Environment monitoring for Asthma Patients

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Abstract

- This paper introduces the relationship between air quality and asthma. Air pollutants, such as particulate matter, ozone, Sulphur dioxide, and carbon monoxide, can exacerbate asthma symptoms and contribute to the onset of asthma in susceptible individuals. The paper outlines the mechanisms.
- This systematic review and meta-analysis aimed to identify the prediction performance of ML-based prediction models for asthma exacerbations and address the uncertainty of whether modern ML methods could become an alternative option to predict asthma exacerbations.
- We take data from different sensors to see how patients are getting affected by various pollutants present in the air. Then use Linear Regression ML model ,Thing speak, Google Collaboratory and different cloud computing aspects to predict air quality.

INTRODUCTION

- **Air quality** refers to the composition of gases and particles present in the atmosphere, which can vary based on factors such as industrial activities, transportation, and natural processes.
- The **Air Quality Index (AQI)** is a standardized measurement used to communicate how polluted or clean the air is in a specific area at a given time. It provides an easily understandable way to convey information about air quality to the public.
- **Key pollutants** such as ozone, nitrogen dioxide, Sulphur dioxide, Carbon monoxide and PM2.5

Poor air quality, characterized by high levels of pollutants, can exacerbate respiratory conditions such as asthma by causing inflammation and irritation in the airways.

a) Ozone (O3): Formed from chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Ozone can irritate the lungs and exacerbate asthma symptoms. It causes irritation to the lungs and trigger asthma

b) Nitrogen Dioxide (NO2) and Sulphur Dioxide (SO2): Produced primarily from combustion processes, such as vehicle emissions and industrial activities. These gases can cause respiratory irritation and worsen asthma.

c) PM2.5: Fine particulate matter with a diameter of 2.5 micrometers or smaller, generated from vehicle exhaust, industrial emissions, and natural sources like wildfires. PM2.5 can penetrate deep into the lungs, triggering asthma attacks and exacerbating respiratory conditions.

d) Carbon monoxide binds more strongly to hemoglobin in red blood cells than oxygen does. When carbon monoxide is present in the air, it can reduce the amount of oxygen that is transported in the blood. This reduced oxygen delivery can exacerbate asthma symptoms, as the lungs and other tissues may not receive enough oxygen to function properly.

Literature Survey-

1) https://circuitdigest.com/microcontroller-projects/arduino-based-air-quality-monitoring-system
The Air Quality Monitoring System operates by utilizing sensors to detect environmental parameters like gas levels, temperature, and humidity. Specifically, analog readings from the gas sensor, connected to an Arduino's analog pin, provide data on the air quality. These readings are mapped to predefined thresholds, categorizing the air quality as "Good," "Poor," "Very Bad," or "Toxic."

2)https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8639242/#:~:text=Niranjana%20et%20al.,to%20display%20all%20the%20information
To develop a user-friendly asthma patient monitoring system to monitor the patient's environment and provide precautions. Researchers used a gas sensor, humidity and temperature sensors to display all the information. The values obtained from the sensor are uploaded to the cloud. Researchers also developed an Android application. The main feature of the application is the asthma and trigger symptom test.

3) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10156986/
This paper provides information about various gases we are checking on and its harmful effects on humans.

4)https://www.researchgate.net/profile/MiguelAriza2/publication/272511376_Impact_of_Environmental_Air_Pollutants_on_Disease_Control_in_Asmathic_Patients/links/55a6b88908ae92aac77f4653/Impact-of-Environmental-Air-Pollutants-on-Disease-Control-in-Asmathic-Patients.pdf
We performed a cross-sectional study of adult asthmatics in stable condition. From the regional environmental authority, we obtained the concentrations of ambient nitric oxide (NO2), ozone (O3), suspended particulate matter up to 10 micrometers in diameter (PM10) and sulphur dioxide (SO2) at fixed geographical points.

5) https://content.iospress.com/articles/journal-of-ambient-intelligence-and-smart-environments/ais200574

6) https://iarjset.com/wp-content/uploads/2021/08/IARJSET.2021.8783.pdf
using ThingSpeak, daily testing, allowing the patient and physician to assess improvement from prior days. According to the suggestions of physicians and telemedicine professionals, the band gadget is also linked with medical criteria. Finally, the smart bronchodilator is linked to the band to make it easier to locate.

7) https://www.irjmets.com/uploadedfiles/paper/issue_5_may_2023/38938/final/fin_irjmets1684333977.pdf
we make predictions about the patient's potential for asthma. The hardware and software components make up the setup's two primary elements. The project's hardware consists of a variety of sensors, including PEFR and ESP8266. The information is sent to cloud servers after it has been collected by the sensors and is then displayed on the website. Our ML model also receives this data, which it uses to predict the the potential for asthma.

8) https://link.springer.com/article/10.1007/s11356-022-24117-y
Deals with COPD

9) https://www.tandfonline.com/doi/abs/10.1080/15287394.2016.1153548
Different effects of long-term exposures to SO_2 and NO_2 air pollutants on asthma severity in young adults.

10) https://erj.ersjournals.com/content/11/3/686.short
ERS Journals Ltd 1998. ABSTRACT: Exacerbations of asthma have been associated with exposure to ozone or particles with a 50% cut-off aerodynamic diameter of 10 µm (PM10). We postulated in this study that the association of summertime air pollution (i.e. ozone and PM10) with acute respiratory symptoms, medication use and peak expiratory flow differs among patients grouped according to asthma severity

11)https://www.google.com/url?q=https://publications.jrc.ec.europa.eu/repository/bitstream/JRC107461/low_cost_sensors_web.pdf&sa=U&sqi=2&ved=2ahUKEwiShvKGo4WFAxXB7zgGHcagAYoQFnoECBIQBQ&usg=AOvVaw0PQ8_C-9AF_9usK48VPE6i
The ultrasensitive H2S gas sensor based on this heterostructure material has been fabricated. It can distinguish asthmatic patients from healthy people roughly by analyzing the H2S concentration in their exhaled breaths. In addition, it can also be used to monitor the severity of asthma.

12) https://pubs.acs.org/doi/10.1021/acssensors.2c00737#:~:text=The%20ultrasensitive%20H2S,monitor%20the%20severity%20of%20asthma
Asthma is a chronic disease characterized by recurrent attacks of breathlessness and wheezing, which vary in severity and frequency from person to person. H_2S is considered as the biomarker of asthma. Here, an ultrasensitive chemiresistive H_2S gas sensor based on a γ-Bi_2MoO_6–CuO heterostructure with a detection limit of 5 ppb has been fabricated. It can distinguish asthmatic patients from healthy people roughly by analyzing the exhaled breaths of 28 asthmatic patients and 28 healthy people, suggesting that the sensor can be used to assist physicians in the diagnosis of asthma.

13) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10386701/
Machine learning (ML)-based prediction models have been increasingly developed to predict asthma exacerbations in recent years. This systematic review and meta-analysis aimed to identify the prediction performance of ML-based prediction models for asthma exacerbations and address the uncertainty of whether modern ML methods could become an alternative option to predict asthma exacerbations.

14)https://d1wqtxts1xzle7.cloudfront.net/53580349/An_investigation_of_the_environmental_de20170619-2985-jv8jgi-libre.pdf?1497880420=&response-content
disposition=inline%3B+filename%3DAn_investigation_of_the_environmental_de.pdf&Expires=1713550148&Signature=GE2zTXXqLtTTd7QEkTsJvP7z0pURe-
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Due to asthma exacerbation are associated with high levels of NO2, low NDVI values, and high temperatures throughout all seasons. Therefore, it can be concluded that asthmatic people living in highly urbanized and sparsely vegetated areas have a greater risk of suffering severe asthma attacks. The availability of new, free remote sensing sensors with high spectral and temporal resolution has permitted long-term time series analysis and enhanced the understanding of health geography
15) https://ieeexplore.ieee.org/abstract/document/7916737
Respiratory monitoring system for asthma patients based on IoT

Aim/Problem Statement-

- To develop a predictive model to forecast asthma exacerbations based on environmental factors.

Objective-

1) It can help identify specific environmental variables that are associated with increased asthma exacerbations. This information can be crucial for understanding the key triggers of asthma attacks and implementing targeted interventions to reduce exposure to these risk factors.

2) Understanding the relationship between environmental factors and asthma outcomes can enable the development of personalized interventions for individuals with asthma. Patients can be provided with guidance on avoiding specific triggers based on their local environmental conditions, ultimately leading to better asthma management and improved quality of life.

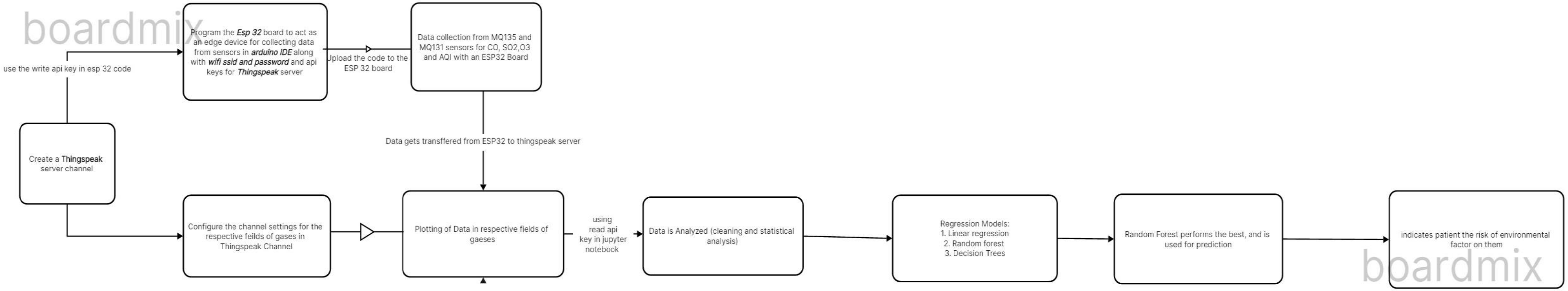
Modelling/Design Flow

<u>Machine Learning Approach:-</u>

- Developing a predictive model to forecast asthma exacerbations based on environmental factors and historical asthma-related events.
- Time-series analysis and regression techniques can be applied to model the relationship between environmental variables and asthma outcomes.

1. **Data Collection**: The first step is to gather relevant data on environmental variables and asthma outcomes and other potential environmental triggers. Asthma outcomes could include hospital admissions, emergency room visits, medication usage, or self-reported symptom severity.
2. **Data Preparation**: Once the data is collected, cleaning the data to remove errors or missing values, aggregating data to appropriate time and ensuring consistency in units and formats.
3. **Exploratory Data Analysis (EDA)**: identify patterns in data is done , trends, and correlations between environmental variables and asthma outcomes. EDA techniques such as time-series plots, correlation analysis, and descriptive statistics can be used
4. **Model Evaluation**: Once the models are developed, they need to be evaluated to assess their predictive performance and validity. This involves techniques such as cross-validation, goodness-of-fit tests, and assessing the residuals for any patterns or biases.
5. **Interpretation and Inference**: Finally, the results of the analysis need to be interpreted in the context of the research question and domain knowledge. Insights gained from the models can help identify significant environmental factors contributing to asthma outcomes, quantify their effects, and inform public health interventions or policy decisions aimed at reducing asthma morbidity and improving air quality.

Block Diagram/Flow Chart



Methodology

1) Collection data collection was done through sensors

2) After collection of data from sensors it was connected to things speak

3) Using the API of things speak it was sent to our Python file from there EDA was done

4) Using Exploratory data analysis data was cleaned, null values were removed ,outliers were detected and the model was fit on the particular data set.

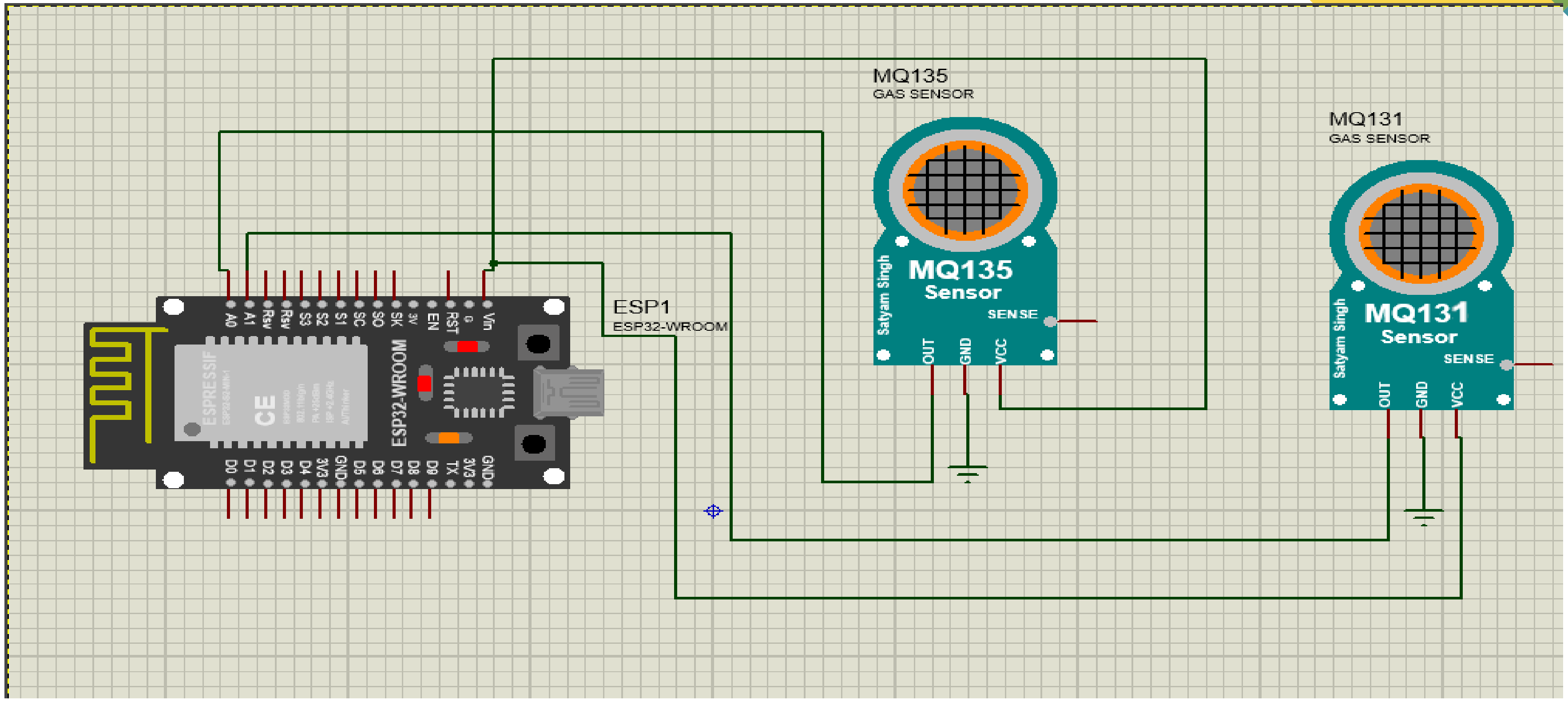
Interpretation of AQI levels:

0-70: Low chance of asthma
70-110: Low risk environment for asthma
110+: Very high risk for asthma

Components used-

S.No.	Components	Quantity
1	MQ135 gas sensor for detecting AQI and CO levels	1 each
2	MQ131 gas sensor for detecting O3 and SO2 gases	1
3	ESP32	1
4	Breadboard	1
5	Jumper wires	As per requirement

Hardware Design-



Code

```

// WiFi credentials
const char* ssid = "Aditya mobile";
const char* password = "aditya06";

// ThingSpeak settings
const char* server = "api.thingspeak.com";
const String apiKey = "USSVFVQP91CK3T3P";
const int port = 80;

// Pin connected to the analog output of the MQ135 sensor
const int MQ135_pin = 34; // Use the appropriate pin on your ESP32 board

// Initialize the MQ135 sensor
const float RZERO = 76.63; // Adjust this value according to your sensor's calibration
const float CALIBRATION_FACTOR = 9.83; // Adjust this value according to your sensor's calibration

WiFiClient client;

void setup() {
  Serial.begin(115200);
  delay(10);

  // Connect to WiFi
  Serial.println();
```

Code

```
  Serial.println("Connecting to WiFi...");
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");
  pinMode(SENSOR_PIN, INPUT);
}

void loop() {
  // Read sensor values
  MQ135 gasSensor = MQ135(34);
  float CO = readCO();
  float SO2 = readSO2();
  float O3 = readO3();
  float AQI = gasSensor.getPPM();
  AQI = AQI/1000;
  // Calculate Air Quality Index (AQI) - You need to implement your own AQI calculation method

  // Print sensor values
  Serial.print("CO: ");
  Serial.println(CO);
```

Code

```
Serial.print("SO2: ");
Serial.println(SO2);
Serial.print("O3: ");
Serial.println(O3);
Serial.print("AQI: ");
Serial.println(AQI);

// Upload data to ThingSpeak
if (client.connect(server, port)) {
  String postStr = apiKey;
  postStr += "&field1=";
  postStr += String(CO);
  postStr += "&field2=";
  postStr += String(SO2);
  postStr += "&field3=";
  postStr += String(O3);
  postStr += "&field4=";
  postStr += String(AQI);
  postStr += "\r\n";

  client.print("POST /update HTTP/1.1\n");
  client.print("Host: api.thingspeak.com\n");
  client.print("Connection: close\n");
  client.print("X-THINGSPEAKAPIKEY: " + apiKey + "\n");
```

Code

```
    client.print("Content-Type: application/x-www-form-urlencoded\n");
    client.print("Content-Length: ");
    client.print(postStr.length());
    client.print("\n\n");
    client.print(postStr);
  }

  delay(200); // Wait for 200MS seconds before next reading
}

float readCO() {
  // Read CO concentration
  // Implement your code to read CO from MQ135 sensor

  // Calibration resistance value of the MQ135 sensor
  const float RZERO = 76.63; // Adjust this value according to your sensor's calibration

  // Ratio of clean air resistance (RO) to the resistance in clean air (RZERO)
  const float RO_CLEAN_AIR = 16.67; // Adjust this value according to your sensor's calibration

  // Load resistance value used in the sensor circuit
  const float LOAD_RESISTANCE = 10.0; // Value in kilohms

  // Read CO concentration from MQ135 sensor
  int CO_gas = analogRead(MQ135_pin);
```

Code

```
  float CO_voltage = (CO_gas / 4095.0) * 3.3; // Convert analog reading to voltage

  // Calculate resistance of the sensor
  float sensorResistance = ((3.3 - CO_voltage) / CO_voltage) * LOAD_RESISTANCE;

  // Calculate CO concentration using the ratio of sensor resistance to clean air resistance
  float CO_concentration = (sensorResistance / RZERO) * RO_CLEAN_AIR;

  return CO_concentration;
}

float readSO2() {
  // Read SO2 concentration
  // Implement your code to read SO2 from MQ135 sensor

  // Calibration resistance value of the MQ135 sensor
  const float RZERO = 76.63; // Adjust this value according to your sensor's calibration

  // Ratio of clean air resistance (RO) to the resistance in clean air (RZERO)
  const float RO_CLEAN_AIR = 16.67; // Adjust this value according to your sensor's calibration

  // Load resistance value used in the sensor circuit
  const float LOAD_RESISTANCE = 10.0; // Value in kilohms

  // Read SO2 concentration from MQ135 sensor
```

Output Serial Monitor

Message (Enter to send message to 'ESP32 Dev Module' on 'COM5') New Line 115200 baud

```
SO2: 15.18
O3: 15.65
AQI: 31.91
CO: 15.33
SO2: 15.42
O3: 15.41
AQI: 29.58
```

Code

```
  // Read SO2 concentration from MQ135 sensor
  int SO2_gas = analogRead(MQ135_pin);
  float SO2_voltage = (SO2_gas / 4012.0) * 3.3; // Convert analog reading to voltage

  // Calculate resistance of the sensor
  float sensorResistance = ((3.3 - SO2_voltage) / SO2_voltage) * LOAD_RESISTANCE;

  // Calculate SO2 concentration using the ratio of sensor resistance to clean air resistance
  float SO2_concentration = (sensorResistance / RZERO) * RO_CLEAN_AIR;

  return SO2_concentration;
}

float readO3() {
  float sensorVoltage = analogRead(SENSOR_PIN) * (3.3 / 4095); // Convert ADC reading to voltage
  float ozoneConcentration = calculateOzoneConcentration(sensorVoltage); // Calculate ozone concentration
  float RS_RO_RATIO = sensorVoltage / 1.4;  // Ratio of RS/R0, adjust this value based on your calibration
  float ozoneConcentration = pow(10, (1.024 * log10(RS_RO_RATIO) - 0.785));
  return ozoneConcentration;

}

```

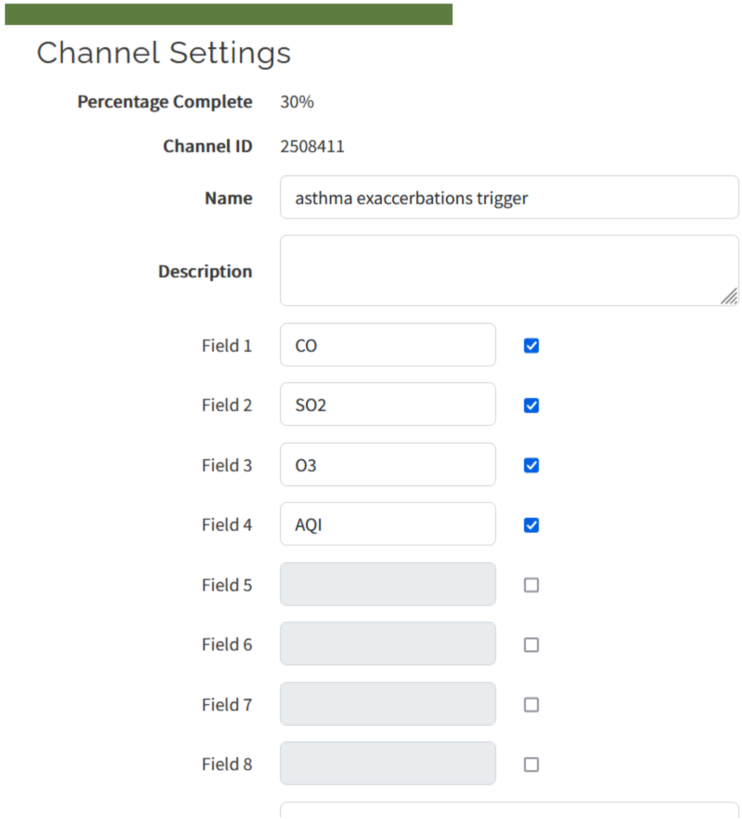
Output   Serial Monitor

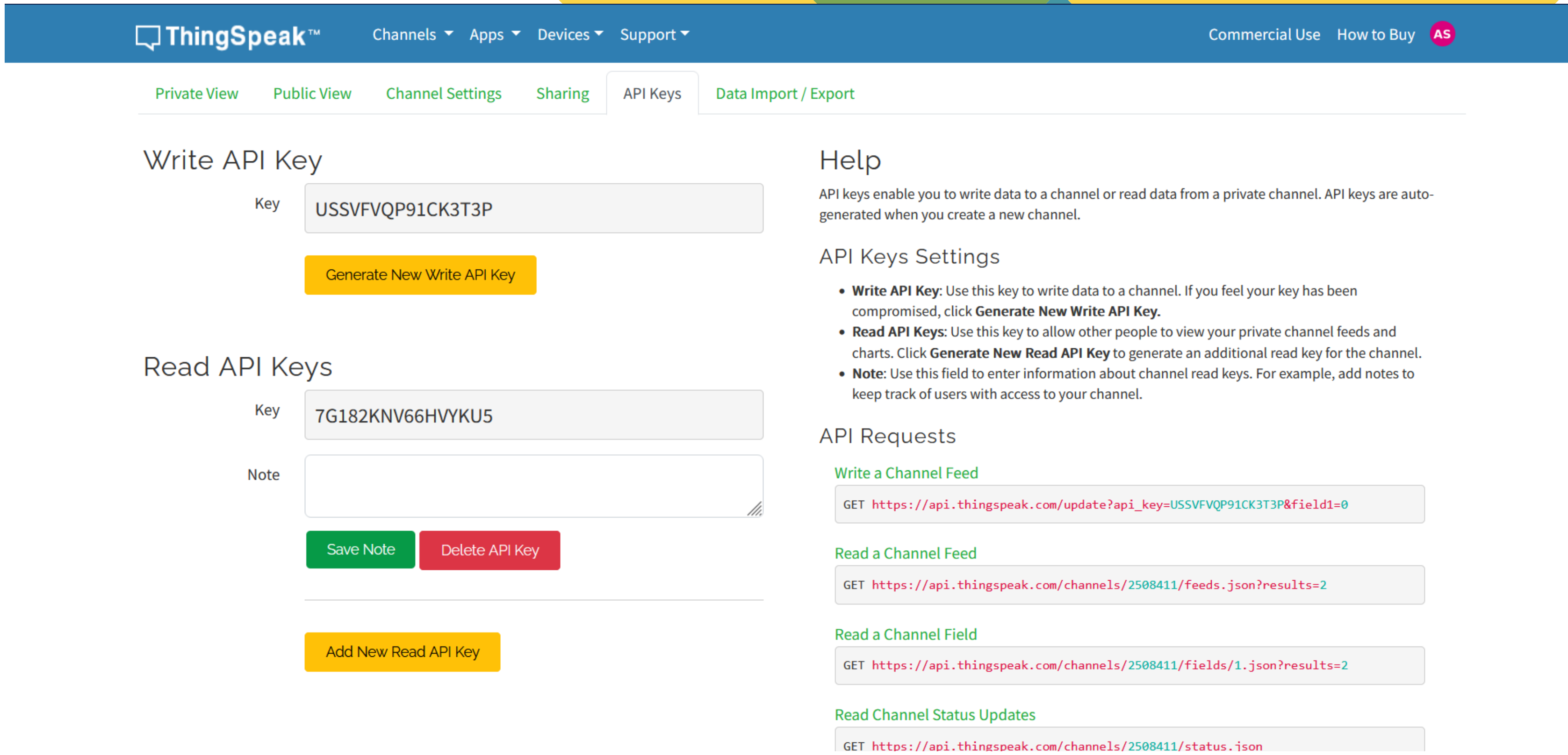
Message (Enter to send message to 'ESP32 Dev Module' on 'COM5')   New Line   115200 baud

```
SO2: 15.25
O3: 15.73
AQI: 29.58
CO: 15.61
SO2: 15.07
O3: 15.41
AQI: 28.63
```

Ln 112, Col 1   ESP32 Dev Module on COM5   2

Thingspeak


Channel Settings
Percentage Complete 30%
Channel ID 2508411
Name asthma exaccerbations trigger
Description
Field 1 CO
Field 2 SO2
Field 3 O3
Field 4 AQI
Field 5
Field 6
Field 7
Field 8


ThingSpeak™
Channels
Apps
Devices
Support
Commercial Use
How to Buy
AS
Private View
Public View
Channel Settings
Sharing
API Keys
Data Import / Export
Write API Key
Key USSVFVQP91CK3T3P
Generate New Write API Key
Read API Keys
Key 7G182KNV66HVYKU5
Note
Save Note
Delete API Key
Add New Read API Key
Help
API keys enable you to write data to a channel or read data from a private channel. API keys are auto-generated when you create a new channel.
API Keys Settings
Write API Key: Use this key to write data to a channel. If you feel your key has been compromised, click Generate New Write API Key.
Read API Keys: Use this key to allow other people to view your private channel feeds and charts. Click Generate New Read API Key to generate an additional read key for the channel.
Note: Use this field to enter information about channel read keys. For example, add notes to keep track of users with access to your channel.
API Requests
Write a Channel Feed
GET https://api.thingspeak.com/update?api_key=USSVFVQP91CK3T3P&field1=0
Read a Channel Feed
GET https://api.thingspeak.com/channels/2508411/feeds.json?results=2
Read a Channel Field
GET https://api.thingspeak.com/channels/2508411/fields/1.json?results=2
Read Channel Status Updates
GET https://api.thingspeak.com/channels/2508411/status.json

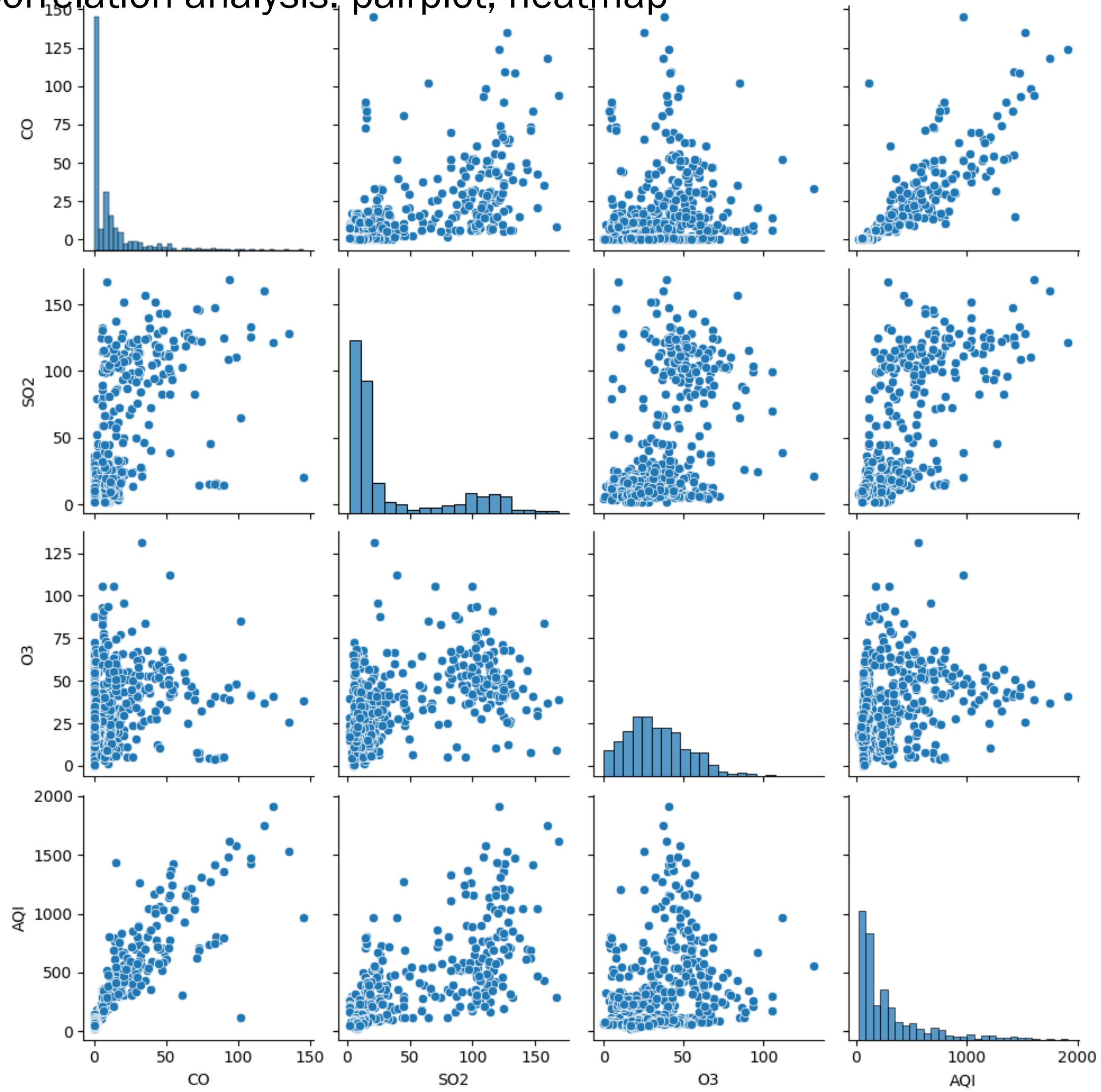
ThingSpeak (Cloud)

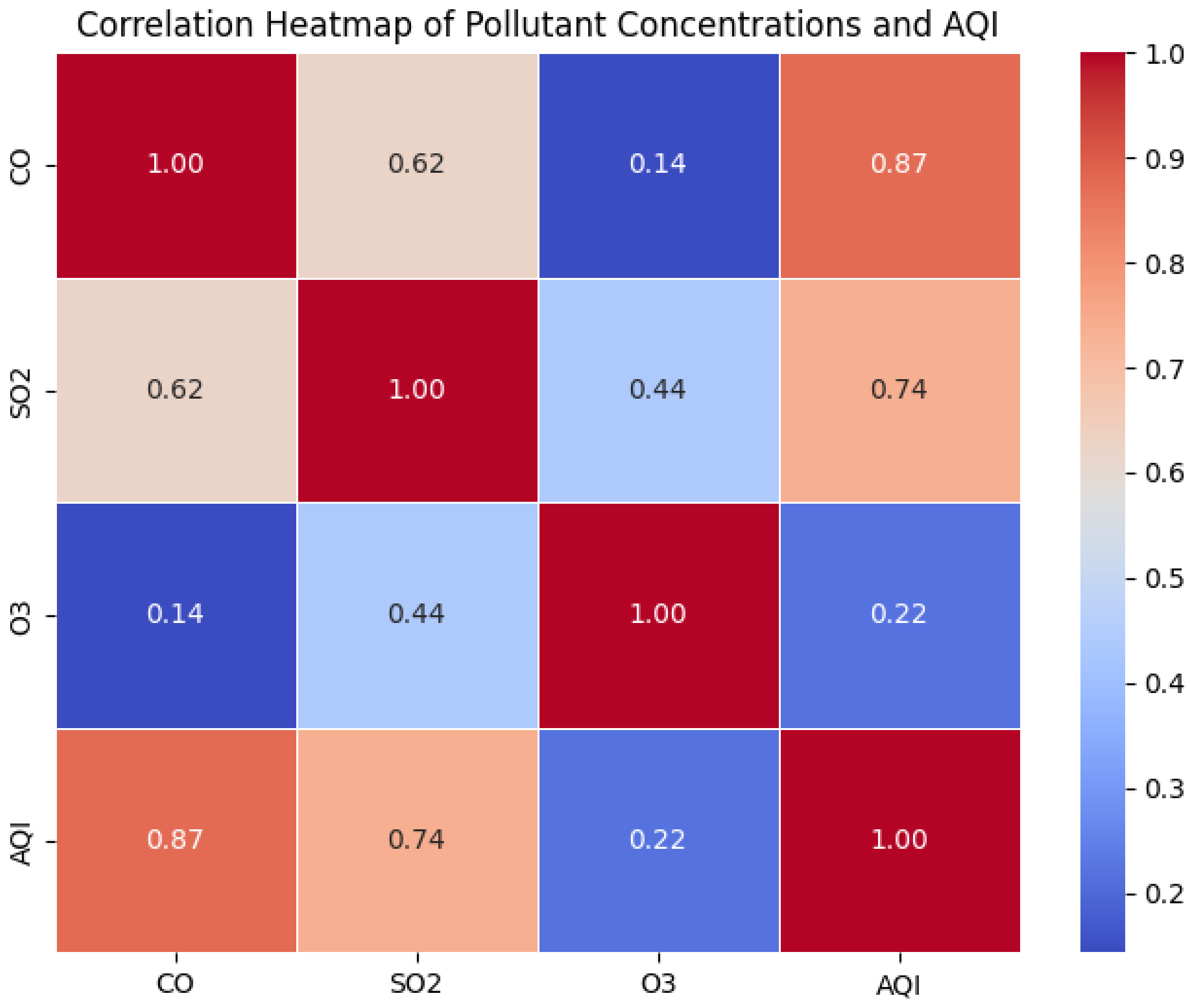
Created: 5 days ago
Last entry: less than a minute ago
Entries: 11

ML- Regression and EDA

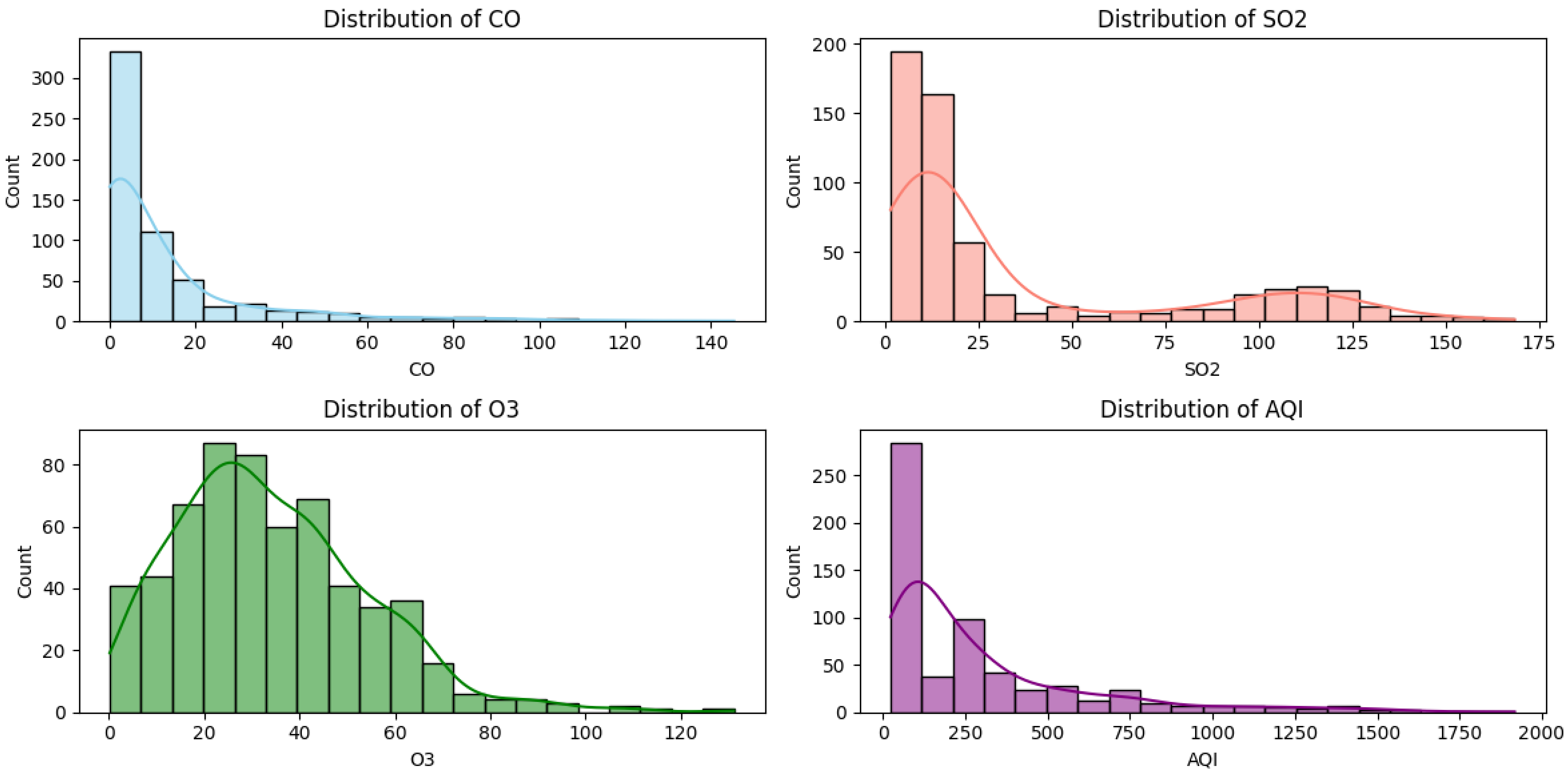
- Linked Thingspeak with API
- Basic statistical analysis, mean, median, quantiles etc
- Handling Null values
- Correlation analysis: pairplot, heatmap
- Distribution analysis: positive skewed – winsorize
- Split train test
- Linear regression, Random Forest , Decision Trees
- Binning the y_pred
- Streamlit

Correlation analysis: pairplot, heatmap

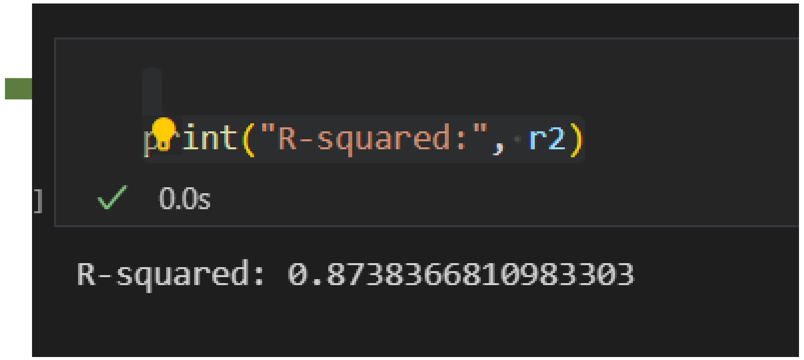




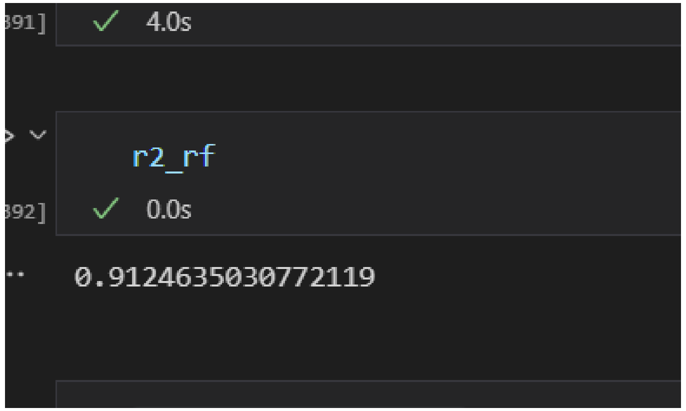
Distribution analysis: positive skewed – winsorize



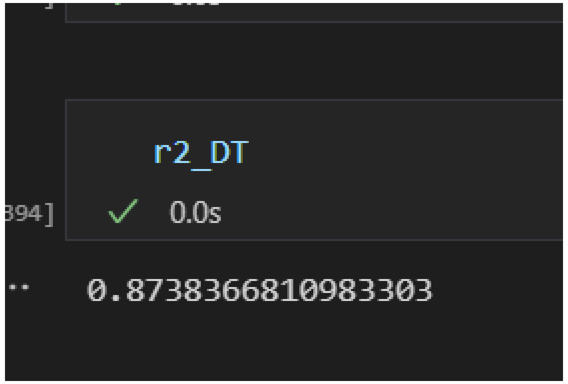
Linear regression, Random Forest , Decision Trees



Linear Regression

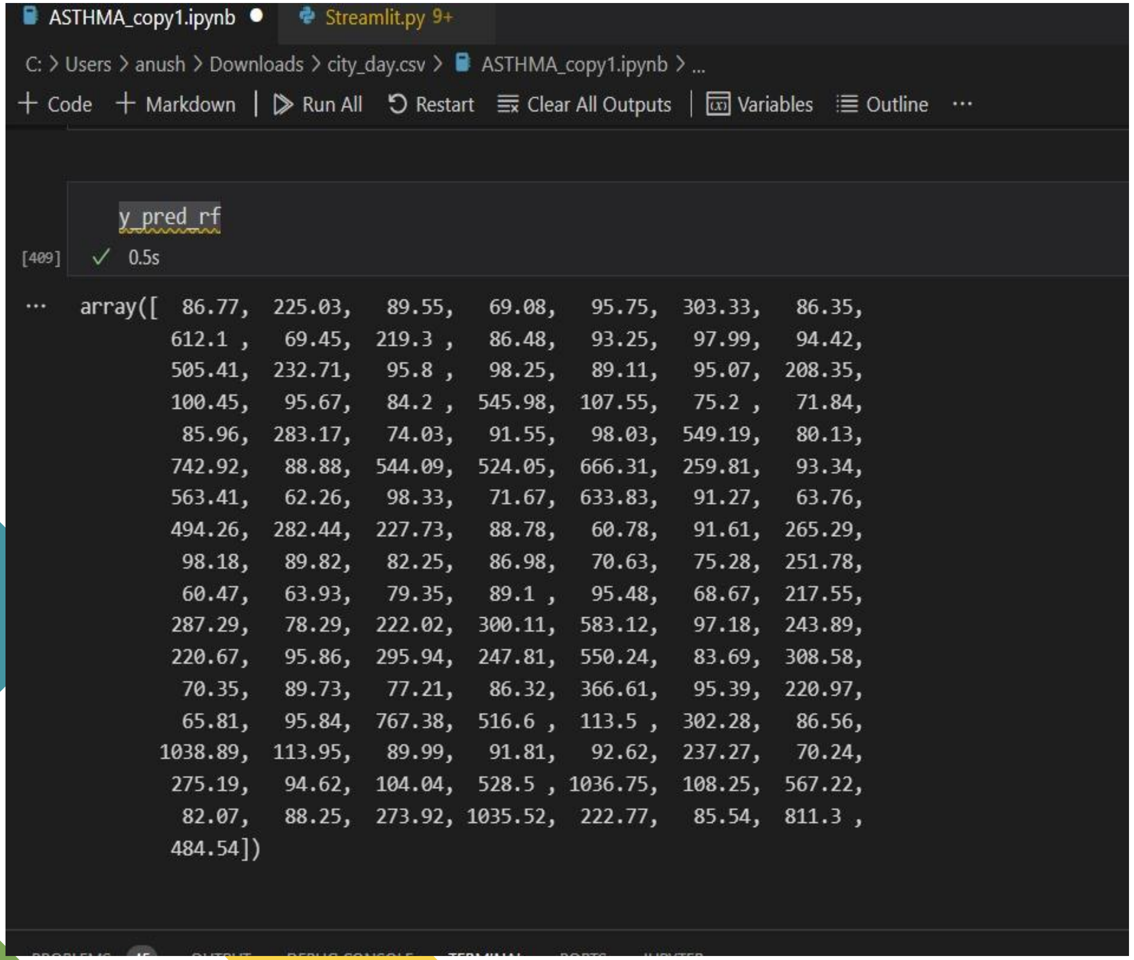


Random Forest



Decision Trees

Result


ASTHMA_copy1.ipynb
Streamlit.py 9+
C: > Users > anush > Downloads > city_day.csv > ASTHMA_copy1.ipynb > ...
Code
Markdown
Run All
Restart
Clear All Outputs
Variables
Outline
y_pred_rf
[409]
0.5s
array([86.77, 225.03, 89.55, 69.08, 95.75, 303.33, 86.35,
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505.41, 232.71, 95.8 , 98.25, 89.11, 95.07, 208.35,
100.45, 95.67, 84.2 , 545.98, 107.55, 75.2 , 71.84,
85.96, 283.17, 74.03, 91.55, 98.03, 549.19, 80.13,
742.92, 88.88, 544.09, 524.05, 666.31, 259.81, 93.34,
563.41, 62.26, 98.33, 71.67, 633.83, 91.27, 63.76,
494.26, 282.44, 227.73, 88.78, 60.78, 91.61, 265.29,
98.18, 89.82, 82.25, 86.98, 70.63, 75.28, 251.78,
60.47, 63.93, 79.35, 89.1 , 95.48, 68.67, 217.55,
287.29, 78.29, 222.02, 300.11, 583.12, 97.18, 243.89,
220.67, 95.86, 295.94, 247.81, 550.24, 83.69, 308.58,
70.35, 89.73, 77.21, 86.32, 366.61, 95.39, 220.97,
65.81, 95.84, 767.38, 516.6 , 113.5 , 302.28, 86.56,
1038.89, 113.95, 89.99, 91.81, 92.62, 237.27, 70.24,
275.19, 94.62, 104.04, 528.5 , 1036.75, 108.25, 567.22,
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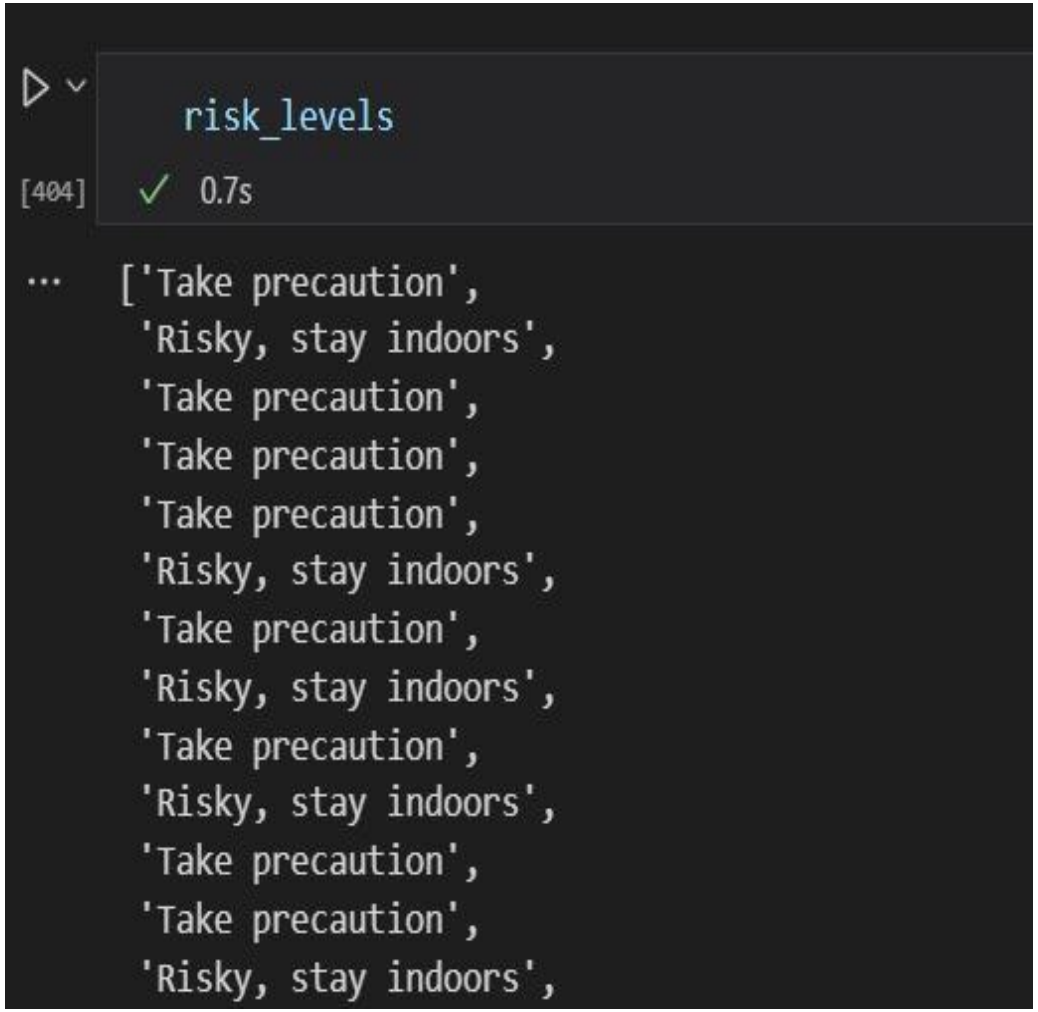
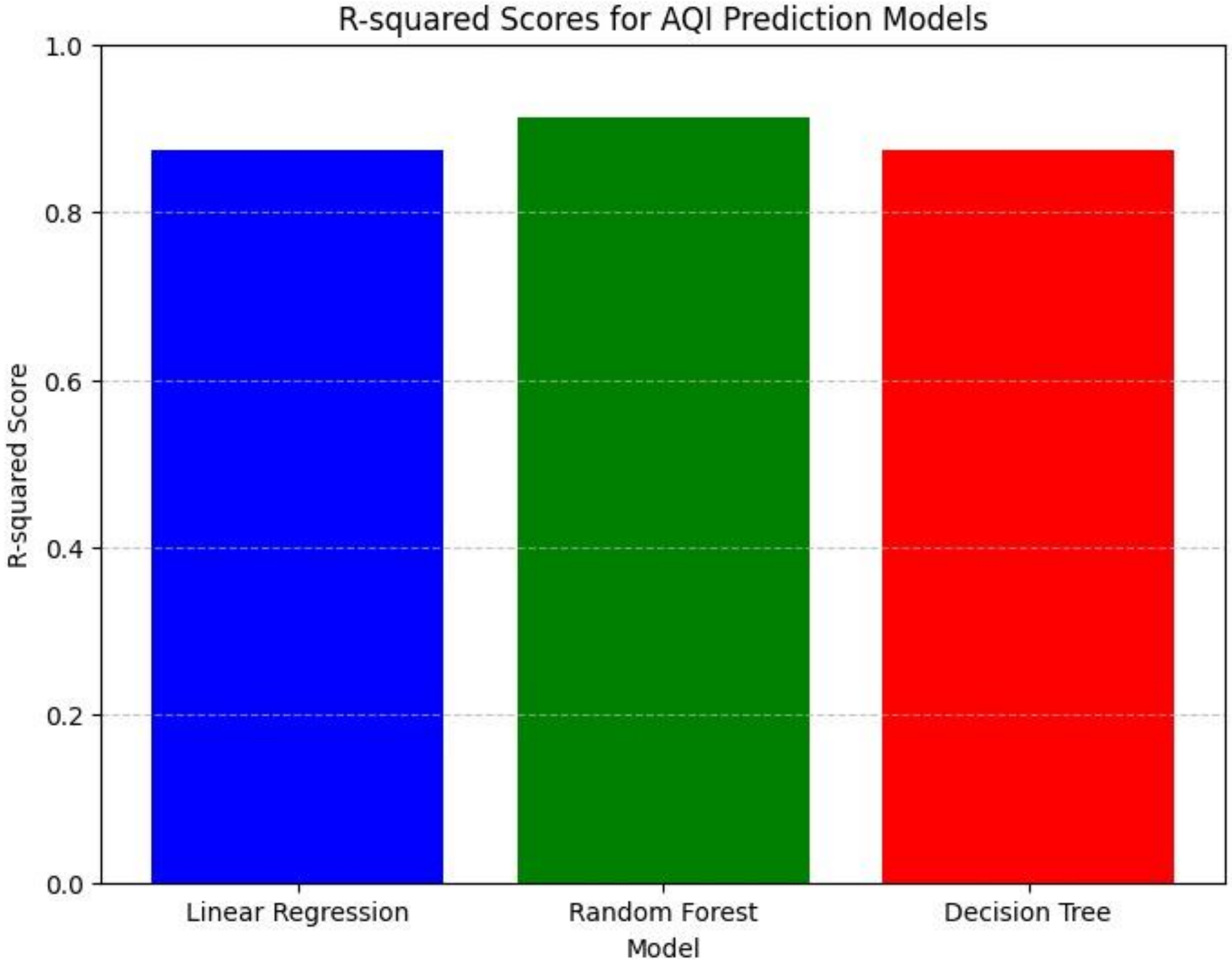
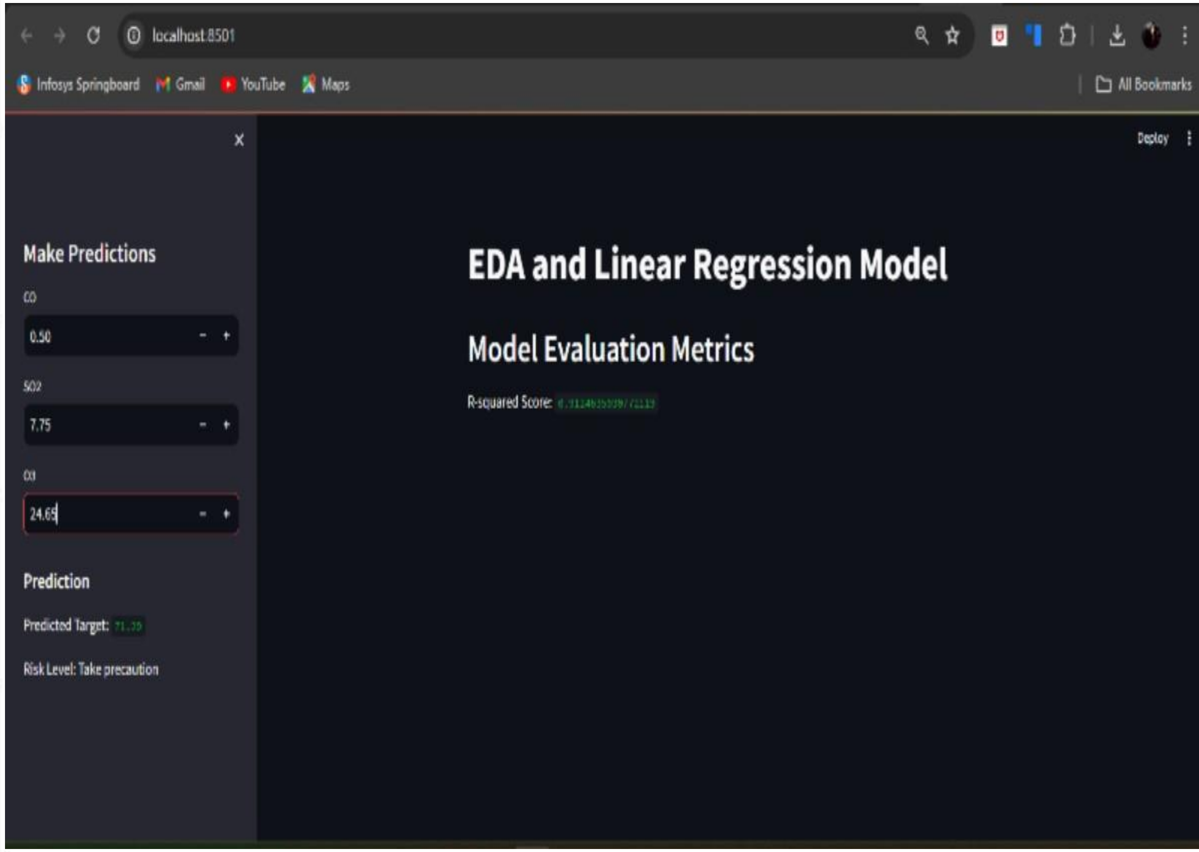
484.54])


risk_levels
[404]
0.7s
['Take precaution',
'Risky, stay indoors',
'Take precaution',
'Take precaution',
'Take precaution',
'Risky, stay indoors',
'Take precaution',
'Risky, stay indoors',
'Take precaution',
'Risky, stay indoors',
'Take precaution',
'Take precaution',
'Risky, stay indoors',

Streamlit


R-squared Scores for AQI Prediction Models
R-squared Score
Model
1.0
0.8
0.6
0.4
0.2
0.0
Linear Regression
Random Forest
Decision Tree


localhost:8501
Infosys Springboard
Gmail
YouTube
Maps
All Bookmarks
Deploy
Make Predictions
0.50
7.75
24.65
Prediction
Predicted Target:
Risk Level: Take precaution
EDA and Linear Regression Model
Model Evaluation Metrics
R-squared Score:

Conclusion-

We linked ML with cloud to analyze data and find how AQI is affecting Health of people in different cities across India.

References-

1) https://circuitdigest.com/microcontroller-projects/arduino-based-air-quality-monitoring-system.
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