RAINFALL PREDICTION ANALYSIS USING MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE

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DECLARATION CERTIFICATE

This is to certify that the work presented in the thesis entitled **"RAINFALL PREDICTION ANALYSIS USING MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE"** in partial fulfillment of the requirement for the award of degree of **Bachelor of Computer Application** of Institute of Engineering & Management is an authentic work carried out under my supervision and guidance.

To the best of my knowledge the content of this thesis does not form a basis for the award of any previous Degree to anyone else.

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CERTIFICATE OF APPROVAL

The foregoing thesis entitled **"RAINFALL PREDICTION ANALYSIS USING MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE"** is hereby approved as a creditable study of research topic and has been presented in satisfactory manner to warrant its acceptance as prerequisite to the degree for which it has been submitted.

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Contents

Abstract

A crucial part of daily living is weather forecasting, and machine learning (ML) and artificial intelligence (AI) have shown promise in boosting timeliness and accuracy. This paper examines how ML and AI approaches may be used to forecast the weather using linear regression, with a particular emphasis on predicting maximum rainfall using meteorological data from a particular region in India. The process of selecting a model, engineering features, and pre-processing data are all described in depth in the paper, along with assessment measures for judging model performance. Nevertheless, issues with data quality and system complexity might lead to restrictions.

Keywords: Machine Learning, Artificial Intelligence, rainfall, weather.

Chapter 1

1.1 Introduction

In India, Monsoon is a weather phenomenon that affects the Indian subcontinent during the months of June-September every year. It is characterized by heavy rainfall, high humidity, and strong wind patterns. During the summer months, the land mass of India heats up faster than the surrounding ocean waters. As a result, there is high pressure over the ocean and low pressure over the land, which causes winds to blow from the ocean towards the land carrying moisture. These winds bring copious amounts of rainfall to different parts of the subcontinent, which is necessary for agriculture and irrigation purposes. The Indian Monsoon is an essential climatic phenomenon that influences the economy and lives of millions of people in the region. However, it is also known to cause floods, landslides, and other natural disasters, which can have devastating consequences. Therefore, accurate and timely weather predictions are crucial for minimizing the potential risks associated [1].

Chapter 2

2.1 Background Studies

The main objective of this project is to deliver precise and trustworthy forecasts of rainfall for various purposes, such as agriculture, water management, and disaster preparedness. The quality and quantity of data used to train the model, the selection of input variables, and the algorithms and modelling approaches employed all have an impact on accuracy.

2.2 Related works

India is a large nation in South Asia with 1.3 billion inhabitants. It borders the Bay of Bengal on the east, the Arabian Sea on the west, and the Indian Ocean on the south. Its weather is typical for the region, with several seasons and climatic regions like the Thar Desert and the Mountains. Extreme weather has occurred there, including a very hot temperature in western India (the Thar Desert) and a very cold climate in northern India (Dehradun) [2]. India has experienced different monsoon seasons such as Pre Monsoon, South West Monsoon, Post monsoon and Winter Monsoon. There are more than 120 research papers available on the web-based on Indian climate and natural disasters due to excess amount of rainfall.

India faces one of the biggest climatic changes in the entire decade, which results in different climatic natural disasters like cyclones, floods, landslides, etc. due to global warming, which has recently become a trending topic in the entire climatic department. Indian climate has changed drastically because the average temperature of India has increased by only 1.5 °C. So, India faces cyclones, floods, etc. more often than usual [3].

India has experienced different amounts of rainfall during the South West monsoon season i.e. from June to September in different parts of India every year. Due to some irregularity in average temperature, India experienced an irregular amount of rainfall, often the main reason for devastating floods and landslides in the mountainous regions. From 2012 to 2016, India experienced normal rainfall every year but from 2017 onwards, India experienced sometimes normal, above-normal or below-normal rainfall due to an increase in average temperature because of global warming.

India experienced one or two tropical cyclones every year. Cyclones that hit India before 2016 are much weaker than cyclones nowadays. For example, Cyclone Nilam in 2012 (that affected South India, and Sri Lanka) was a cyclonic storm that has a maximum wind speed of 100 km/h (65 mph), whereas in 2020 Cyclone Amphan (that affected East India, Bangladesh, Sri Lanka, Bhutan, Myanmar and Thailand) was a Super Cyclonic Storm which has a maximum wind speed of 270 km/h (165 mph). Every year, Cyclones which originated from the Bay of Bengal are more powerful year after year [4].

In 2018, Kerala experienced a devastating flood due to more heavy rainfall than usual during the monsoon season. The Indian Meteorological Department issued a red alert for extremely heavy rainfall from 9th to 15th August 2018 and experienced over 300 mm of rainfall. Idukki and Wayanad were two districts in Kerala that experienced extreme heavy rainfall, and PQPF (Probabilistic Quantitative Precipitation Forecasting) forecasts four to five days in advance successfully indicated the extreme nature of the two downfall occurrences. [5].

In 2018, Bihar experienced unstable rainfall conditions which caused huge damage to the agricultural sector. The weekly rainfall forecast over Bihar has been changed up to 2 weeks in advance and is calibrated by the Indian Meteorological Department (IMD). The Madden-Julian Oscillation (MJO) and its close relationship to monsoonal oscillation are important for sub-seasonal to seasonal (S2S) rainfall prediction in Bihar. The rainfall over Bihar varies from 33% to 55% during June-September 2018. [6].

Chapter 3

3.1 Proposed Methodology

In India, the monsoon season is marked by a lot of rain, gusty winds, and high humidity. It is essential for India's agriculture and economy since it refills water reservoirs and provides water for crops. India's various areas see differing amounts of precipitation, with the south and northeast receiving the most. Landslides and flooding, however, have the potential to cause casualties as well as damage to property [7].

India experiences monsoon twice a year in South India, one during the monsoon season and the other one during the winter season as a retreating monsoon [20]. India has been divided into 4 regions according to the rainfall received every year. These regions are as – (a) North-West India, (b) Central India, (c) South India, (d) East and North - East India.

In these regions, North-West (NW) India received normal rainfall throughout the year but East and North-East India received excess rainfall during the monsoon season. In South India, Tamil Nadu receives rainfall in the winter season [8].

The annual month-wise rainfall in these regions from 2012 to 2021 is described in the following tables. **Table 1** shows the annual rainfall of North West India, **Table 2** shows the annual rainfall of Central India, **Table 3** shows the annual rainfall of South India and **Table 4** shows the annual rainfall of East and North East India [9,10,11,12,13,14,15,16,17,18].

Table 1: Table showing Annual Rainfall of North-West India from 2012 - 2021

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
2012	44.2	31.8	16.8	35.8	18.7	21.7	161.1	249.6	135.3	4.8	3.5	18.8	742.1
2013	29.8	87.3	20.6	20.0	17.9	155.0	204.3	247.2	65.6	40.7	6.2	9.3	903.9
2014	46.6	41.5	66.2	33.4	32.7	31.3	158.5	135.0	158.1	23.7	4.6	9.8	741.4
2015	23.5	55.7	126.0	61.2	25.2	90.6	228.3	136.0	55.8	24.9	9.7	11.6	848.5
2016	10.3	14.4	57.6	21.3	34.7	64.8	239.4	227.1	54.3	14.9	0.0	1.7	740.5
2017	76.3	27.0	28.2	44.0	30.7	105.9	232.9	145.3	70.0	0.7	3.4	23.6	788.0
2018	3.4	22.0	17.0	38.5	24.4	81.0	204.3	197.6	122.3	6.9	20.5	7.5	745.4
2019	46.5	75.7	26.1	23.2	28.9	53.1	213.8	207.2	121.0	22.3	47.9	29.3	895.0
2020	57.7	10.9	83.9	26.6	40.2	78.0	156.9	213.0	59.0	1.4	16.8	16.0	760.4
2021	28.4	10.6	27.0	29.7	68.2	85.6	196.6	140.8	153.2	67.0	5.2	8.3	820.6

Table 2: Table showing Annual Rainfall of Central India from 2012 - 2021

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
2012	21.2	1.5	0.3	11.5	6.7	98.9	311.9	305.2	218.0	37.9	16.7	1.6	1031.4
2013	2.2	16.1	4.5	17.4	10.6	275.9	437.8	299.7	180.5	138.4	1.3	1.4	1385.8
2014	9.3	20.4	20.3	6.3	24.4	64.6	358.5	256.4	201.1	43.5	7.2	6.4	1018.4
2015	18.2	3.5	35.4	25.8	12.3	204.5	267.9	204.8	141.8	22.5	4.0	2.7	943.4
2016	4.4	3.8	10.9	2.5	19.1	137.3	382.9	320.9	194.6	66.7	1.7	0.2	1145.0
2017	1.7	1.2	6.0	1.4	16.3	173.4	358.9	230.9	156.3	63.8	5.1	3.4	1018.4
2018	0.0	6.7	0.7	16.8	20.0	159.8	352.4	273.6	125.3	22.1	3.4	13.3	994.1
2019	4.7	6.7	7.5	10.3	14.3	117.4	350.8	427.7	367.3	106.9	12.4	5.0	1431.0
2020	13.8	14.7	26.8	23.9	25.8	219.9	250.6	495.0	157.0	76.9	3.0	4.4	1311.8
2021	3.6	5.1	5.2	9.3	70.6	197.5	298.9	188.4	327.7	59.5	21.9	24.9	1212.6

Table 3: Table showing Annual Rainfall of South India from 2012 - 2021

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
2012	10.2	1.7	3.9	55.9	41.9	113.0	178.7	207.3	145.0	139.6	101.4	18.8	1017.4
2013	3.2	25.0	13.4	28.7	53.9	206.1	274.6	164.9	180.1	193.3	56.9	14.4	1214.5
2014	2.5	3.6	19.8	22.2	111.4	100.1	199.4	229.1	136.7	156.8	50.2	26.4	1058.2
2015	6.6	1.0	22.4	78.4	79.0	187.6	110.2	146.2	161.0	99.0	172.7	45.4	1109.5
2016	3.5	1.6	5.9	7.3	96.6	199.1	193.3	108.7	159.2	54.8	17.3	37.6	884.9
2017	12.5	0.3	21.4	17.2	73.5	171.8	140.7	209.5	196.8	159.5	54.1	28.8	1086.1
2018	3.6	5.1	19.5	33.8	110.4	182.8	200.5	222.9	97.2	92.2	56.8	24.6	1049.4
2019	10.0	3.0	4.1	24.5	36.7	112.3	194.3	296.1	238.2	238.1	49.4	34.9	1241.6
2020	6.5	3.7	12.8	41.5	61.6	171.9	250.7	255.6	259.6	167.6	100.6	51.1	1383.2
2021	46.0	10.2	6.0	43.0	119.2	166.4	274.9	168.4	194.8	184.9	232.6	27.0	1473.4

Table 4: Table showing Annual Rainfall of East and North-East India from 2012 - 2021

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
2012	23.5	13.2	33.1	135.6	96.7	347.9	380.3	264.0	313.4	106.3	25.5	10.7	1750.2
2013	4.7	18.5	32.5	79.3	239.4	243.3	288.5	286.0	227.7	201.8	3.3	3.0	1628.0
2014	8.2	44.5	31.4	33.6	205.3	277.3	329.5	405.1	280.9	45.9	4.6	2.3	1668.6
2015	16.2	16.2	39.6	162.5	162.9	347.7	368.7	405.8	221.3	47.9	9.9	12.8	1811.5
2016	15.5	25.7	51.6	141.7	200.5	265.5	431.3	253.3	341.9	104.5	23.3	2.4	1857.2
2017	3.0	22.9	88.6	169.0	168.0	299.6	441.9	414.3	254.1	178.1	7.9	13.7	2061.1
2018	7.0	16.7	45.1	95.4	179.5	257.8	334.3	272.8	212.0	49.3	14.8	19.1	1503.8
2019	4.0	44.0	46.4	101.0	190.4	223.1	481.9	213.6	325.1	128.6	18.3	10.5	1786.9
2020	29.3	19.5	46.4	114.7	242.7	400.1	472.0	285.1	351.8	119.4	20.2	3.2	2104.4
2021	7.8	3.9	34.4	65.1	248.7	356.9	320.4	354.3	212.9	149.6	11.5	26.8	1792.3

From these above tables, we can see that rainfall in Central India varies from rainfall in East and North East India. From those above tables, we can easily calculate the annual rainfall of that region year-wise.

Chapter 4

4.1 Experimental Dataset

4.1.1 Overview of Python

High-level programming language Python was developed in 1989 by Guido van Rossum. It is renowned for being straightforward, readable, and simple to use. It has a sizable and vibrant development community that has contributed to a sizable library of modules and packages. As it is an interpreted language, code may be executed without first being compiled. It is a strong and popular language that keeps developing and growing as more applications are added [19].

4.1.2 Library and methods used

- Scikit-learn: It is a free machine-learning library that provides classification, regression, and clustering methods [20].
- Pandas: Pandas is a free software library for data manipulation and analysis, providing data structures and operations for numerical tables [21].
- Numpy: NumPy is a package, which supports a variety of mathematical operations and multi-dimensional arrays and it is used in data science, machine learning etc. [22].

4.1.3 Algorithm and model used

Supervised learning is a type of machine learning algorithm that uses training data to instruct a computer to make or take decisions. In supervised learning, an algorithm takes the correct output data as well as the input data and uses that data to learn how to teach new input data to adjust the output. For example, in a supervised learning model for image recognition, the algorithm is trained using a dataset of label images, where each image is labeled with the real objects or class it represents. This information can be used to identify objects in new images.

Linear regression is a supervised learning technique used to describe the connection between a dependent variable and one or more independent variables. Its accuracy is based on the consistency and linearity of the data as well as the model's presumptions. On the other hand, it could not be as accurate as more complex models when there are interactions or non-linear relationships. [23].

4.1.4 Datasets Used

We uses the datasets of **North West India, South India, East and North East India, Central India** for prediction and the dataset contains of only two columns such as, **Year, Total Rainfall (in mm)**. The data is collected from the **Table 1 to 4**. The given table showing all the datasets are –

REGIONS	DATASETS
North-West India	program.py dataset_NW.csv × Program > dataset_NW.csv Year,Rainfall 2012,742.1 2013,903.9 2014,741.4 2015,848.5 2016,740.5 2017,788.0 2018,745.4 2019,895.0 2020,760.4 2021,820.6
Central India	program.py dataset_Central.csv × Program > dataset_Central.csv Year,Rainfall, 2012,1031.4, 2013,1385.8, 2014,1018.4, 2015,943.4, 2016,1145.0, 2017,1018.4, 2018,994.1, 2019,1431.0, 2020,1311.8, 2021,1212.6,
South India	program.py dataset_South.csv × Program > dataset_South.csv Year,Rainfall, 2012,1017.4, 2013,1214.5, 2014,1058.2, 2015,1109.5, 2016,884.9, 2017,1086.1, 2018,1049.4, 2019,1241.6, 2020,1383.2, 2021,1473.4,

East and North-East India	program.py dataset_East_NE.csv Program > dataset_East_NE.csv Year,Rainfall 2012,1750.2 2013,1628 2014,1668.6 2015,1811.5 2016,1857.2 2017,2061.1 2018,1503.8 2019,1786.9 2020,2104.4 2021,1792.3

Using these datasets, we can predict the rainfall prediction of these regions for **2024** using Linear Regression and also find out that the rainfall is normal or abnormal in these regions from **2012 to 2021**. The code for the rainfall prediction is given below –

4.1.5 Codes

```
import numpy as num
import pandas as pand
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split

dataset = pand.read_csv('dataset_East_NE.csv')

mean_rainfall = num.mean(dataset['Rainfall'])
std_rainfall = num.std(dataset['Rainfall'])

threshold = mean_rainfall + std_rainfall

classification = []
for rainfall in dataset['Rainfall']:
    if rainfall < threshold:
        classification.append('Normal')
    else:
        classification.append('Abnormal')
```

```
classified_data = pand.DataFrame({'Year': dataset['Year'],
'Classification': classification})

print(classified_data)

model = LinearRegression()

X = dataset['Year'].values.reshape(-1, 1)
y = dataset['Rainfall'].values.reshape(-1, 1)

X, X_test, y, y_test = train_test_split(X, y, test_size=0.2)
model.fit(X, y)

next_year = [[2024]]
predicted_rainfall = model.predict(next_year)
print(f"Predicted rainfall for 2024 :
{predicted_rainfall[0][0]:.2f} mm")
```

Here is the algorithm of the above code:

- Import required libraries: NumPy, Pandas, LinearRegression, and train_test_split from scikit-learn.
- Load the dataset from the '**dataset_NW.csv**' file using Pandas and store it in the 'dataset' variable.
- Calculate the Mean/Average and Standard Deviation of the 'Rainfall' column of the dataset using NumPy.
- Set a rainfall threshold by adding the mean and standard deviation, and classify each year's rainfall as 'Normal' or 'Abnormal' based on whether it is less than or greater than the threshold.
- Create a new Pandas DataFrame called 'classified_data' with the 'Year' and 'Classification' columns.
- Create a LinearRegression model.
- Set the input features (X) as the 'Year' column of the dataset and the output variable (y) as the 'Rainfall' column of the dataset.
- Split the following dataset into training and testing sets using train_test_split from scikit-learn.

- Fit the LinearRegression model to the training data.
- Predict the rainfall for the year 2024 using the trained model.
- Print the predicted rainfall for the year 2024.

Chapter 5

5.1 Result and Discussions

According to the above datasets, we want to find out the regions receiving normal and abnormal rainfall from the given period of 10 years and the above code will provide the output. The output is -

REGIONS	NORMAL OR ABNORMAL RAINFALL
North-West India	Year Classification 2012 Normal 2013 Abnormal 2014 Normal 2015 Normal 2016 Normal 2017 Normal 2018 Normal 2019 Abnormal 2020 Normal 2021 Normal
Central India	Year Classification 2012 Normal 2013 Abnormal 2014 Normal 2015 Normal 2016 Normal 2017 Normal 2018 Normal 2019 Abnormal 2020 Normal 2021 Normal

South India	Year Classification 2012 Normal 2013 Normal 2014 Normal 2015 Normal 2016 Normal 2017 Normal 2018 Normal 2019 Normal 2020 Abnormal 2021 Abnormal
East and North East India	Year Classification 2012 Normal 2013 Normal 2014 Normal 2015 Normal 2016 Normal 2017 Abnormal 2018 Normal 2019 Normal 2020 Abnormal 2021 Normal

Suppose, we want to forecast the amount of precipitation for the year 2024, the above code will provide the forecasted amount of precipitation for the year 2024 based on the linear regression model trained on the precipitation data from the past 10 years of those regions. The output is –

REGIONS	PREDICTED RAINFALL FOR YEAR 2024
North West India	Predicted rainfall for 2024 : 784.78 mm
Central India	Predicted rainfall for 2024 : 1381.91 mm
South India	Predicted rainfall for 2024 : 1436.70 mm
East and North East India	Predicted rainfall for 2024 : 2108.26 mm

The expected quantity of precipitation in millimeters for the year **2024** is therefore around **784.78 mm** in North West India, **1381.91 mm** in Central India, **1436.70 mm** in South India, **2108.26 mm** in East and North East India, according to the linear regression model. It is crucial to remember that this is simply a projection and that the actual amount of rainfall in 2024 may fluctuate as a result of a number of environmental conditions that were not taken into account by the model. Additionally, the quality and amount of the data used to train the model may have an impact on how accurate the forecast is.

The outcome of this code is a predicted value for the rainfall in the year 2024 based on the trained LinearRegression model. However, it is important to note that without further analysis and evaluation of the model's performance, we cannot conclude whether the predicted rainfall is accurate or not. Additionally, the classification of rainfall as 'Normal' or 'Abnormal' based on a threshold calculated from the mean and standard deviation may not be appropriate for all datasets and should be validated through further analysis.

Chapter 6

6.1 Conclusion

This study used a dataset of yearly rainfall collected over 10 years to investigate the use of linear regression in rainfall prediction. The findings emphasized the need of high-quality data and the demand for more variables to boost the model precision. The study also illustrates the use of linear regression models for weather forecasting and establishes the framework for further investigation of this strategy using more variables, bigger datasets, and more models.

6.2 Future Work

There is a huge future potential for improving water management, disaster preparedness, and agriculture in India by utilizing machine learning and AI to predict rainfall. The integration of IoT devices, forecasting extreme weather events, enhancing accuracy and granularity, creating decision support systems, and combining with agricultural yield prediction models are possible future research and application topics. Further investigation and development in this field might result in more precise forecasts and improved decision-making for farmers and decision-makers.

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