Rain Fall Prediction using Data Mining Techniques with Modernistic Schemes and Well-Formed Ideas

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Abstract: ***Weather forecasting is essential because it helps to deal with the environment related future anomalies. Accurate and timely predications can contribute largely for taking safety measures in the ongoing projects such as agriculture tasks, flight operations, transportation tasks and many others. There are large number of meteorologist all over the world who are trying their level best to predict the aspects of environment using data mining techniques. This paper contains some of the best work done in rain fall prediction using data mining techniques. This paper helps the researchers to study the literature of this field in a crisp, summarized and encapsulated way.***

Keywords: Data mining, Bayesian Classifier, Clustering, Rain fall prediction, Linear Regression Technique, K-fold, Weather predictions, Multiple Regression Technique.

I. INTRODUCTION

Weather forecasting is essential because it helps in dealing with the environment related future anomalies. Accurate and timely predictions can contribute largely for taking safety measures in the ongoing projects such as agriculture tasks, flight operations, transportation tasks, and many others.

There are a large number of meteorologist all over the world who are trying their level best to predict the aspects of the environment using data mining techniques.

Rainfall is a complex atmospheric process and a result of interaction between several environmental aspects. It is a natural phenomenon yet very difficult to predict due to a large number of dependent factors such as temperature, relative humidity, wind speed, wind direction, cloud coverage. Rainfall involved a large number of atmospheric processes and almost all of them follow a complex nonlinear pattern.

Rain is an essential part of the agriculture industry. In countries like India where 52.27% population directly or indirectly depends on agriculture for their living. By predicting rainfall accurately and precisely, we can take necessary measures to deal with the problems if they exist.

Rainfall prediction is very important not only in the agriculture area but for the non-agriculture part. In some areas, landslides occur due to heavy rainfall which is capable of huge damage to the living population. Rainfall prediction is an indispensable part of the flood management module.

The season of heavy rain during the summer in hot Asian countries is called monsoon. A monsoon is a seasonal wind shift. Approximately 50% of India's total food comes directly as a result of summer crops which can be delayed with the delay in monsoon. Also, low rainfall can cause a drought-like situation which India witnessed during the first two years of Sh. Narendra Modi govt.

Approximately 70% annual rainfall witnessed during monsoon season in India. Farmers start planting crops with the arrival of monsoon rains in June. Whenever there is good monsoon season the output of farms goes high which increases demands of the consumer as well as the income of farmers. It also increases the buying capacity of the rural people which ultimately results in the economic growth of companies selling products in rural areas.

However, a poor monsoon season decreases the income of farmers which leads to a decrease in the capacity to repay his loans which he had taken earlier for seeds and other requirements of cultivation.

By Predicting rainfall, we can find out the details about the monsoon and can deal with the future problems with better arrangements. For example, if we are getting patterns of bad monsoon so in that case, we can arrange another method by which water can be supplied for the cultivation of crops.

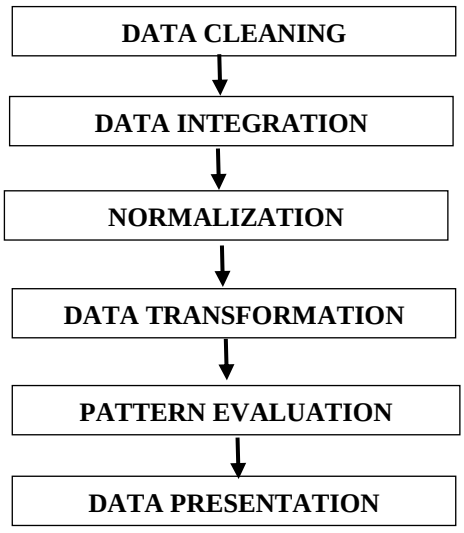

Fig. 1. Process of Data Mining

Why rainfall predictions are not accurate? The answer to the question lies in the fact that rainfall is a nonlinear random natural phenomenon. It is practically not possible to tell that on which factors does rainfall actually depends and on which it doesn't. Rainfall also

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depends on the natural condition of not only area under test but also the surrounding areas.

Rainfall prediction is essential because India is an agriculture-based country and rainfall plays a key role in agriculture. Farmers depend on rain forecasts during the summer monsoon season (June-Sept) to decide on what crops to sow.

According to an article published in the newspaper "Hindustan times" on April 22, 2019, Approximately 700 million people in India are directly or indirectly depends upon agriculture for their survival. The agriculture share in the gross domestic product of India is 20.5%.

After prediction, if we come to know that the rainfall is less than average, then we can arrange some additional methods so that our crops get the desired water and they can flourish well. By this, the overall production will not be affected. Good agriculture can result into a good income of peasants and it will ultimately affect the market and increase the GDP.

Rainfall prediction is not everybody's cup of tea even the Indian Meteorological Department (IMD) has forecasted accurately only once every five years over the past two decades even after taking into account for error band of plus or minus 5% points.

II. LITERATURE REVIEW

Literature review is the most important part of any research study because it helps the researcher in getting famillier with the work which is already done in the concern field and the problems faced during that work. Some of the best work in the concern field are discussed in this section.

Aswini.R, Kamali.D, Jayalakshmi.S, and R.Rajesh [1] proposes a model for rainfall prediction using Multiple Linear Regression (MLR). The objective of this work is the prediction of rainfall and forecasting of weather sensitivity. They observed seven parameters which are shown in table 1. Multiple Linear Regression (MLR) technique is used to predict the rainfall. Multiple linear regression is basically an extension of the existing Simple Linear Regression (SLR) technique. In SLR we have one predicator variable and on response variable. In MLR we have two or more predicator variable and one response variable.

Single Linear Regression is used where the response variable depends only on one predicator variable. Multiple linear regression is used where the response variable depends on multiple predicator variable. In MLR, by changing the values of coefficient researchers can find better results. In this, a proposed model based on empirical statistical techniques is used. The data file used in this model was saved in a commas separated value (CVS) file format. Attributes which are taken into consideration:

Table- I: Attribute used

ATTRIBUTE	TYPE
Year	Numerical
Month	Numerical
Wind Speed	Numerical
Evaporation	Numerical
Cloud Form	Numerical
Radiation	Numerical
Sunshine	Numerical

After critically analyzing this work we find out that using a statistical approach with multiple linear regression is a good option to deal with the unpredictability of the rainfall system. In this work values of coefficients are fixed and results can be improved by changing the values of the coefficients used in the multiple linear regression.

Chowdari K.K, Dr. Girisha R and Dr. K C Gouda [2] proposes a model for prediction of rainfall over different locations of India using spatial-temporal mining. The objective is this work is to analyze the rainfall over India using classification and clustering data mining techniques. This paper facilitates a more clear understanding of the analysis of weather and climate data with the help of spatial and temporal mining. In this work, Classification (Bayesian classification), as well as clustering data mining techniques, are used to analyze the multi-format data which is collected over a period of **53 years from 1951 to 2003.**

The data used in this work is in a multi-format data file. Some of the formats are ASCII, NetCDF, and HDF format. Data is collected by the India Meteorological Department (IMD) using more than 3700 rain gauge stations. The daily station data are analyzed over a period of 53 years.

Two Data Mining Techniques are used in this work. One is Classification and other is Clustering. The bayesian classifier is used to predict that to which group a data object belongs. Bayesian classifier comes under the family of "probabilistic classifier" and clustering technique is used to group objects into resembling groups or classes by using some attribute values.

Sandeep Kumar Mohapatra, Anamika Upadhyay and Channabasava Gola [3] introduced a prediction model for rainfall prediction of Bangalore city using linear regression technique. The objective is this work is to predict rainfall of Bangalore city on the basis of dependent attributes using data mining techniques. In these 100 years of data provided by the meteorological department has been analyzed and on the basis of that data, a prediction model was created.100 years of rainfall data ranging from 1901 to 2002 of Bangalore city is analyzed using linear regression data mining technique.

The performance of this model was further improved by using the Ensembles technique using K fold. Two Sampling Techniques are used in this work. One is 80-20 fixed sampling technique i.e. 80% of total data is used as a training set and 20% data is used for validating the model and other is K fold Validation sampling techniques. In this linear regression model, **seven data parameters** were used. They are Rainfall, Maximum temperature, Precipitation Wet dry frequency**,** Mean temperature**,** Relative humidity**,** Total cloud amount**,** Wind speed.

Tharun V.P, Ramya Prakash and S. Renuga Devi [4] predicted rainfall for Nilgiris district, Tamil Nadu. In this work statistical modeling and various regression techniques such as Support Vector Regression (SVR), Random Forest (RF) and Decision Tree (DT) are used. The objective of this work is to provide an accurate prediction of rainfall and also the comparative study of the regression techniques on the basis of accuracy. After comparing the regression techniques using R-square and adjusted R- square values Random Forest technique reflected as superior. It is also concluded that Statistical Modelling falls to provide accuracy due to complex input parameters and nonlinear machine learning algorithms

such as neural networks should be used.

Abishek.B, R.Priyatharshin, Akash Eswar M and P.Deepika [5] introduced a new prediction model for effective and accurate prediction of rainfall and need of water for irrigation. In this work, data mining techniques such as classification (J48, Naïve Bayes and Regression) is used. This model was introduced with the objective of helping farmers in choosing the right irrigation system for optimum growth of crops. This model was selectively focused on three aspects. First was a prediction of rainfall, the second was an accurate estimation of crop water needs for irrigation during the cultivation process, third was increasing the productivity of crops by helping farmers in the selection of irrigation system.

Chandrasegar Thirumalai, M Lakshmi Deepak, K Sri Harsha and K Chaitanya Krishna [6] formulated a model based on linear regression techniques. The main agenda of this work is to help farmers in executing the agriculture work smartly which ultimately leads to the improvement in the production of the crops as well as revenue generated. Using linear regression previous year data is used as a training set for the prediction of next year values. This model clams to predict which crop is best to harvest in a particular season.

Minghui Qiu, Peilin Zhao, Ke Zhang, Jun Huang, Xing Shi, Xiaoguang Wang and Wei Chu [7] proposed a model using multi-task convolutional neural network for prediction of rainfall. This model collects data from different sites and observed a correlation between them. The results of this model are compared with the data of public weather forecast center and concluded the effectiveness of the model.

Valmiki B Nikam and B.B.Meshram [8] recommended a model based on Bayesian classifier for rainfall prediction. Bayesian classifier falls in the category of supervised techniques and can be viewed as a predictive as well as descriptive phenomena. Data collected from the Indian meteorological department (IMD) Pune contains a total of 36 measured parameters out of which 7 parameters are selected after deep analysis.

Table- II: Attribute used [8]

Attribute	Type	Description
Temperature	Numerical	Temp in deg. C
Station level Pressure	Numerical	SLP in hpa
Mean Sea Level Pressure	Numerical	MSLP in hpa
Relative Humidity	Numerical	RH in percentage
Vapour Pressure	Numerical	VP in hpa
Wind Speed	Numerical	Wind Speed in Kmph
Rainfall	Numerical	Rainfall in mm

The complete data set is divided into the ration of 70:30. 70% data is used for training of the model and 30% data is used for testing of the model. This Bayesian model is data-intensive model and also better than the existing computation model. This model fails in case of rare predicator value when a predicator category is absent in the training data then model assumes that new value with that category has a zero probability. The accuracy and applicability of this model can be improved by making it a hybrid model of multiple data mining techniques.

Geetha and Dr. G.M.Nasira [9] observed that classification techniques such as decision tree can lead to a successful prediction in rainfall analysis. They have collected data of two years (2013 and 2014) and applied classification techniques using twelve attributes. The 2013 data is used as a training set and 2014 data is used for testing. Problem with this approach is that Decision trees are unstable, a very little deviation in data results in a significant change in the structure of the Decision tree. The proposed model can be improved with soft computing techniques such as fuzzy logic, genetic algorithms and artificial neural.

Table- III: Attribute used [9]

S No	Attribute	Type	Description
1	STN	Integer	Station number of the location
2	DAY	Integer	Year, month, day
3	TEMP	Numeric	Mean temperature In F
4	DEWP	Numeric	Mean dew point In F
5	SLP	Numeric	Mean sea level pressure In mb
6	STP	Numeric	Mean station pressure In mb
7	VISIB	Real	Mean visibility In miles
8	WDSP	Numeric	Mean wind speed In knots
9	MXSPD	Numeric	Maximum sustained wind speed In knots
10	MAX	Numeric	Maximum temperature in F
11	MIN	Numeric	Minimum temperature In F
12	PRCP	Binomial	Total precipitation In inches.

Soo-Yeon Ji, Sharad Sharma, Byunggu Yu and Dong Hyun Jeong [10] introduced a prediction model using classification and regression tree (CART) and C4.5 techniques. In this work, they have taken data set from a weather station which was installed in the University of Columbia. Thirteen variables are selected from a total of fifty-one variables. Ten-fold cross-validation method is used to validate the observed model. Accuracy of prediction of hourly rainfall using CART and c4.5 are 92.8% and 93.4% respectively. This model can be further improved by intelligently selecting more attributes so that accuracy can be further improved.

R. Sukanya and K. Prabha [11] compared some of the best-known data mining techniques such as CART, C4.5, artificial Neural network, Naive Bayes, KNN and Lazy Learning. Rainfall being a random natural phenomenon is very complex to predict. Some of the classification algorithms such as CART, C4.5 are easy to implement and gives good accuracy. After analyzing it is to be concluded in this work that hybrid (Combination of more the one data mining techniques) can lead to better accuracy but the complexity of the prediction model is high.

Fahad Sheikh, S. Karthick, D. Malathi, J. S. Sudarsan and C. Arun [12] proposed a prediction model based on Naïve Bayes and C4.5 Decision Tree. They have collected data from the meteorological tower of SRM University Chennai, India in CSV format which includes parameters like humidity, temperature, cloud cover, wind speed, etc. Accuracy of Naïve Bayes and C4.5 Decision tree algorithms are 54.8% and 88.2% respectively. It is already emphasized in the previous research work that the performance of C4.5 algorithm improves with large data sets. Performance and accuracy of the C4.5 Decision Tree can be increased by applying an appropriate filter to the data sets during the pre-processing phase.

Ram Sundaram N, Sathya S and Karthikeyan S [13] attempted to develop a methodological model for efficient prediction of rainfall using decision tree and artificial neural network. While designing the model, they mainly focused on climate variables such as temperature, humidity and wind speed. In this model, a huge historical database is used which might lead to poor knowledge recovery which results in less accurate predictions. 80-20 fixed sampling is used in which 80% of the data is used for training of the model and 20% data is used for validation. This Decision tree model predicts the rainfall with Nash Sutcliffe efficiency of 0.85. Range of Nash Sutcliffe efficiency varies from –infinity to 1.

Bhaskar Pratap Singh, Pravendra Kumar, Tripti Srivastav and Vijay Kumar Singh [14] predicted rainfall using double hidden layers artificial neural network and single hidden layer artificial neural network. In case of double hidden layers, artificial neural network model becomes more complex and requires high computation power but in case of single hidden layers, the artificial neural network model is much simpler, easy to implement and requires less computation. In the overall research, it is observed and noted that vapor pressure is the highest sensitive parameter for rainfall prediction.

III. COMPARATIVE ANALYSIS

In this section, a more outlined analysis is given of all the papers studied in previous section in a tabular form. These type of analysis helps the researcher in finding out what techniques are already used and what are the limitations of these techniques. It will be very helpful for researchers who want to contribute in this field in future.

Table- IV: Comparative Analysis

Pub. Year	Title of the Paper	Techniques Used	Research Gaps
2018	Predicating Rainfall and forecast weather sensitivity using data mining techniques [1]	Multiple Linear Regression (MLR)	In this work values of coefficients used in MLR are fixed.
2015	A study of rainfall over India using data mining [2]	Bayesian Classifier and Clustering.	Predictive analysis techniques should be used for better analysis.
2017	Rainfall prediction based on 100 years of Meteorological Data [3]	Simple Linear regression (SLR), Fixed sampling 80-20 Method, K-fold validation method	This model is based on one city only i.e. Bangalore.
2018	Prediction of Rainfall Using Data Mining Techniques [4]	Regression techniques(Support Vector Regression, Random forest, Decision Tree) and Statistical Modelling	Statistical Modelling falls to provide accuracy due to complex input parameters
2017	Prediction of Effective Rainfall and Crop Water Needs using Data Mining Techniques [5]	Classification (J48, Naïve Bayes and Regression)	Model is applied only on a small area (Bijapur district of Karnataka)
2017	Heuristic Prediction of Rainfall Using Machine Learning Techniques [6]	Linear Regression (LR)	Linear regression techniques are more suitable for linear datasets.
2017	A Short-Term Rainfall Prediction Model using Multi-Task Convolutional Neural Networks [7]	Multi-Task Convolutional Neural Networks with deep learning techniques	Proposed model is only used for short term predications and results may vary in case of long term predictions.
2013	Modeling Rainfall Prediction Using Data Mining Method: A Bayesian Approach [8]	Bayesian Classifier	This model fails in case of rare predicator value (Classifier model assume it as a new category with zero probability)

2014	Data Mining for Meteorological Applications: Decision Trees for Modeling Rainfall Prediction [9]	Decision Tree (Classification)	Decision trees are unstable, a very little deviation in data results in significant change in the structure of DT
Pub. Year	**Title of the Paper**	**Techniques Used**	**Research Gaps**
2012	Designing a Rule-Based Hourly Rainfall Prediction Model [10]	Classification and regression tree(CART), C4.5, ten-fold cross-validation	The data set used is very small and can lead to a small variation in the data set could lead to different decision trees
2017	Comparative Analysis for Prediction of Rainfall using Data Mining Techniques with Artificial Neural Network [11]	CART, C4.5, Artificial Neural network, Naive Bayes, KNN,	Combining two or more data mining techniques could lead to better accuracy
2016	Analysis of Data Mining Techniques for Weather Prediction [12]	Naïve Bayes and C4.5 Decision tree algorithms	Accuracy of Naïve Bayes algorithm is very less i.e. 54.8%
2016	Comparison of Decision Tree Based Rainfall Prediction Model with Data Driven Model Considering Climatic Variables [13]	Decision tree and Artificial Neural Network	Prediction using Artificial Neural network fails to give accurate results
2017	Estimation of Monsoon Season Rainfall and Sensitivity Analysis Using Artificial Neural Networks [14]	Artificial Neural network (ANN)	Double hidden layers artificial neural network are very complex and required more computation time

IV. PROPOSED APPROACH

In this section, we are trying our level best to deal with some of the research gaps that were found in the existing work and suggesting some REFINED APPROACHES about the same. As we all know that nothing is perfect and always there is chance of improvement in each and every scenarios. Some of the refined ideas are shown in table below.

Table- V: Refined Approaches

Pub. Year	Title of the Paper	Refined Approache
2018	Predicating Rainfall and forecast weather sensitivity using data mining techniques [1]	Results can be improved by changing the values of the coefficients used in the multiple linear regression.
2015	A study of rainfall over India using data mining [2]	Accuracy can be improved by considering external parameter like a greenhouse gas, urbanization
2017	Rainfall prediction based on 100 years of Meteorological Data [3]	A more generic and robust model can be built by using different sampling technique.
2018	Prediction of Rainfall Using Data Mining Techniques [4]	Nonlinear machine learning algorithms such as Neural networks should be used.
2017	Prediction of Effective Rainfall and Crop Water Needs using Data Mining Techniques [5]	More areas should be included to form a generic and comprehensive model.
2017	Heuristic Prediction of Rainfall Using Machine Learning Techniques [6]	Prediction model solely based on previous year data and can be improved by taking at least 10 years of data.
2017	A Short-Term Rainfall Prediction Model using Multi-Task Convolutional Neural Networks [7]	This model can be further extended for long-term Rainfall prediction to increase the application and usability of the model.
2013	Modeling Rainfall Prediction Using Data Mining Method: A Bayesian Approach [8]	Accuracy and Applicability of this model can be improved by making it a hybrid model of multiple data mining techniques
2014	Data Mining for Meteorological Applications: Decision Trees for Modeling Rainfall Prediction [9]	Proposed model can be improved with soft computing techniques such as fuzzy logic, genetic algorithms and artificial neural networks
2012	Designing a Rule-Based Hourly Rainfall Prediction Model [10]	The proposed model can be improved by adding more generic techniques such as Artificial neural networks.

2017	Comparative Analysis for Prediction of Rainfall using Data Mining Techniques with Artificial Neural Network [11]	Techniques such as classification (CART, C4.5) and artificial neural network can be combined to yield better accuracy
Pub. Year	**Title of the Paper**	**Refined Approache**
2016	Analysis of Data Mining Techniques for Weather Prediction [12]	Performance and accuracy of the C4.5 DT can be increased by applying an appropriate filter to the data sets during the pre-processing phase
2016	Comparison of Decision Tree Based Rainfall Prediction Model with Data Driven Model Considering Climatic Variables [13]	The accuracy of the prediction model can be improved by increasing the length of database and inclusion of most correlated variables
2017	Estimation of Monsoon Season Rainfall and Sensitivity Analysis Using Artificial Neural Networks [14]	For Rainfall prediction single hidden layers artificial neural network suits best as it is simple and easy to implement.

V. CONCLUSION

In this paper, we have explained about some of the best work in the rainfall predictions using data mining techniques. We deeply explained about their significance and agendas of the work. After critically analyzing the work we have suggested some of the modern approaches for each exiting model and work for improvement in both performance and accuracy. We also tried our level best to give a complete and brief overview of all the modern data mining techniques. Before doing research in a particular field it is always an important and recommended step to study about the exiting works in that field. Also, one should never miss this opportunity of learning from someone else's experience.

This paper not only contains some of the best and trusted approaches of modern day data mining for rainfall prediction but also contain some of the finest work from recent times and some modern ideas to improve the accuracy and performance of these modern approaches.

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