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SCHOOL OF ELECTRONICS ENGINEERING

Department of Electronics and Communication, and Sensors and Biomedical Technology

IOT based Air Quality Monitoring System Using MQ135 and MQ3 Sensors with DatasetAnalysis

Project Report
ECE3502 – IoT Domain Analyst
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1.Abstract :

The air pollution rates now a days are drastically increasing in all the developed and the developing countries, which requires a more portable and cost-effective solution. The proposedsystem includes a design for monitoring air pollution and creating awareness among the public. This paper aims at using IOT along with cloud to make the services real time and faster. The proposed system consists of a microcontroller unit (MCU), MQ3 and MQ135 sensors, anda Wi-Fi module. The MQ3 and MQ135 sensors are connected to the MCU, which collects thesensor data and sends it to a web server using the Wi-Fi module. The web server processes thedata and displays it in real-time on a web page. The proposed system is installed in a particularlocality where there is acute air pollution. The level of each hazardous pollutant is monitored at periodic intervals. The Air Quality Index (AQI) for the observed pollutants is determined using random forest tree algorithm and linear regression and awareness is created among the public by displaying the air quality index in that particular location. Thus, the quality of air in that area can be understood by the public by viewing the concentration of the gases in both numerical and graphical format. Further this system is to be extended in future by allowing the public to register themselves in an app which pushes weeklyor monthly air quality report through message which reaches the user as a notification that is more comfortable in access.

Key words: IoT, MQ135, MQ3, ThingSpeak, Data analysis.

2.Introduction

Air pollution is the worst environmental problem, and it causes a multitude of adverse effects on human health, water bodies and climate. The main source of air pollution in all major cities is due to vehicles and the second major source remains industries. The massive use of vehicles has resulted in a vital increase of toxins in the atmosphere. This is the cause of environmental pollution affecting human health. It has also resulted in other respiratory problems like asthma attacks and skin rashes. The Central Pollution control board has set a standard to these levels, but the public is reluctant to follow them. The pollutants which spoil the air are invisible which has led to the negligence of the people. So, public acknowledgement is the prime requisite of today. Hence the proposed system solves this major issue. The air pollution monitoring system is installed in a particular locality where there are traces of acute air pollution to detect the constituent gases of air which may lead to harmful effects on human health and other living beings.

The release of toxic gases by industries, vehicle emissions, and increased concentrations of harmful gases and particulate matter in the atmosphere are all contributing to air pollution. Pollution levels are rapidly rising due to factors such as industry, urbanization, population growth, and vehicle use, all of which can harm human health. Particulate matter contributes the most to the increase in air pollution. This necessitates the measurement and analysis of real-time air quality monitoring to make appropriate decisions in a timely manner. This paper describes a standalone real-time air quality monitoring system.

The Internet of Things (IoT) is now widely used in virtually every industry and plays an important role in our air quality monitoring system as well. Our setup will display the air quality in PPM (Parts per Million) on a web page and graph so that we can easily monitor it. Air pollution is becoming increasingly severe as a result of numerous important factors such as vehicle emissions, deforestation, and industrialization. Older vehicles may emit more smoke and thus be prohibited from being used. But we need a proper metric that tells us whether the level of air pollution is low, medium, or high. So, we can use various sensors to detect air quality, and based on the corresponding values, we can perform mathematical calculations, and from the results, we can determine whether the desired air quality is below the threshold value or not. The Internet of Things allows us to connect these sensors to the Cloud, from which we can access the system using login credentials from anywhere. There are numerous free online resources (Thingspeak) aimed at the Internet of Things (IoT) that can provide a ready dashboard as well as a means of connecting the account to the physical system. Finally, we could use machine learning to perform detailed analyses such as determining which areas have higher airquality than the desired threshold and when we are receiving more values from the sensors. Ifwe can integrate these values at specific locations on maps, we can raise awareness so that people will take the necessary steps to improve air quality, such as afforestation, growing pot plants inside, upgrading engine quality to reduce bad emissions from vehicles, encouraging electric vehicles, and so on. It is critical to calibrate the sensors before installing them in a location. In addition, almost all electronic components deteriorate with age.

3.Literature Survey

S. No.	Paper Title	Year	Proposed Concept
1.	IoT based Air and Sound Pollution Monitoring System for Smart Environment	2022	Air and noise pollution is an increasing concern these days. Air quality monitoring is vital for a bright future and a healthy life for all of us. This study presents an air Quality and noise pollution monitoring system that uses the internet of things (IoT) to monitor and check real-time air quality and noise pollution in a given place for smart environment. It uses air sensors to detect harmful and poisonous compounds such as NH3, benzene, smoke, and CO2. Furthermore, the device continuously analyses sound levels and activates a buzzer if they surpass the defined threshold. The publication's main objective is to keep track of air pollution and noise pollution in various regions of the city.
2.	Advanced Air Quality Monitoring System Using Raspberry Pi	2020	In response to rising air pollution, they created an Advanced Air Quality Monitoring System based on the Raspberry Pi 3B+. The system monitors air quality by considering characteristics such as suspended particle matter (SPM), carbon dioxide, ozone, carbon monoxide, smoke, temperature, and humidity. Particulate matter, as a critical metric, provides a clear indication of pollution inthe area at that moment. These pollution data are collected utilizing sensors such as the MQ7, MQ135, MQ9, DSM501A, DHT11, and others.
3.	Development of a Low-Cost Air Quality Data Acquisition	2020	Describes the development of a low-cost, portable air pollution monitoring system based on Arduino and a variety of sensors. The system was able to measure concentrations of PM2.5, PM10, CO, NO2, and sulfur dioxide (SO2) in the air. The data was then transmitted to a cloud-based server and could be accessed remotely

	IoT-based System using Arduino Leonardo		via a mobile app. The study found that the system was able to accurately measure the concentrations of pollutants in the air and could be used as a useful tool for monitoring air quality in both indoor and outdoor environments.
4.	IoT Based Air Quality Index Monitoring System – Monitor PM2.5, PM10, and CO using ESP32	2018	Describes the design and implementation of an IoT-based air pollution monitoring system using Arduino. The system uses sensors to measure the concentrations of particulate matter (PM2.5 and PM10), carbon monoxide (CO), and nitrogen dioxide (NO2) in the air. The data is then transmitted to a cloud-based server using a wireless communication module and can be accessed and analyzed by authorized personnel through a web-based interface. The study found that the system was able to accurately measure the concentrations of pollutants in the air and that the data was consistent with that of other air quality monitoring stations

4.Problem Statement

Rapid urbanization, industrialization, poor maintenance of roads, poorly maintained vehicles and lack of public awareness is responsible for deuterating air quality. Poor quality has harmful effects on human health, particularly the respiratory and cardiovascular systems. pollutants damages plants and buildings, and smoke or haze can reduce visibility. Because of the above mentioned fact, control and prevention of air pollution is important.

5. Proposed Work

To Propose a circuit to measure the concentration of various gases like NH3, NOx, alcohol, Benzene, smoke, CO2 etc. Convert the voltage obtained from MQ135 sensor to PPM. To analyze the output data and to calculate the AQI value using the values recorded.

6.Hardware and Software Details

Block Diagram and Project Description

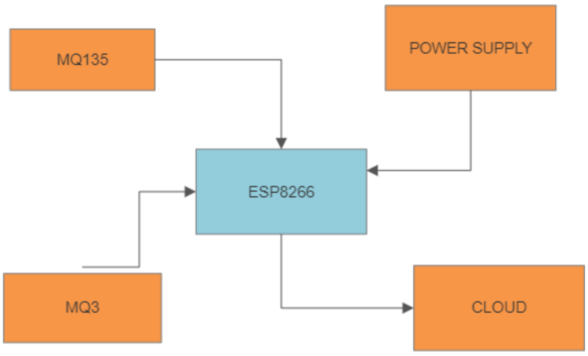


Fig:1 Block Diagram

MQ135 Sensor

MQ135 Sensor is a popular gas sensor module used in air quality monitoring applications. It is based on metal oxide semiconductor technology and is designed to detect a wide range of gases, including carbon monoxide, nitrogen oxides , ammonia, and other harmful gases.MQ135 is particularly useful in monitoring the air quality indoors and outdoors especially in areas with high population levels.

The MQ135 sensor operates on a 5V DC power supply and produces an analog output voltage that is proportional to the gas Concentration. The output signal can be interfaced with microcontrollers, such as Arduino, to obtain real time gas concentration data. The sensitivity of the sensor can be adjusted by varying the load resistance and the temperature of the sensing element.

MQ3 Sensor

MQ3 sensor is a gas sensor module used to detect alcohol vapor in the air. It is based on metal oxide semiconductor technology and is widely used in Breathalyzer and alcohol detection systems. The MQ3 sensor is designed to detect ethanol gas with a high degree of accuracy.

The MQ3 sensor operates on 5v 5 DC power supply and produces an analog output voltage that is proportional to the gas Concentration. The MQ3 sensor is used to detect alcohol vapor in the air and also have certain degree of sensitivity to other gases such as methane and propane.

Air Quality Index(AQI)

AQI stands for Air Quality Index, which is a measure used to describe the quality of the air in a particular area. The AQI is typically calculated based on the levels of various air pollutants such as particulate matter (PM2.5 and PM10), ozone (O3), nitrogen dioxide (NO2), sulphur dioxide (SO2), and carbon monoxide (CO).

The AQI is represented as a numerical value ranging from 0 to 500, with higher values indicating poorer air quality. The AQI is divided into six categories, with each category representing a different level of health concern:

Good (0–50)	Minimal Impact	Poor (201–300)	Breathing discomfort to people on prolonged exposure
Satisfactory (51–100)	Minor breathing discomfort to sensitive people	Very Poor (301–400)	Respiratory illness to the people on prolonged exposure
Moderate (101–200)	Breathing discomfort to the people with lung, heart disease, children and older adults	Severe (>401)	Respiratory effects even on healthy people

Pollutants		concentration in µg/m3 (except for CO)	Sub-Index	check
PM10	24-hr avg	121.00	114	1
PM2.5	24-hr avg	34.00	57	1
SO2	24-hr avg	0.00	0	0
NOx	24-hr avg	8.00	10	1
*CO (mg/m3)	max 8-hr	0.00	0	0
O3	max 8-hr	57.00	57	1
NH3	24-hr avg	34.00	9	1

Air Quality Index

AQI = 114

* Concentrations of minimum three pollutants are required; one of them should be PM10 or PM2.5

* The check displays "1" when a non-zero value is entered

7.Implementation:

After connecting the ESP-01 successfully to the hotspot, it gets established with Thingspeak website and the account API Key is written in Arduino Code which helps to save the data only to our account bearing the given API key. Things speak needs 15 seconds of refresh interval topush to the data.

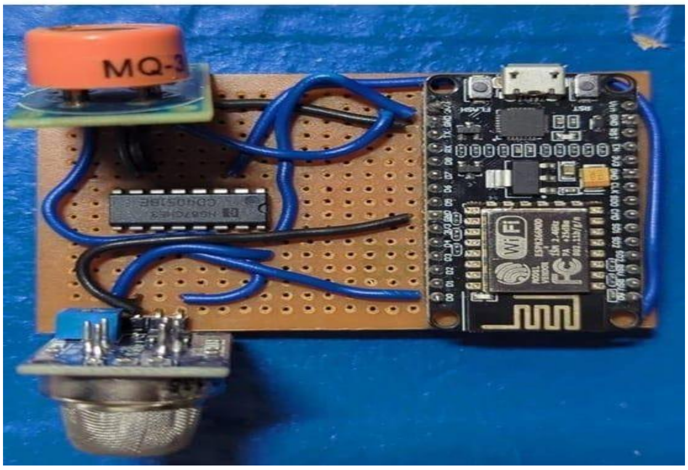


Fig:2 IoT based Air Quality monitoring system using MQ135 and MQ7

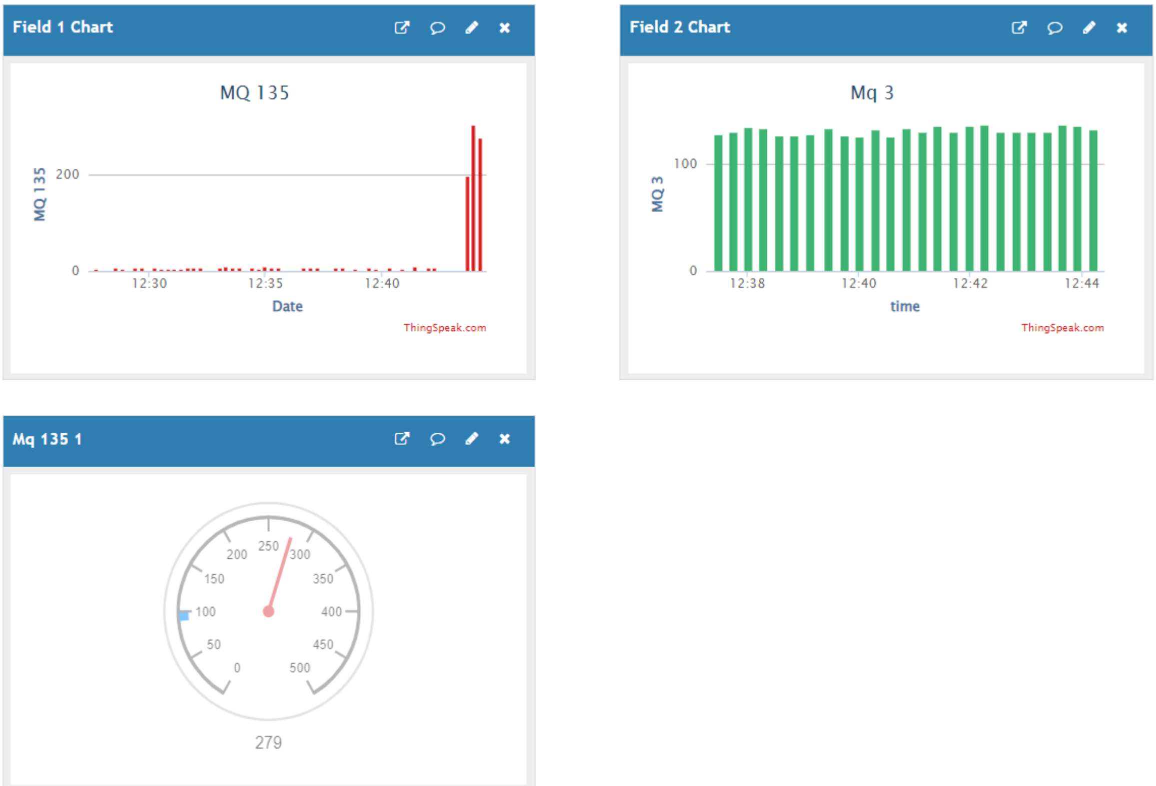


Fig:3 shows the visualization charts for corresponding sensors.

8.Results

Correlation:

- Correlation describes the strength of an association between two variables .A correlation is a statistical measure that indicates the degree to which two variables are linearly related to each other.MQ135 sensor is designed to detect gases such as ammonia, nitrogen oxides, and Sulphur dioxide.
- MQ3 sensor is designed to detect gases such as methane, propane, and smoke.
- The correlation between their values will depend on the specific gases being detected and the environmental conditions in which they are being used.

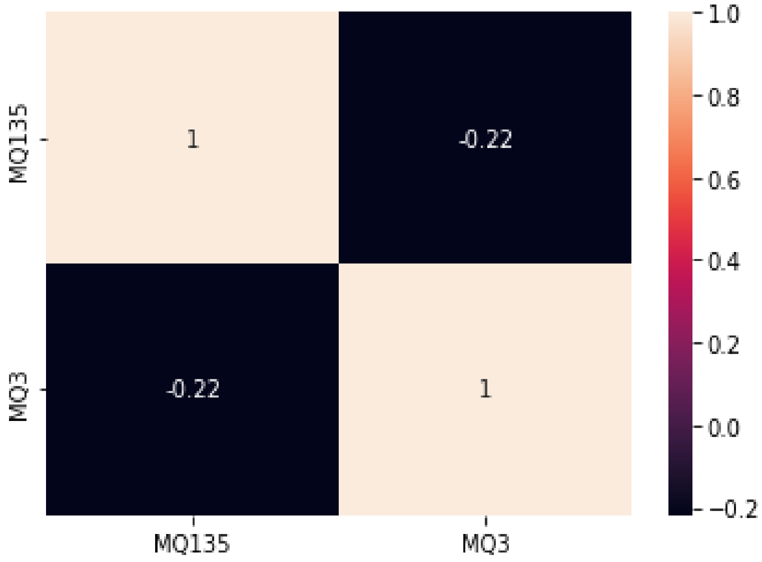


Fig4(a)-Heatmap

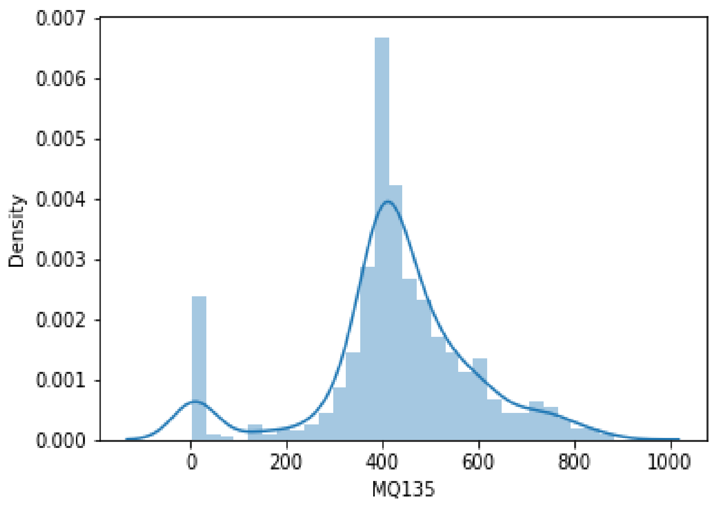


Fig4(b) Histogram plot

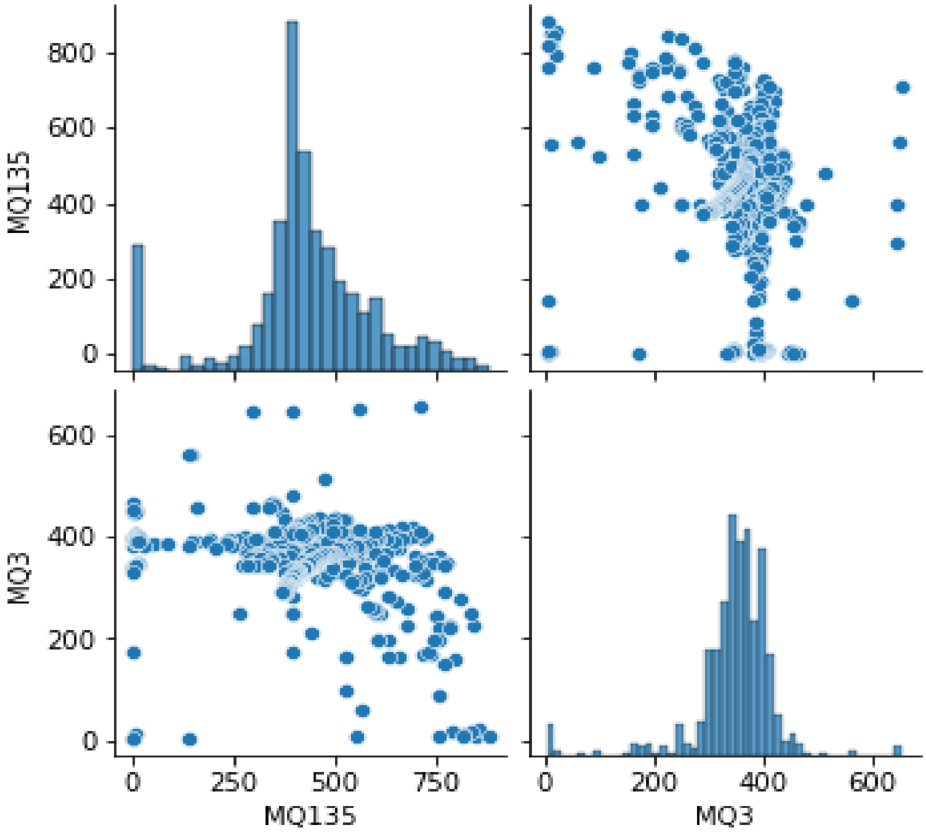


Fig.4(c) Correlation of collected data (MQ135,MQ3).

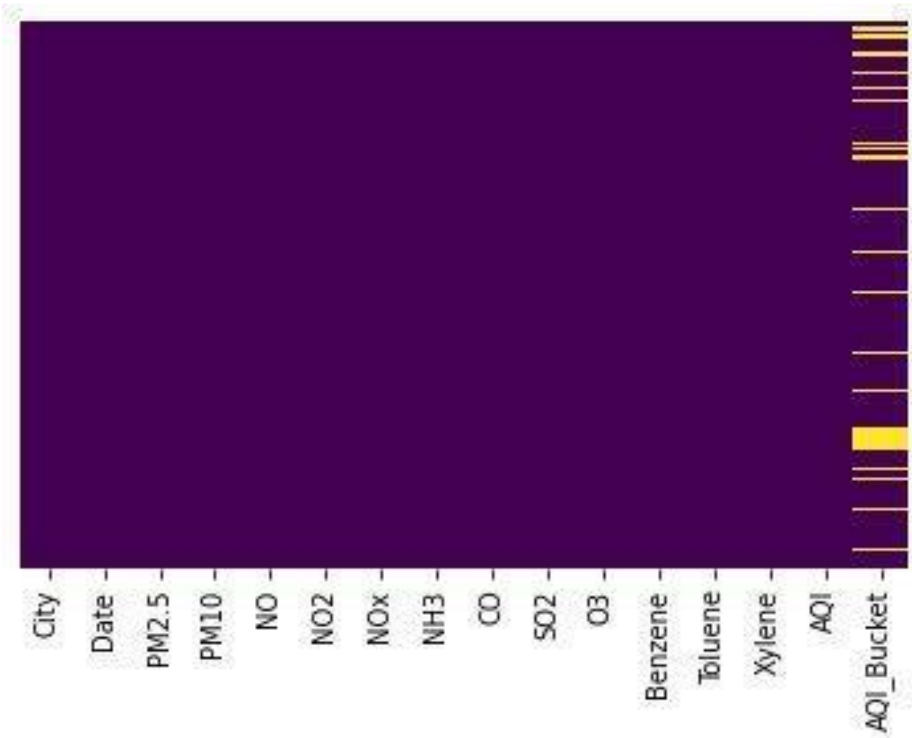


Fig:5(a) Filling Null values in the dataset gases concentration

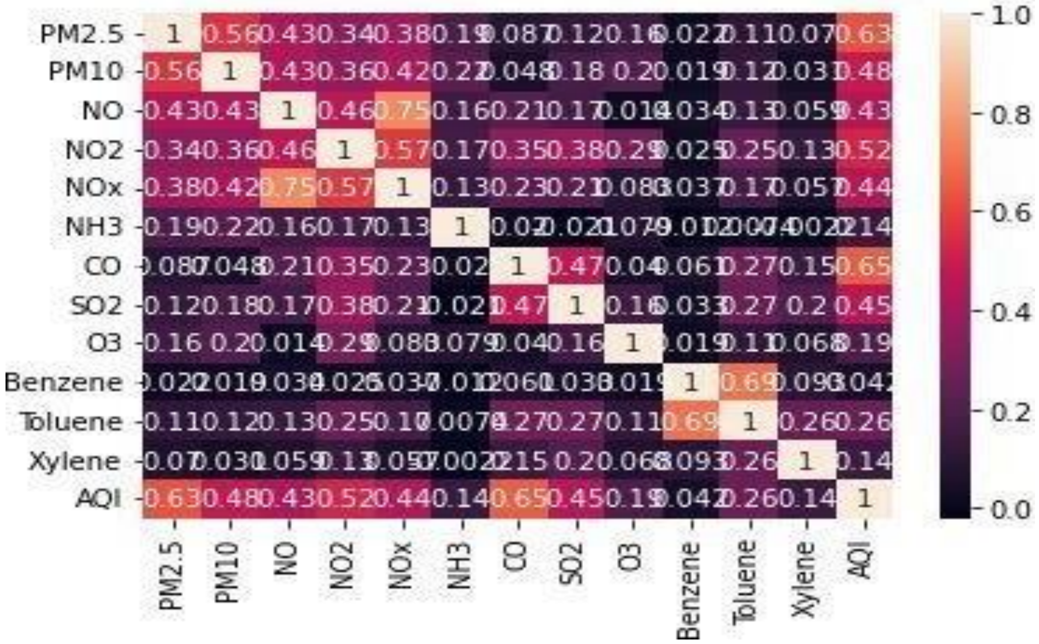
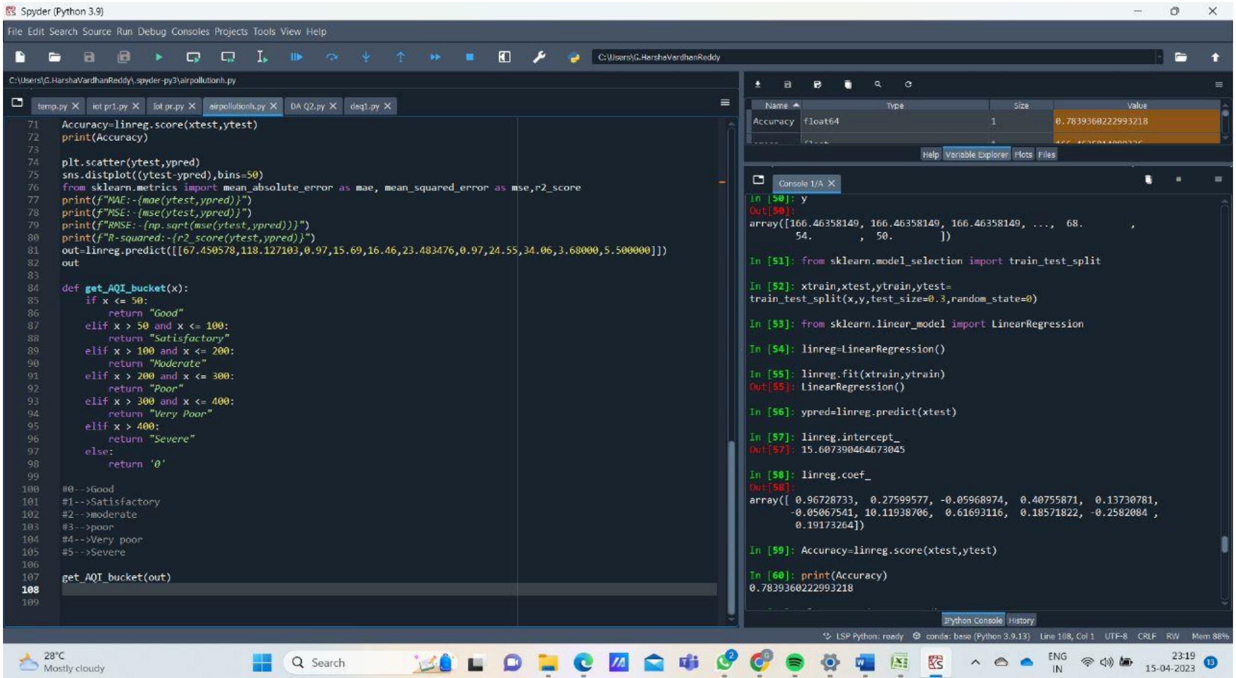


Fig:5(b) Correlation of gases concentration

Linear Regression :

Linear Regression is a data analysis technique that predicts the value of unknown data by using another related and known data value. It mathematically models the unknown or dependent variable and the known or independent as a linear equation.

The accuracy of a linear regression model is typically evaluated using a metric called the coefficient of determination, also known as R-squared (R^2). R^2 measures the proportion of the variance in the dependent variable that can be explained by the independent variable(s) in the model.R^2 ranges from 0 to 1, with higher values indicating a better fit between the model and the data. An R^2 value of 0 indicates that the model explains none of the variance in the dependent variable, while an R^2 value of 1 indicates that the model explains all of the variance.



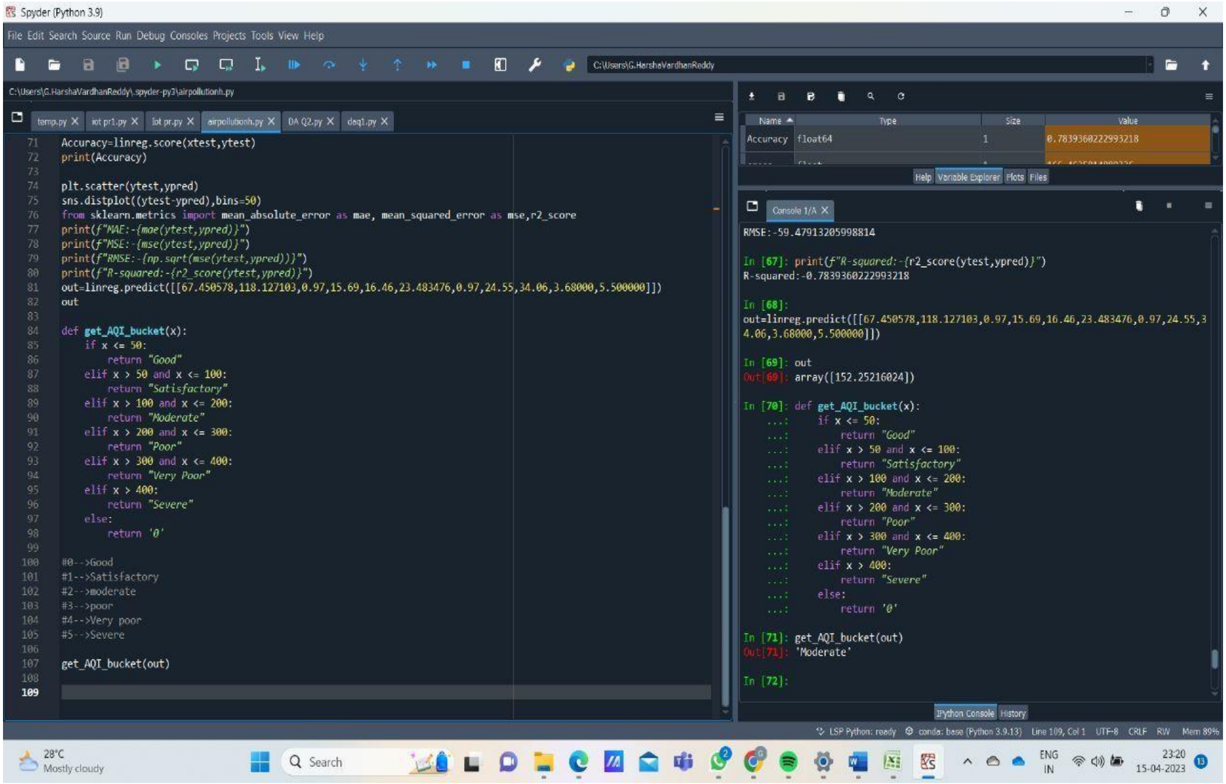


Fig 6(a) (b) It represents Linear Regression applied on the dataset collected from Thing speak account in CSV format (Comma separated values). Using Python and Anaconda, linear regression AQI is calculated.

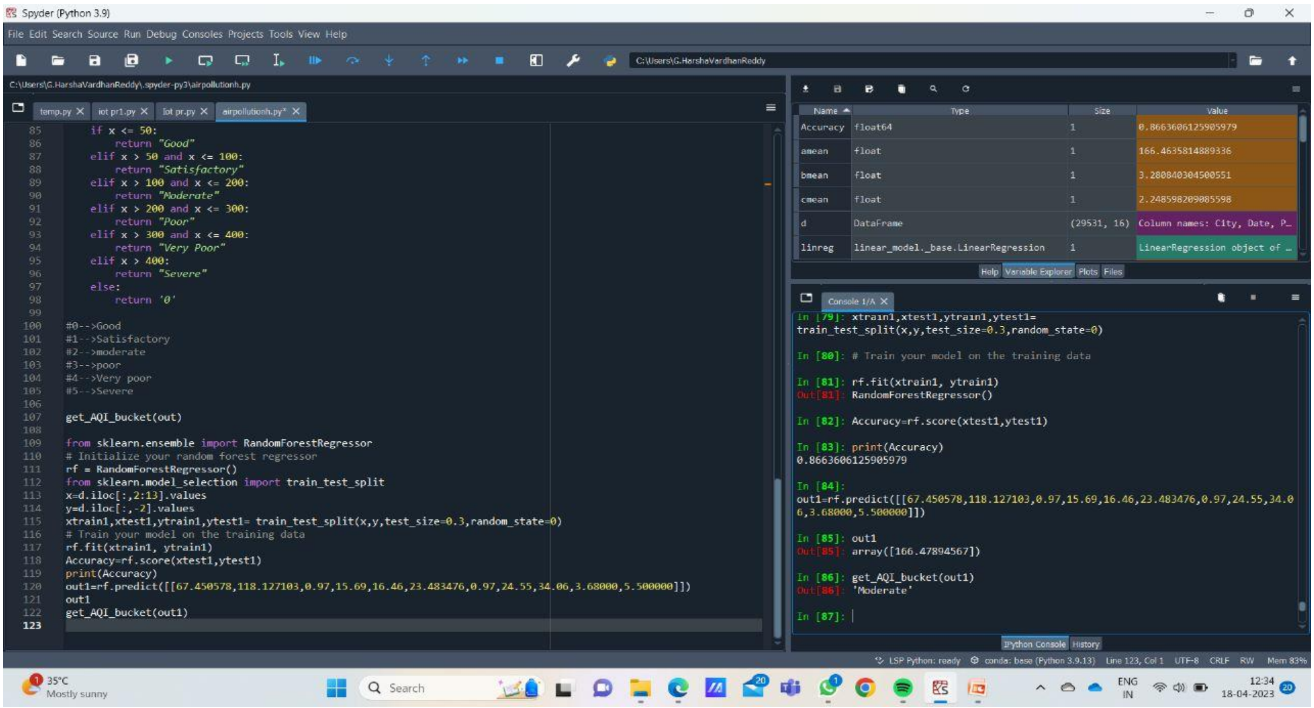


Fig: 7 AQI is calculated using random forest algorithm and accuracy of the algorithm is calculated.

9.Conclusion:

In this project, a smart air pollution monitoring system that constantly keeps track of air quality in an area and displays the air quality Index. It also sends data measured to the “Thing speak” platform. The system helps to create awareness of the quality of air that one breathes daily. This monitoring device can deliver real-time measurements of air quality. we developed an air monitoring system to collect and analyze air quality data for various pollutants, including PM2.5, PM10, O3, NO2, SO2, and CO. We used the Random Forest algorithm and linear regression Model to model the relationship between these pollutants and the resulting Air Quality Index (AQI), and to predict AQI values based on the pollutant concentrations. Our analysis of the data revealed several important findings. First, we found that PM2.5 had the highest impact on AQI, followed by O3 and PM10. This suggests that efforts to reduce PM2.5 emissions would have the greatest impact on improving air quality. Second, we found that the **Random forest tree model is effective** in predicting AQI values based on the pollutant concentrations, compared to the **Linear Regression model(Approx-79%).** with a high degree of accuracy **(Approx-86%).**

10.Future Scope:

Our air monitoring system has demonstrated the feasibility and effectiveness of using the Linear regression model to analyze air quality data and predict Air Quality Index (AQI) values. However, there are several opportunities for future research and development to further enhance the system's capabilities and impact.

First, we recommend expanding the system to cover more geographic regions and to include additional pollutants and meteorological data. This will provide a more comprehensive picture of air quality trends and patterns and enable more targeted and effective policy and individual interventions to reduce air pollution.

Exploring the use of other machine learning algorithms, such as deep learning or neural networks, to further improve the accuracy and predictive power of the system. Additionally, incorporating data visualization techniques and tools, such as heat maps or interactive dashboards, can enhance the usability and accessibility of the air quality data for various stakeholders. Exploring the use of low-cost air quality sensors and citizen science initiatives to increase the spatial and temporal resolution of the air quality data. This can enable more localized and real-time monitoring of air pollution and empower communities to take more proactive and participatory roles in addressing air quality issues.

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Dataset link: https://tinyurl.com/AQIDataset

Code: https://tinyurl.com/AQIPython-code