVM's aim is finding hyperplane in an N-dimensional plot it differentiates among dataset spikes as depicted in Figure 6. These various hyperplanes that to find to divide the two groups of data points. The aim is to find the plane with the largest margin, or distance across data picks from classes (Kashiwao *et al.*, 2017). Extending the path that provides reinforcement, making future data easier too.

3.5. ARIMA Model

It is used to analyse future output based on previous values. It is blend of three operators (Wu *et al.*, 2013), Auto regressive, moving average and integration as shown in Figure 7.

In this work, explanation of various common algorithms for rainfall prediction is identified. There can be various issues that can affect the solution of this problem. A limited data from meteorology department or any

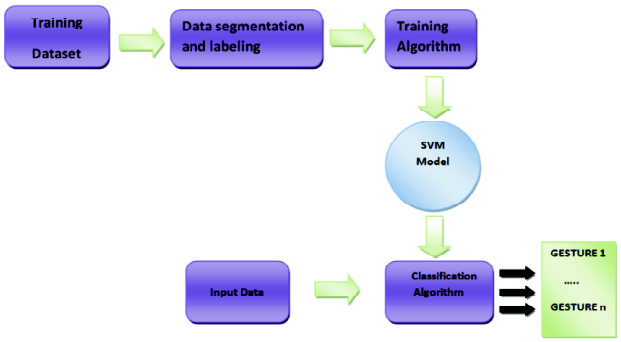

Figure 6: Working Flow of SVM

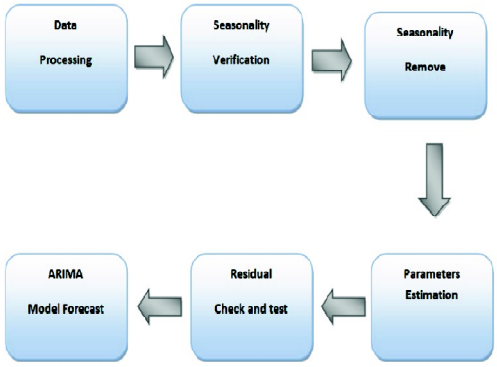

Figure 7: Working Flow of ARIMA Model

different weather conditions (Nanda *et al.*, 2013; Dabhi and Chaudhary, 2014; Banerjee *et al.*, 1978; DelSole and Shukla, 2002; Ganguly and Bras, 2003; Kawasaki and Herath 2011). Here, author also explains the various NN and ML based methods for the detection and right rainfall data prediction.

4. Conclusion

Water Resource Management and their environment, rainfall estimation is critical. It can be met with erroneous or insufficient information. Because rainfall estimation is impacted, there are challenges with estimation. From changes in geographical and regional features and many more. This study provided an overview of various ways of rainfall forecasting and issues one can come across while different ways of rainfall forecasting are being used (Anctil *et al.*, 2004). Due to rainfall data with nonlinear correlations and learning agility artificial neural network is a better alternate than the other approaches based on all accessible options. This study looked at the many methods for forecasting and anticipating rainfall, as well as the issues that can occur when employing different methodologies. According to the survey, most researchers employed back propagation networks to predict rainfall and received substantial results. The survey also concludes that (MLP), (SOM), and (SVM) forecasting approaches are more suitable for predicting rainfall than some other forecasting techniques like numerical and statistical techniques.

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