Rainfall prediction using Machine Learning

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***Abstract*—Rainfall will be difficult to predict using old methods, there are various ways for predicting the rainfall up until now, the prediction of the rainfall is accurate enough it will help many people in planning their days, farmers for their crops, and fishermen for their daily job basis. To solve this problem we developed a model using Machine learning Algorithms, which can predict the Rainfall based on the atmospheric factors to conclude whether it will rain or not. This will be extremely helpful for the meteorological department in forecasting rainfall.**

***Index Terms*—Machine learning, rainfall, prediction**

I. Introduction

Predicting rainfall accurately has long been a challenge, having devastating effects for a variety of industries, including agriculture, fisheries and meteorology. The reliability of weather forecasts has a direct impact on daily operations and long-term planning strategies for farmers scheduling crop planting, fishermen identifying best fishing periods, and meteorological organizations issuing warnings for extreme weather events. Despite advances in traditional forecasting approaches, there is still a pressing need for more precise and timely predictions to adequately reduce the dangers associated with rainfall variability. In response to this demand, we created a novel model that uses machine learning methods to increase rainfall prediction accuracy. By studying a wide range of atmospheric variables, our model strives to produce improved forecasts, providing essential insights to stakeholders that rely on weather data for decision-making. Our approach provides an important step in addressing the difficulties of rainfall prediction, with the potential to transform how we anticipate and adapt to changing weather patterns. By leveraging machine learning, we can better capture the intricate connections between atmospheric conditions and rainfall incidence. This improvement not only improves meteorological departments' operational skills, but also enables individuals and enterprises to plan ahead of time and adjust to weather-related issues. With more precise rainfall estimates, stakeholders can optimize resource allocation, reduce risks, and ultimately develop resilience in the face of unpredictable weather conditions.

II. Literature Review

[1] This work examines a number of atmospheric factors. Various meteorological parameters, including temperature, humidity, and dew point, are identified, and an extensive analysis is provided. Though just a few of the factors were significant in rainfall prediction. Based on these, a dataset machine learning method for rainfall prediction uses an effective collection of features. [2] In this article, hybrid optimized-by-PSO support vector regression (PSO-SVR), long-short term memory (LSTM), and convolutional neural network (CNN) rainfall forecasting techniques are presented.According to this article, PSO-SVR and LSTM methods outperformed CNN by about the same margin. [3] This paper assesses machine learning techniques for long-term daily rainfall prediction in a semi-arid climate, based on atmospheric patterns.Numerous indicators and data pertaining to rainfall intensity and frequency at daily, monthly, and annual aggregation scales are used to assess the models' performance. To assess the variations between models, analysis of variance is employed. [4] Simplified rainfall estimation models based on traditional machine learning algorithms—which are effective for these kinds of applications—present a comparative analysis in this paper. Using time-series data, models based on XGBoost and an ensemble of XGBR, Linear SVR, were assessed for rainfall forecasting.[5] This paper talks about the various methods and models utilized in rainfall prediction: These models focuses on machine learning algorithms remote sensing techniques and hybrid approaches and highlights the significance of accurate rainfall forecasting for various sectors. Machine learning algorithms used are decision trees, random forests, support vector machines and recurrent neural networks. The paper uses remote sensing techniques, utilizing satellites and radar systems provide valuable data for rainfall estimation over large areas and in real time, enhancing the precision and timeliness of forecasts.

Hybrid models combining machine learning and remote sensing offer promising avenues for improving prediction accuracy. The paper talks about using advanced technologies for more accurate and reliable rainfall forecasting. [6] This paper basically compared 24 machine learning models for day ahead photovoltaic (PV) power forecasting using numerical weather predictions (NWP). They found that the kernel ridge (KR) model performed best in terms of accuracy, although it required extensive training time and memory usage. The multilayer perceptron (MLP) model showed identical accuracy but with lower training time The paper showed that including additional predictors beyond basic NWP outputs led to a reduction in root mean square error (RMSE), Hyperparameter tuning was also found to be usefull for optimizing model performance with tuned models achieving lower RMSE compared to default settings. Their findings provide valuable insights into selecting the most suitable ML models and input features for operational PV forecasting. '[7] This research focuses on predicting rainfall across Ghana's distinct ecological zones. In this paper, five classification algorithms were used: Decision Tree, Random Forest, Multilayer Perceptron, Extreme Gradient Boosting, and K-Nearest Neighbor. They evaluated the classifiers' performance using criteria such as precision, f1-score, recall, total accuracy, and execution time. The findings show distinct classification criteria for rain and no rain classes in different zones. Decision Tree exhibited the fastest execution time across all zones, whereas Random Forest, Extreme Gradient Boosting, and Multilayer Perceptron performed consistently, indicating their potential for rainfall prediction. They have stated that future research should look into other classification methods and hybrid models. [8] The paper demonstrates two methods for forecasting rainfall: One based on Autocorrelation Function (ACF) and the other on projected error. they have also used various regression models like Bayesian Linear Regression (BLR), Boosted Decision Tree Regression (BDTR), Decision Forest Regression (DFR), and Neural Network Regression (NNR). They have observed that BDTR performs best in predicting rainfall using ACF with noticeable improvements achieved through cross validation and hyper parameter tuning. BDTR and DFR with LogNormal normalization demonstrated superior performance particularly in weekly error prediction. The study concludes that method 1 which is based on ACF provides the best rainfall prediction while acknowledging the potential for further enhancement. [9] The paper is a study on rainfall prediction in India: Various machine learning algorithms such as ARIMA, Artificial Neural Networks (ANN), Support Vector Machines (SVM), and Self Organizing Map (SOM) are used in this paper. Deep learning techniques like Multilayer Perceptron (MLP) and Auto Encoders are introduced for rainfall prediction which outperforms the traditional methods in terms of Mean Squared Error (MSE) and Root Mean Squared Error (RMSE). The study highlights the significance of accurate rainfall prediction for agricultural planning and disaster prevention and shows the potential of Artificial Neural Networks in handling nonlinear relationships in rainfall datasets. [10] The paper introduces a study focused on improving weather prediction methods to address the challenges posed by climate change: The paper particularly focuses on sectors like agriculture heavily reliant on weather conditions. The paper uses data analytics and machine learning like the random forest classification algorithm This method demonstrates results with an accuracy of 87.90 percent in predicting rain occurrences.

III. Design Methodology

The first part of our methodology involves the preprocessing the data which includes handling missing data, removing outliers, normalization. We after categorize the data into 2, training data and testing data. After that we will present the results based on the performance of the models. To evaluate accurate results, EDA Exploratory Data Analysis is used.

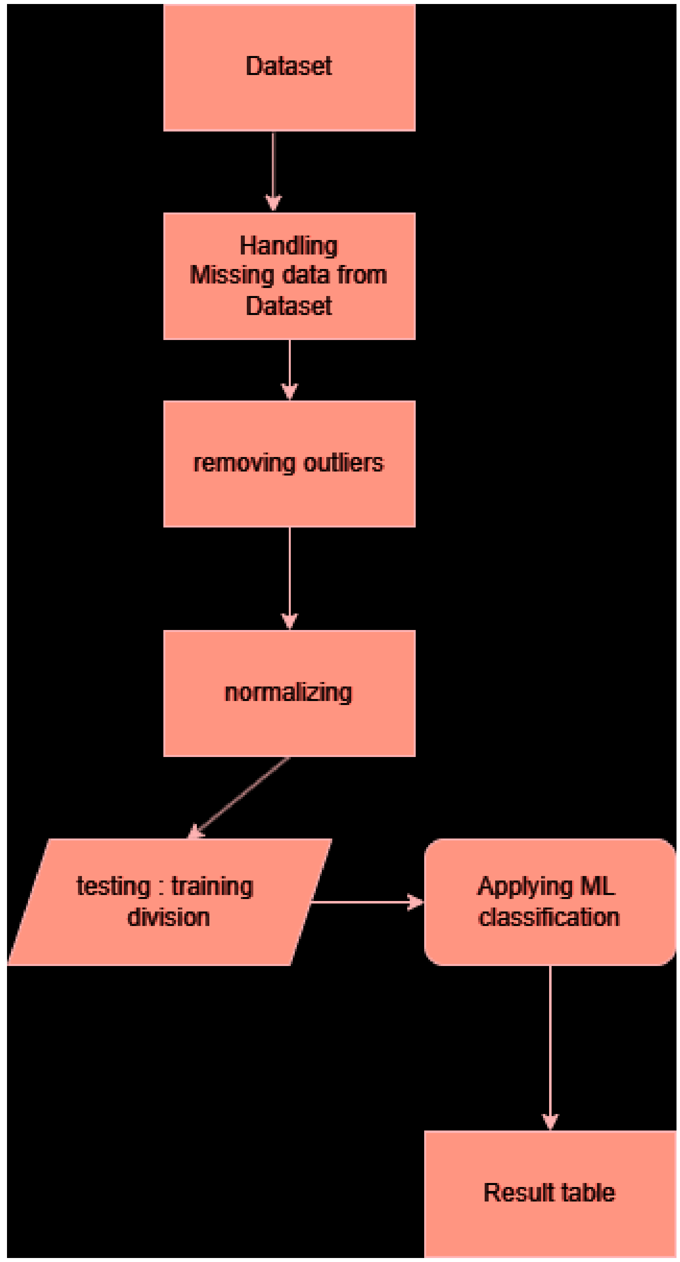

Fig. 1. Design Flowchart

A. understanding the data

In this section, we discuss about the dataset. We have used a dataset that contains the rainfall factors details categorised according to the location in Austrailia. (weatherAUS.csv). This dataset contains features such as Date, Location, MinTemp, MaxTemp, Humidity, WindGustSpeed, evaporation, sunshine, windDir, pressure some are categorised according to the time, for example cloud at 9 am, cloud at 3 pm. Finally there is target label which declares whether it rained on that particular day or the day after or not also the risk factor is mapped.

B. Pre-processing the Data

Pre-processing or cleaning the data is necessary, this will increase the accuracy of the calculation and also provide clarity to each segment of the data. We start of with the process of removing unwanted features such as the date, location, Rainfall, cloud9am, cloud3pm, risk-MM. Winddir. some of these features contains many null values, too much categorical data, irrelevant data. Next, we go with the process of replacing the null values with either mean/median for numerical data, or most-frequent for categorical data. So now we have a clean accurate data with relevant features. Next we will replace the null values of each columns. All these changes will be saved into the dataframe which will then be used for the next section that is Plotting the data.

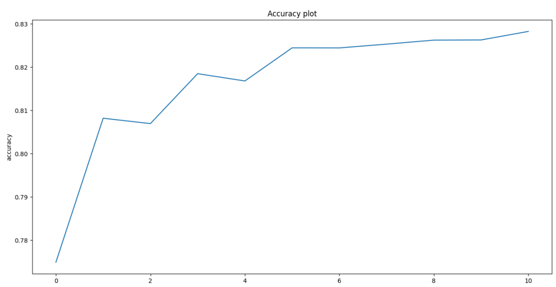

Fig. 2. Accuracy Plot

	precision	recall	f1-score	support
No	0.86	0.90	0.88	55435
Yes	0.57	0.49	0.53	15662
accuracy			0.81	71097
macro avg	0.72	0.69	0.70	71097
weighted avg	0.80	0.81	0.80	71097

Fig. 3. Performance score

C. Applying KNN classifiers

In this section we first classify the data into X-test,y-test,X-train and y-train with the test size of 0.5, that means 50percent will be split into test and 50percent to train dataset. After this we apply the KNNclassifiers() with k value of 3 and train the dataset. Further we predict the test-vector. we shall experiment the above prediction from K ranging from 1 to 11. For K=3 we calculate the accuracy and the performance metrics such as F1-score,recall and accuracy. Finally we store the accuracy that we got from K=1 to K=11 and plot it.

D. Tuning Hyper-parameter

In This section we will be finding the best K value to insert in KNN classifier using method called hyper-parameter tuning.Initially we take the K value as 3 and use the method RandomSearchCV(), we use this method instead of Grid-searchCV() is that, because the frequency of our dataset is huge in number. So we give the SearchCV values from 1 to 100 to give us the best K value out of which we are going to be using in our model. For now we just find the best value for n-neighbors. In this case we got the best K value as 68. refer fig. [5].

```
best K value: {'n_neighbors': 68}
```

Fig. 4. Fitting

IV. Results

Lab - 3 progress :- Understood to topic, Structured the introductions and abstract, conducted a literature survey and designed methodology.

Lab - 4 progress :- data pre-processing.

Lab - 5 progress :- pre-processed data more effciently and implemented used KNNclassifiers, compared the K values and plotted accuracy and checked the fitting of our data set.

Lab - 6 progress :- Hyper parameter tuning for KNNclassifiers, tuned n-neighbors. some minor changes in the report.

V. Conclusion

Do you think the classes you have in your dataset are well separated? Justify your answer. Yes, partially though, even when we get accuracy above 80 we still had to drop some of the columns to remove the outliers. Explain the behavior of the kNN classifier with increase in value of k. Explain the scenarios of over-fitting and under-fitting in kNN classifier. As we plotted the accuracy plot we can see that we get a curve shaped line structure this means upto k=11 the accuracy is varying with slight variance. Underfitting occurs when the train accuracy is less and Overfitting occurs when the testing accuracy is less. In our case we get the both testing and training accuracy more that 80percent which is a Good fitting dataset. Do you think the kNN classifier is a good classifier based on the results obtained on various metrics? although we get 80% accuracy by using KNNclassifiers, we can train the model with other classification or regression algorithm. Also the accuracy can be increased in KNNclassifier by label encoding, since we did not do label encoding in our progress, the more we add the features the more accuracy will increase. Do you think the model has regular fit situation?Use train and testset performances to arrive at this inference. Yes as you can see in Fig. 4. we get the testing accuracy and training accuracy ¿ 80%. Overfitting happens when the testing accuracy is less. which in our case, is not.

```
testing_accuracy: 0.8274188784336892
training_accuracy: 0.8534516709800832
lets consider 80% as a good accuracy
good fitting
```

Fig. 5. Fitting

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