Journal of Information Systems Engineering and Management
2025, 10(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Predicting Future Rainfall with Various Machine Learning Models

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ARTICLE INFO

Received: 04 Oct 2024
Revised: 28 Nov 2024
Accepted: 20 Dec 2024

ABSTRACT

This research presents a machine learning technique that improves the prediction of the annual rainfall total. Predicting the amount and timing of precipitation in a given region is known as rainfall prediction. The global community is quite concerned about the accuracy of rain forecasts. People know this is the cause of floods and other natural disasters every year. Any number of industries might feel the effects of inclement weather, including farming, building, power generating, and tourism. Precipitation forecasting is one of the most challenging and uncertain undertakings due to the far-reaching effects it has on human society. The only way to reduce needless pain and financial losses is with timely and accurate predictions. Using historical meteorological data for a single day in major Australian cities, this paper describes a series of experiments that build models that can anticipate the possibility of rain tomorrow using cutting-edge machine learning techniques. This comparative study will look at inputs, methodologies, and pre-processing strategies in great detail. Using a variety of measures that measure the algorithms' capacity to understand weather data and predict the likelihood of precipitation, the results reveal how well these machine learning algorithms performed. Machine learning has proven to be extremely useful at predicting when it will rain, which is currently the most fundamental need, At the moment, it's quite tough to say with any certainty when it will rain. In our endeavors to forecast precipitation, we have employed a plethora of methods, such as Decision Tree Algorithm, Linear Regression, Support Vector Regression, Random Forest Regressor, and Random Forest Classifier. In agricultural contexts, the effective rainfall is a key factor in deciding the rate of crop growth. Forecasting rainfall using machine learning can improve water resource planning, agricultural production, and water usage prediction.

Keywords: Machine Learning, Random Forest, Regression, Classifier, Decision Tree, SVM.

INTRODUCTION

Indian culture and human survival are profoundly affected by the ability to forecast when and how much rain will fall. The meteorological department has a tough and time-consuming job trying to predict the frequency of rainfall with any level of precision. The ever-changing weather makes rain prediction a challenge. When it rains in the summer or any other season, it's hard to say when exactly. A multitude of models have been developed by researchers worldwide in an effort to forecast the precipitation total. Importantly, these models depend on climatic data as well as random numbers. A series of linear regressions were used to build the model that was proposed. In order to predict when it will rain, the suggested approach looks at weather data from India. Two main types of machine learning algorithms are supervised and unsupervised learning. Supervised machine learning encompasses all clustering approaches. A variety of machine learning algorithms were used to generate the classifications shown in Figure 1. Figure 2 shows the results of the study on neural network-based rainfall prediction in the Indian environment.

Despite the proliferation of models, more study with machine learning algorithms is required to generate reliable predictions. Improved agricultural and other industry planning is a direct result of the error-free forecast. Better methods of predicting the amount and timing of precipitation would be extremely beneficial to all stakeholders engaged in risk management, including corporations, government organizations, and scientists. A lot of things that people do are influenced by rainfall, which is a climatic factor [1]. Included in this category are activities such as food production, construction, electricity generation, tree cutting, and tourist entertainment. To avoid the most devastating forms of nature's destruction—landslides, floods, mass movements, and avalanches—it is essential to know when and how much precipitation will fall. These events had a significant impact on society [2]. Having a dependable way to estimate when it will rain is crucial for preparing for and reducing the effect of severe weather events [3]. We eliminated any room for doubt by providing fast, accurate forecasts using a variety of machine learning models and approaches. This initiative is designed to address every aspect, beginning with data preprocessing and continuing through model building and evaluation. Some of the many tasks that make up data preparation include encoding features, scaling features, transforming features, selecting features, and injecting missing values into features. We used a variety of models, including Decision Tree, Rule-based, K-Nearest Neighbor, Logistic Regression, and Ensembles. With the purpose of evaluation in mind.

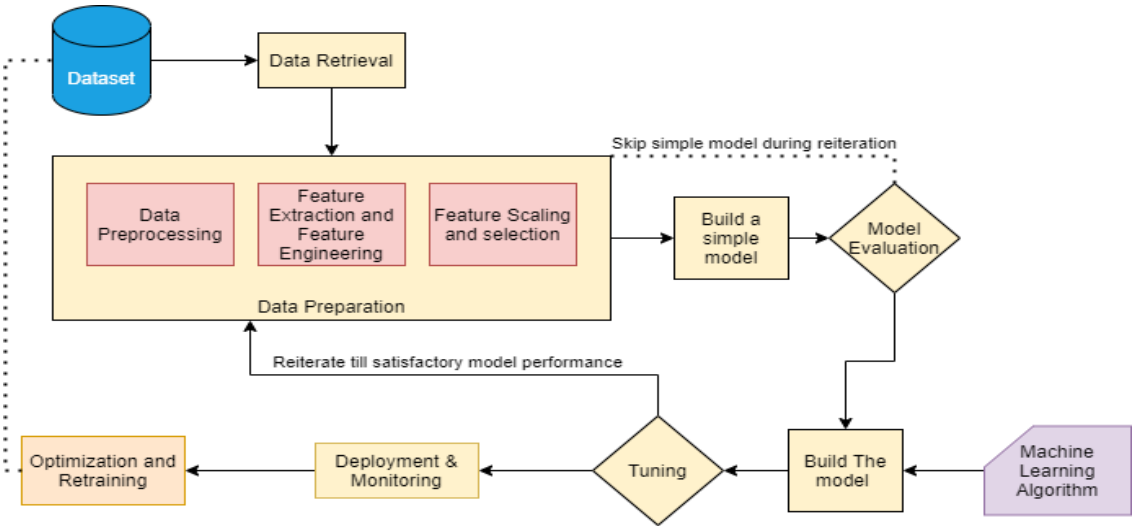

Fig. 1. Standard Machine Pipeline [3]

The objective of the paper is to make a system to predict rainfall. In order to build such as system complete machine learning is needed. A complete and efficient system which can provide the rainfall prediction the basic objective of the paper. The system can be implemented in the form of a machine learning.

A Dataset is the basic container of data in PyMVPA. It acts as the primary form of data storage, but also as a container for results sent by most algorithms. The data used in here have been downloaded from government website. Rainfall data of coastal and non-coastal region of all states have been given in dataset, Data cleaning has been done on it. Predicted rain by using algorithms. One hot encoding done on dataset.

LITERATURE REVIEW

Researchers have been experimenting with various methods in an effort to refine the art of rainfall prediction. Predicting when it will rain requires a variety of methods and methodologies, including clustering, regression analysis, and artificial neural networks. The empirical and dynamic approaches are two pillars upon which weather prediction rests. Your decisions should be based on empirical evidence, which is obtained through scientific observation and experimentation. The development of DNA testing is an example of an empirical test. The three most common empirical approaches are fuzzy logic, artificial neural networks (ANNs), and regression. This technique is always improving, just like machine learning. It will carry out the optimal plan of action after it has been determined. Additionally, it is a method for resolving problems that involves analyzing and studying oneself. The dynamical method is adequate for handling issues of a grand scale. Some people have used a variety of techniques to forecast when it will rain, including ANN, LR Logistic regression, NN, Linear Regression, Naïve Bayes, SVV, and Random Forest Regression. The subject of rain prediction is explored further in the academic literature. The following works

of literature are relevant to the strategy we suggest. In their work on neural network-based rainfall prediction, Kumar Abhishek et al. [2] present a novel approach. We can predict when it will rain in the Udupi district in the Indian state of Karnataka using the model given in [2]. Researchers are looking into several neural network types, including cascade feedforward neural networks and BPNNs with recurrent layers. The suggested model divides the data usage in half, with 70% going into training and 30% into testing. In terms of accuracy, the recurrent network outperforms the BPNN. For BPNN, the MSE is relatively high. Given the difficulties, Minghui Qiu et al. proposed a temporary solution to the problem of inaccurate rainfall projections. A convolutional neural network (CNN) model was used to forecast future rainfall by compiling a set of weather features from many nearby observations. This made the problem go away. It performed far better than the public weather forecast model.

Aswin et al. proposed an LSTM and ConvNet-based model for precipitation prediction in [4]. Using LSTM and ConvNet architectures, we model and forecast the average monthly rainfall for 10368 locations around the globe over a 468-month period. The suggested system, LSTM, achieves 2.55, in contrast to ConvNet's 2.44 RMSE.It is still possible to decrease errors by increasing the number of hidden layers. Precipitation prediction using back propagation neural networks is one topic that Xianggen Gan et al. have addressed. The dataset was used to evaluate the proposed model. It includes sixteen meteorological parameters and spans from 1970 to 2000. With a value of 0.01 for the target error and learning rate, the network is ready to go. We used Matlab's neural network framework to build the model you recommended. While BPN Network prediction is 100% accurate, regression prediction is only 67% accurate. A Genetic Programming method was suggested by Sam Cramer et al. to forecast the onset of precipitation. We compared GP and MCRP with data sets from 21 European cities.

The training data consisted of daily rainfall records from the past decade, whereas the testing data was derived from the most recent year. When it comes to predicting the different climates, GP performs better than MCRP since it gets beyond MCRP's restrictions. Rainfall prediction using FFNN, RNN, and TDNN outperformed other methods, as shown by Mohini P et al. One drawback of NNs is that they are not very accurate at monthly rainfall predictions, just at annual ones. Weather conditions could be used to fix the problem. From 1901 to 2002, Sandeep Kumar Mohapatra and colleagues offered a method for predicting the rainfall in Bangalore, India. Data mining technique Linear regression was used for data analysis. We used pandas and scikit-learn to evaluate our results and get computational insights. The K-fold method was used to forecast the amount of precipitation expected throughout each season. Forecasts for the wetter months were more precise than those for the warmer months. Precipitation forecasting using Neural Networks was suggested by Sankhadeep Chatterjee et al. Data collected from 1989 to 1995 was gathered at the Meteorological Station in Dumdum, West Bengal. The data was clustered using K-means algorithm. In reference [9], the MLP-FFN classifier was shown to be comparable to the HNN. When comparing the two methods, HNN achieved a higher accuracy rate (89.54% with selection features and 84.26% without). This put it ahead of MLP-FFN. To anticipate when it will rain, Sunil Navadia et al. suggested a technique that makes use of Hadoop predictive analytics. Using Apache PIG to analyze the data, we were able to predict when it would rain.

The future version will include the ability to leverage Appache Hadoop, which will boost the accuracy rate. Table 1 displays the outcomes of a literature study that contrasted several approaches to precipitation forecasting. Prioritizing Pritpal Singh and colleagues Quantitative study explains the concept of ISMR; reliable forecasting based on insights and facts alone is unattainable. This article covers three different approaches: object construction, entropy, and artificial neural networks (ANNs). Now that we have more information, we can tackle the ISMR problem from a different angle and try to anticipate when it will happen. Approval has been extended to this model by both the studio and the exploration data. An explanation of general knowledge based on careful examination of multiple sources. In this group, you can find notable figures like Antonios Alexandridis, Alex A. Freitas, Michael Kampouridis, and Sam Carmer.[2] Compared to more complex techniques of rainfall evaluation, smart frameworks make the benefits of AI computations more apparent, and this update mainly serves to emphasize these advantages. Momentum execution is a Markov chain that has been enhanced by rainfall research. It is compared to six well-known AI systems: genetic programming, vector relapse support, radio organizations, M5 organizations, M5 models, and Happy models. To help with a more comprehensive assessment, we combined rainfall data from 42 big cities to create a rainfall summary.

Notable names on the list include Shamsuddin Shahida, Eun-Sung chungb, Sahar Hadi Poura, and others in a similar vein. In order to forecast the probability of precipitation on particular days, we used the RF approach. For days with strong winds, we used the SVM method. Reducing daily precipitation at three sites in eastern Malaysia increased the

upper limit of the Hybrid model. Crossover models can reproduce not just the overall change but also the distribution of the measured rainfall, the number of days in a row, and 95% of the monthly rainfall. A method has been devised by experts in the field, including Tanvi Patil and Dr. Kamal Shah, that enables them to anticipate four Table The prediction will be updated. For several reasons, the weather remains unpredictable. As a whole, they are utilized in climatic forecasts. There is no room for delay when making a choice of this magnitude. Underlying displaying is utilized by a great deal of data commerce, character analysis, demonstration fate, artificial intelligence (AI), and AI itself.

P. Radha, Divya Prabha, and coworkers [5] Creating an accurate water summary here takes a significant portion of the day, unlike in other places where rainfall data is not available. Utilizing enhanced complex neural networks greatly simplifies the process of predicting the arrival of storm season. A high-tech perceptron neural network confirmed the rainy season. Early modeling, usually early mistake, and the generation of data sets for short-term planning are revealed by analyzing Adanaive and other businesses. Well, howdy! It is I, AdaSVM. Contributors include Senthamil Selvi and Seetha. [6] Using Indian rainfall data, this research develops a climate forecast system based on artificial neural networks. This is why a Feed Forward Neural Network (FFNN) and the Backpropagation Algorithm were both used. Two measures that can be used to compare the two models' performance are mean square error (MSE) and relative error (MRE). In addition, you can use the book as a reference for predicting when it will rain. Including contributions from: SrinidhiHR, SagarK, YashasAthreya, VaishaliBV, and others. [7] These are the results of the precipitation studies that were predicted using Machine Learning. In order to safeguard their devices from flooding, most individuals install this software. This program can be used by anyone, including the government, to predict the path of the flood. After then, the flood card can be useful because it will transmit important or flexible steps.

PROPOSED MODEL

Rainfall forecasting is one of the most critical tasks in modern society. Rainfall prediction need generalized and advanced computing solutions.

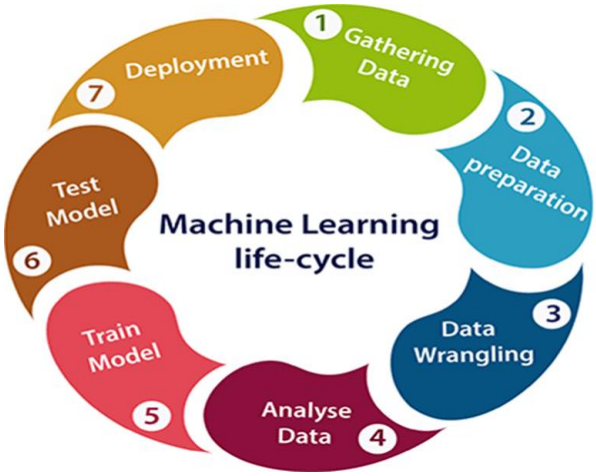

Fig. 2. Machine Learning Process

3.1. Methodology used for this paper

Linear Regression: What a stunning role model. Supervised learning is its foundation. Making a prediction regarding the relationship between x and y, the independent and dependent variables, is our objective here. This falls within the purview of machine learning and statistics. Delivering accurate forecasts while minimizing model error are the primary goals of predictive modeling. The equation y = B0 + B1*x can be used to represent a simple regression with one independent variable (x) and one dependent variable (y).

Linear regression can be regularized in two ways: one involves modifying Lasso regression to minimize the total number of coefficients, and the other involves using another method. Reduced absolute sum of squared coefficients is an extra perk of Ridge Regression.

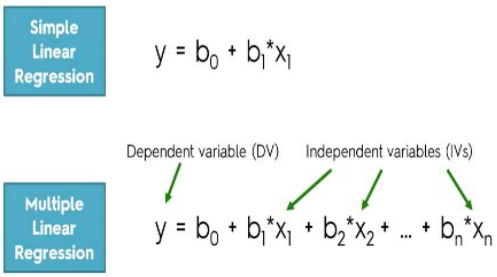

Fig. 3. Linear Regression

Naïve Bayes- The Bayes theorem is the foundation of classification methods. It is quite easy to test and implement using the test data set. This program can sort data into several categories as well as binary ones. Representation of models with Naïve Bayes - Probabilities are used as a representation. This file stores the learned model's probability. The content includes In the training set, every class has the same probability. Chances under certain conditions: Each class value reveals the input value's condition. As a theorem, it is stated here, As a result of Bayes Theorem [12], NB classifiers are able to aggregate algorithms for classification. Every pair of categorized attributes is unique from every other pair; this is the basis of these methods. Estimates of classification parameters can be obtained using this method even when training data is scarce [13]. As an example, our library includes tomorrow's weather forecast.

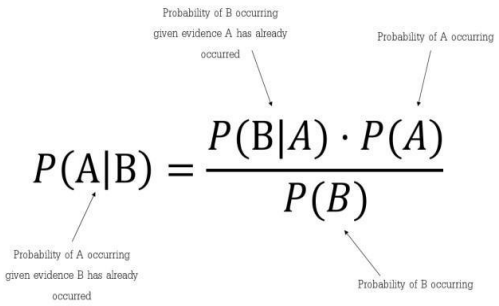

Fig. 4. Naïve Bayes

Random Forest -It is a method for acquiring knowledge through group projects. Random forest is the best method for purposeful classification and regression. The Random Forest algorithm can be put into action by following these steps:
Step 1 – Select a random sample from a given dataset.
Step 2 – The algorithm generates a decision tree based on the sample size that is appropriate. It will provide a forecast for the decision tree.
Step 3 – For every predicted result voting will be performed.
Step 4 – Select the best correct result.

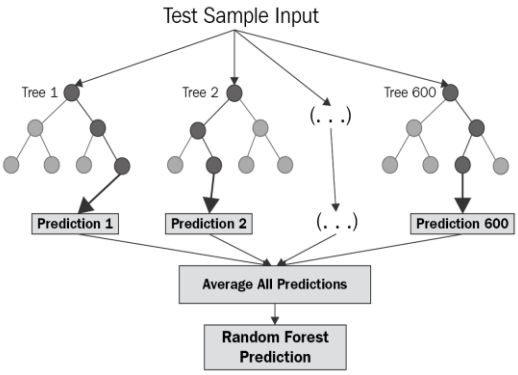

Fig. 5. Random Forest

Decision Tree-One important part of supervised learning is dividing the data into several sets based on certain factors. They are useful for situations involving classification and regression. Every node in a tree has two possible functions: leaf and decision. Decision nodes divide data into several categories. The following are some ways decision trees can be categorized, In J48, the C4.5 technique is utilized frequently. Using the J48 decision tree method, subtree attributes are generated following the identification of the most and least essential aspects. Instead of decision trees, it produces binary trees, much like Random Forest. [14]. Applying the chi-square, information gain, or Gini index to decision tree construction is one option. Splitting the data into smaller subsets and then using the information from those subsets to prioritize the qualities is what the decision-tree approach is all about. [11]. Figure 7 shows the flow diagram of the Decision Tree. When creating DT, there are two separate but complementary steps: first, constructing the tree; and second, doing classification using the top-down technique. The ideal split at each node is determined by using the predicted value. The structure of the tree is enhanced by each node, which brings its own set of decision rules and expected values. To avoid overfitting, we can confidently identify the optimal tree size using cross-validation. Every node in the decision tree has the most important qualities because of this method [12]. The decision tree algorithm relies on features to gather relevant domain knowledge, making them crucial.

3.2. Platform Used

Python 3.5 is the language and technology used to implement a machine learning technique. While the implementation is underway, editing is done in Anaconda's Jupiter Notebook. R Anaconda offers Jupyter, a Python tool. Jupyter allows you to run scripts, make graphs, and add annotations. Its true strength lies in data science forecasts. Python is one of the most powerful interpreted languages. Python, similar to R, is a language and platform that can be utilized for both R&D and the development of production systems. The numerous libraries and modules are at your disposal, so you may pick and choose what you need. Machine learning's end goal is to enable computers to learn how to process data on their own. With this information, we can teach the machine to do new things without any help from a human teacher. With the use of algorithms, forecasts can be made. One crucial aspect of machine learning is feeding a learning system with data to use as training. Python on Machine Learning: Run the program by obtaining the Python interpreter. Create a strategy on a little piece of paper. Start a student newspaper of your own, Design and implementation.

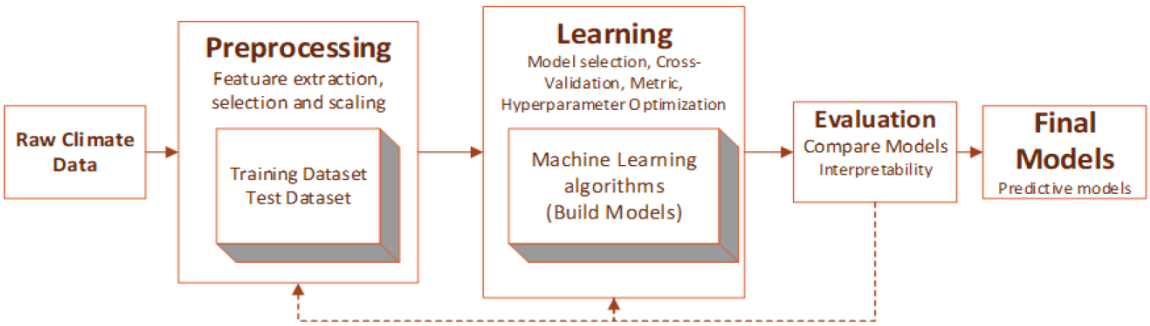

Fig. 6. Flow Diagram

When combined with machine learning, this method improves our ability to forecast annual precipitation. Scientific and technical advancements might occasionally be useful in the quest to predict when rain will fall. The world's population has a serious issue with the reliability of rain forecasts. This is supposedly the reason why natural calamities like droughts and floods happen every year. To eventually allow computers to learn data processing on their own is the ultimate aim of machine learning. Using this data, we can program the computer to learn new tasks independently of a human instructor. Predictions are possible with the use of algorithms. Training a learning system requires data, which is an essential part of machine learning.

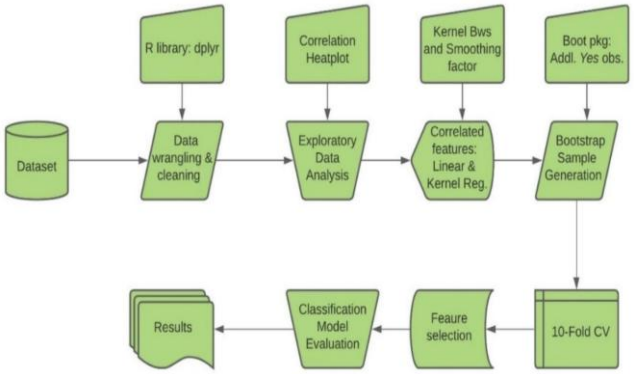

Fig. 7. Processing Diagram

Which has different columns and state which includes

Data Collection: This investigation was made possible by the data provided by the meteorologist's center. Between 2012 and 2015, the case data was gathered. Methods employed up to this stage in the investigation included data processing, sorting, cleaning, and mining.

Data Cleaning: Missing data searches, duplicate data discoveries, and defective data eliminations are all part of the data model's consistent format at this point. The data was converted into a data mining-friendly format once the program completed cleaning it.

Data Selection: We have retrieved the most important variables from the dataset using analysis approaches like decision trees. For the forecasts, we utilized two out of the ten features in the weather dataset. We did not include data from Sunshine or Cloud Form, where many things are missing, or from which every input is the same.

Data Transformation: "Data consolidation" is another word for what is happening here. To make data mining easier, the chosen data is now converted to the right formats. We converted all of the datasets to CVS format and standardized them to reduce the impact of size.

Data Mining Stage: The data mining process consisted of three distinct steps. At each stage, the weather datasets were processed using the corresponding algorithm. Percentage split testing was used in this study. This method comprises training on a portion of the dataset, then doing cross-validation on that portion and testing on the rest of the dataset. After that, intriguing patterns that mirrored what was known were discovered.

In meteorology, a "rainfall prediction" is an educated guess as to the when and where of precipitation (rain, snow, sleet, etc.) for a given location and time period based on a number of factors. Precipitation forecasting is an essential part of a meteorologist's job. This data can be useful in many different areas, such as transportation, agriculture, electricity generation, water resource management, emergency response, and disaster planning. Numerical weather models, ground-based measurements, and remote sensing can be combined to improve the accuracy of precipitation forecasts. The traditional method of measuring rainfall—ground-based rain gauges—cannot compare to the accuracy of rainfall estimations made possible through remote sensing employing satellites and radar. Numerical weather models try to simulate the current environment and predict its future patterns using mathematical equations [1-4]. In order to better manage agricultural areas and decrease risks to life and property, a more precise forecasting model is needed for early warning in the event of heavy and unpredictable rainfall, which can have numerous negative outcomes, such as crop loss and property damage. For that reason, knowing when it will rain is crucial. If this prediction pans out, water supplies could be better utilized, which is great news for farmers. Although the technique is challenging, accurate rain projections are vital. Numerous modern technological advancements have made it possible to foretell the arrival of precipitation by analyzing variables such as atmospheric pressure, temperature, and humidity. Machine learning techniques allow us to obtain accurate findings even when more conventional methods fail miserably. Planning for water distribution and supply, operations at reservoirs and dams, and other aspects of water resource management rely heavily on rainfall estimates. Disasters like floods, landslides, and droughts can be lessened with the help of accurate rainfall predictions. Those responsible for water distribution, discharge, and conservation initiatives will find this data extremely useful. By utilizing early warning systems that are based on precipitation estimates, we can reduce property damage and casualties [9,10]. When it comes to building, fixing, and

ensuring the safety of roads and bridges, transportation planners might benefit greatly from accurate rainfall predictions. With its help, we can potentially reduce accidents and weather-related delays. In order to plan and track energy production, hydroelectric power stations rely on precipitation estimates. Rainfall influences the effectiveness of various energy generation techniques in the same way as it influences the efficiency—and consequently, the planning and maintenance—of solar and wind power. Sustainable development, disaster preparedness, and community well-being all depend on accurate and timely rainfall forecasts. Because it helps to decrease economic losses, preserves the environment, and improves living conditions, timely and accurate forecasting is vital for many organizations [11,12]. For instance, in agriculture, emergency management, and infrastructure construction, inaccurate rainfall projections can wreak havoc. Actions are being taken to enhance the accuracy of weather predictions, and it is essential to notify individuals who depend on them about any potential gaps in data. This study aims to evaluate the advantages and uniqueness of rainfall prediction models by reviewing and analyzing a large number of current and past studies that utilized machine learning and remote sensing methodologies. After the EDA was done, according to the dataset selecting the proper algorithm is must.

Algorithm - According to EDA-Selected algorithm for our dataset is: -

- Random Forest Regression
- Random Forest Classifier
- Linear Regression
- Decision Tree
- SVR

Model steps: As part of the testing process for machine learning algorithms, a tester creates a separate training dataset and a separate testing dataset, which are both subsets of the original training dataset.

RESULTS AND DISCUSSION

Performed EDA to visualized relationship between mean and the annual rainfall and temperature information given in the dataset.

Graph 1:

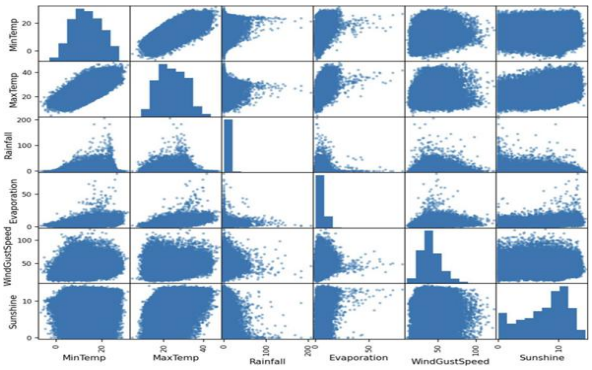

Fig. 8. The yearly temperature and precipitation graph

Graph 2:

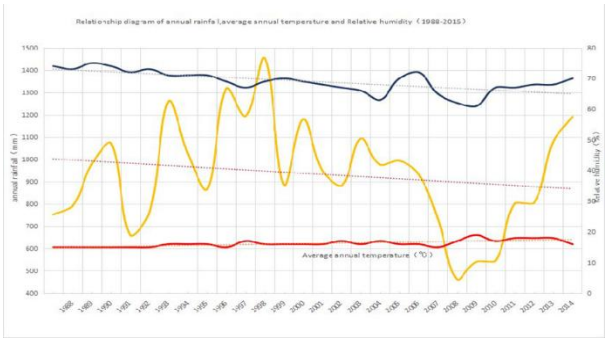

Fig. 9. Comparing the years 1988–2014 on a graph showing the average yearly temperature

Graph 3:

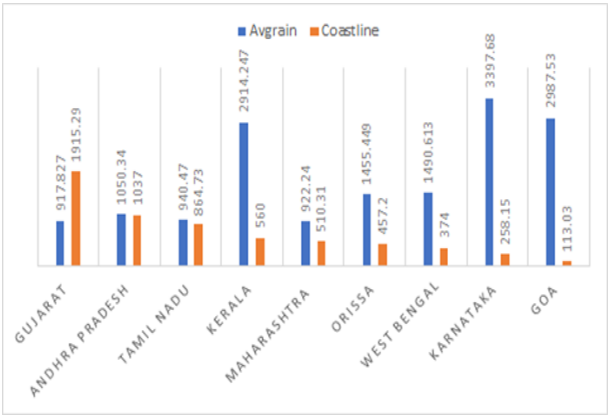

Fig. 10. Visual representation of the correlation between coastline and annual rainfall.

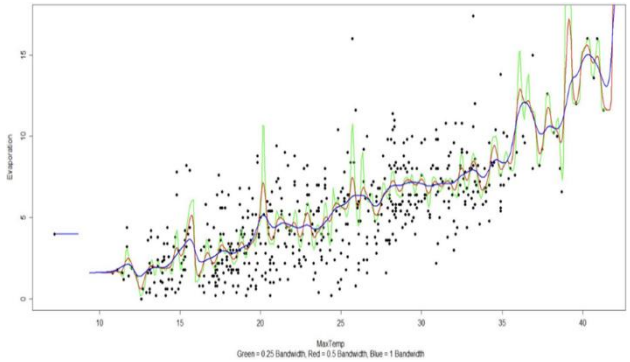

Fig.11. Comparison of Real and Estimated Data.

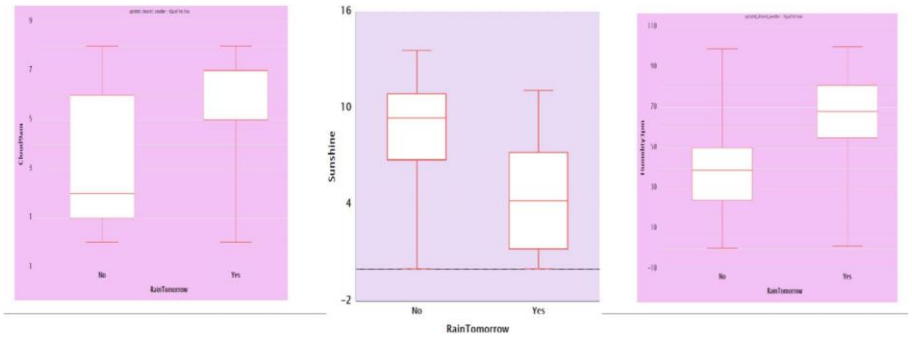

Fig.12. Feature Importance.

The purpose of this interactive user input capability is to enhance the user's comprehension of the text while viewing the predicted yearly rainfall in a specific location for a specific year. The output of this function is retrievable with only the year and state input.

CONCLUSION AND FUTURE SCOPE

India is among the nations that experience the effects of rain and bountiful harvests due to its economy's heavy dependence on agriculture. Predicting when it will rain is crucial for farmers to assess crop output. The primary goal of precipitation prediction systems is to provide you with information about when and how much precipitation is likely to fall. Reliable rainfall forecasts are essential for optimizing agricultural output, planning for future water infrastructure needs, and making optimal use of water resources. When doing so, it makes use of a plethora of data mining techniques. A numerical estimate of the rainfall is obtained by utilizing data mining techniques. The focus of this piece is on predicting when it will rain using data mining techniques. The management of water resources and agricultural practices in India is greatly influenced by rainfall. When people work together to make a decision, machine learning greatly increases the likelihood that they will share what they know. Predictions may be easily

made with machine learning, according to observations. Knowing how much rain and harvest to expect for the next season allows farmers to both make a name for themselves and prevent huge losses. With the use of these papers, we can easily predict when it will rain, giving farmers more options to prevent crop failure. More than one algorithm is compared in the article. Neural Networks, K-Nearest Neighbor, Decision Trees, and Naive Bayes are a few examples. Which method yields more precise rainfall predictions can be ascertained by contrasting the two. Forecasting when it will rain is no easy feat. Even though several approaches have been suggested, accurately predicting rainfall is still a difficult issue. Water scarcity and crop failure are persistent problems for the people of India because the country is heavily reliant on agriculture. Tiny shifts in the typical seasonal rainfall pattern can have a major impact on the farming sector. If weather forecasts were more reliable, natural disasters might be less devastating and inflict fewer casualties. An accurate rainfall forecast is useful for agricultural management and for preventing disasters like floods and droughts. You can get a detailed description of the outcomes of comparing several algorithms on this page. Predicting when it will rain requires the use of data mining techniques. Precipitation predictions can be enhanced going forward thanks to this work. Future iterations of this ML Model can be fine-tuned in a number of ways to make it even more effective and easier to use. These days, this model makes use of random forest classifier, linear regression, decision trees, and random forest regression. The challenge of rain prediction has multiple solutions. Predictions of future rainfall will be crucial for many industries, including agriculture, tourism, and the economy.

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