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ijirset@gmail.com



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IoT based Secure Supervision of Air Quality

G Naga Sujini¹, J Sreedevi²

Assistant Professor, Department of Computer Science & Engineering, MGIT, Hyderabad, India^{1,2}

ABSTRACT: Air pollution is increasing at a rapid rate due to factors like urbanization, excessive vehicle use, increase in population etc. Reducing the air pollution is the need of the hour as breathing polluted air can cause serious health problems like asthma, cardiovascular diseases in humans. Poor quality air also damages our ecosystem and biodiversity. Monitoring the air quality from time to time creates awareness among people how good or bad is the air we inhale and take appropriate actions to improve the quality of air. A low-cost Air quality monitoring platform was developed to monitor air quality anywhere with the help of Internet of Things. Sensors like MQ135, MQ2, MQ3, and MQ7 were used to detect the concentration of gases in air. Raspberry Pi was used as the microcontroller. Since security of data is also crucial, Advanced Encryption Standard (AES) algorithm was used to encrypt the data. Whenever the concentration of the gases goes beyond a permissible limit a sms alert is sent to the user stating the concentration of that particular gas is high. The data is collected and stored in a cloud called Thingspeak where the data is analysed in the form of graphs.

KEYWORDS: Internet of Things, Raspberry pi, Thingspeak, Air Quality

I. INTRODUCTION

Good Quality air contains a smaller number of solid particles and chemical pollutants whereas air with poor quality contains a large concentration of harmful gases which is hazardous to the environment we live in and people's health. Inhalation of polluted air can also trigger asthma attacks [1].

Air quality tells us if the air we respire is good or bad. The AQI decides how good the air is at a location. Air quality can change from time to time as air keeps moving. Monitoring the air quality helps in understanding the extent of pollution in an area with reference to the standards of air quality. Monitoring helps us to avoid any uncertain events and take immediate action. Generally, the present national air quality monitoring network is limited in scope [2] and reporting the data takes lots of time. Monitoring the quality of air is mostly confined to industries. There is a requirement for a simple, easy to operate air quality monitoring system which can be utilized to inspect the quality of air anywhere and anytime, Whenever the concentration of the gases increases beyond a certain limits SMS alert needs to be sent to the user. The data can also be sent to a cloud like Thingspeak.

A secure Air Quality Monitoring Platform has been developed to check the quality of air at a particular location from time to time and store the data in the cloud with an analysis using graphs. The platform uses Raspberry Pi and MQ series sensors like MQ135, MQ2, MQ7 is used to measure the concentration of gases. The system involves monitoring the air quality by considering parameters like carbon dioxide, carbon monoxide, combustible gases, smoke, temperature and humidity. The data is uploaded to Thing Speak where data is analysed. When the concentration is high an SMS alert is sent to the authorities. Security for the data is provided using AES algorithm.

The air quality monitoring systems are generally used near industries but not in urban cities. A total of 523 manual monitoring stations are being operated across states and hence there is a need to increase, they are huge and expensive to maintain and cannot be accessed by all. The data collected is not provided with enough security and hence can be tampered easily.

Paper is organized as follows. Section II describes the related work. In Section III proposed the block diagram of a secure air quality monitoring platform using IoT sensors. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

II. RELATED WORK

In this section we have seen various research papers on secure air quality monitoring platform using IoT sensors. "Design and Analysis of IoT based Air Quality Monitoring System" was published by Ajitesh Kumar, Mona Kumari,

and Harsh Gupta in 2020. Node MCU was used as the microcontroller. MQ2 and MQ9 sensors were used to measure the concentration of LPG gases. The monitoring system is low cost and occupies less space. Other gases could also have been considered.

"IoT Air Quality Monitoring System" was published by Fathima Shifana N S, Jensi Jahfar, Mubeena M J, Najiya Shafi, Asmin M K, Shamna A R in 2020. Arduino UNO was used as the microcontroller. MQ135, MQ2 and MQ7 sensors were used to measure the concentration of gases like carbon monoxide, methane, alcohol, formaldehyde etc. The system also had a GSM module to send alerts to the users. The proposed system faced a problem of computational complexity when dealing with big sensor data and fog computing was suggested as alternative to cloud computing.

"Air Quality Monitoring Using IOT: A Survey" was published by Hocine Mokrani, Razika Lounas, T. Bennai in 2020. A detailed survey was conducted to collect information about the various kinds of pollutants in air, the diseases caused by them and the existing air quality monitoring system. Some challenging aspects such as security and privacy, adaptability, are not discussed.

"Sensor-based optimization model for air quality improvement in home IoT" was published by Kim, Jonghyuk, and Hyunwoo Hwangbo in 2018. The data could be used for further analysis. The disadvantage is that there is a delay of 10 seconds for the data to be updated.

"Implementation of IoT-Based Air Quality Monitoring System for Investigating Particulate Matter (PM10) in Subway Tunnels" was published by Jun Ho Jo, Byung Wan Jo, Jung Hoon Kim, Ian Cho in 2018. A smart air device was used to measure the amount of particulate matter in subway tunnels. An analysis was performed to follow up after implementation and assess how the change improved conditions. Only particulate matter was checked and there was no discussion about security.

III. METHODOLOGY

Architecture:

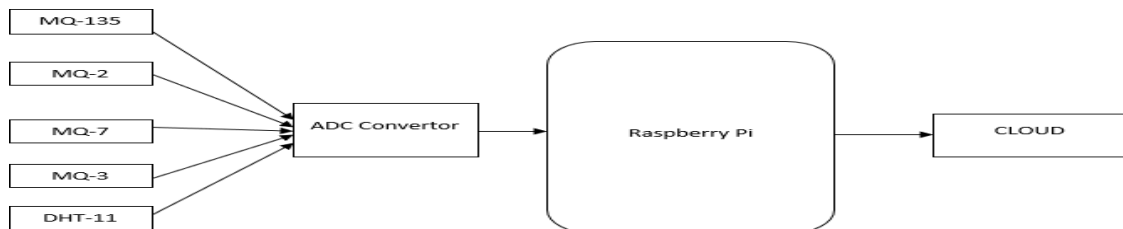


Fig1: Basic Architecture of secure air quality monitoring platform using IoT MQ135 sensor

The above figure describes the block diagram of a secure air quality monitoring platform using IoT MQ135 sensor detects gases like NH₃, NO_x, alcohol, Benzene, Smoke, CO₂. MQ2 sensor is used to detect LPG, Propane, methane, hydrogen. MQ3 sensor detects smoke and MQ7 sensor detects carbon monoxide. DHT-11 sensor is used to detect temperature and humidity. The sensors give the output in form of analog signals which are then converted into digital signals with the help of ADC converter. The output analog signals are then given as input to the Raspberry Pi [8] which is a microcontroller. The data is collected and stored in the cloud.

The following procedure is followed in the secure Air Quality Monitoring Platform using IOT:

1. The sensors are connected to the raspberry pi via the adc using jumper wires.
2. First power should be supplied to the hardware setup.
3. The sensors sense the number of gases in the form of analog signals.
4. Analog signals are sent to ADC converter where they are converted into digital signals.
5. These digital signals are given as input to the Raspberry pi.
6. Using the VNC Viewer open the Raspbian OS and code is run.
7. The data about the quantity of gases is displayed and if the amount of any gas is high an SMS alert is sent.
8. Then the collected information is uploaded to the cloud and is further analysed.
9. The data collected in excel sheet is also analysed.

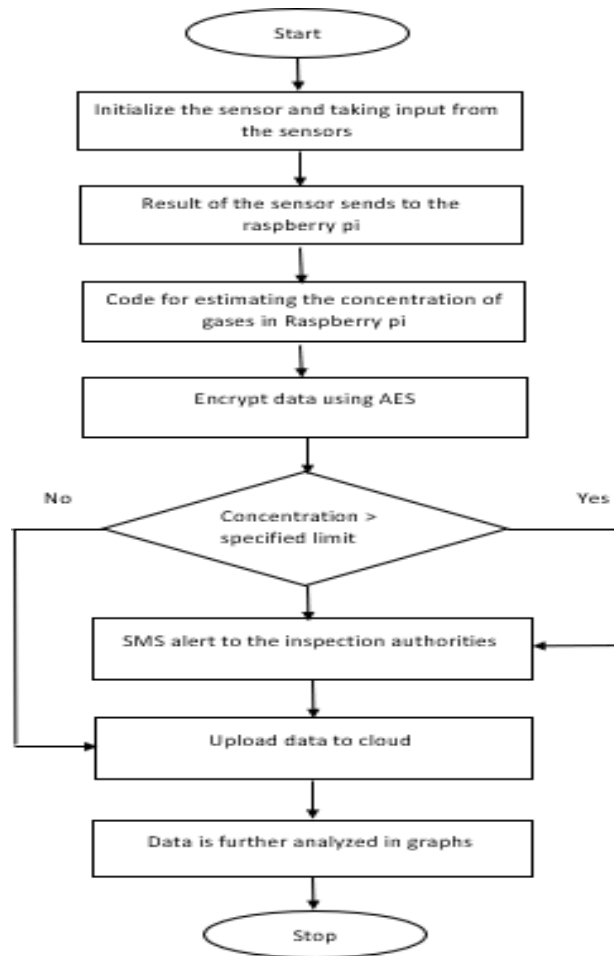


Fig2: Flow chart for air quality monitoring platform

Algorithm

The algorithm used for encryption is the Advanced Encryption Standard. AES is implemented in software and hardware throughout the world to encrypt sensitive data. It is essential for government computer security, Cyber security and electronic data protection [9]. AES algorithm is a block cipher algorithm and uses only one key and the no of rounds depends on the size of the key. We are using the 256-bit key, 128-bit data and 14 rounds. Every round of AES has the following functions:

Add Round Key: State is the block of information that is to be encoded. In this function a bitwise xor operation is performed considering byte of the state and the round key.

Sub Bytes: It is a substitution step where each byte is replaced with another byte based on a lookup table.

Shift Rows: In this operation the bytes in each row of the state are shifted left.

Mixed Columns: A fixed polynomial is multiplied with each column of the state.

In AES, Sub Bytes, Shift Rows, Mixed Columns and Add Round key are performed for n-1 rounds, whereas all other functions excluding mixed columns is performed in the nth round.

IV. EXPERIMENTAL RESULTS

The following figures describe the outputs and the test cases of how the air quality monitoring platform works:

i. Hardware Setup:



Fig3: Hardware setup

The above figure consists of the hardware setup for the air quality monitoring platform which has sensors like MQ2, MQ3, MQ7 and MQ135 to detect concentration of gases like CO₂, CO, smoke, combustible gases etc. The ADC Converter is used to convert the analog signals generated from the sensors to digital signals (in the form of 0's and 1's) and the following figures describe the outputs and the test cases of how the air quality monitoring platform works:

ii. The graphical user interface:

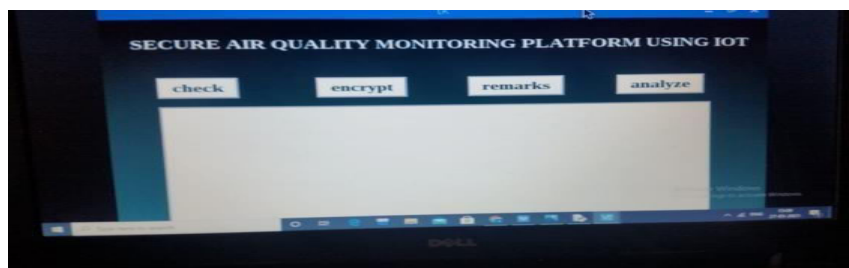


Fig4: GUI for Secure Air Quality Monitoring Platform using IOT

The above figure describes the GUI for the Air Quality Monitoring Platform it has 4 buttons which have the following functionalities:

Check: Used to check the concentration of gases.

Encrypt: To demonstrate how the data is encrypted and displays the cipher text.

Remarks: Displays comments about the air quality based on concentration of the gases.

Analyze: This shows the graphs of each gas with respect to the value of air quality sensor.

iii. The output: The output for two cases has been demonstrated.

-Case 1: The air quality was checked outdoors on the terrace. The following figure shows the output obtained. Since the air quality was good and a fresh breeze was there no messages were sent to the user. All the concentration of gases was very low.

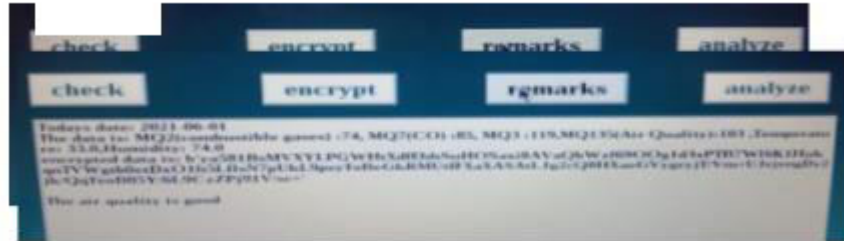


Fig5: Output for outdoor air quality

Case 2: Indoors: The air quality was checked indoors. The following figure shows the output obtained.

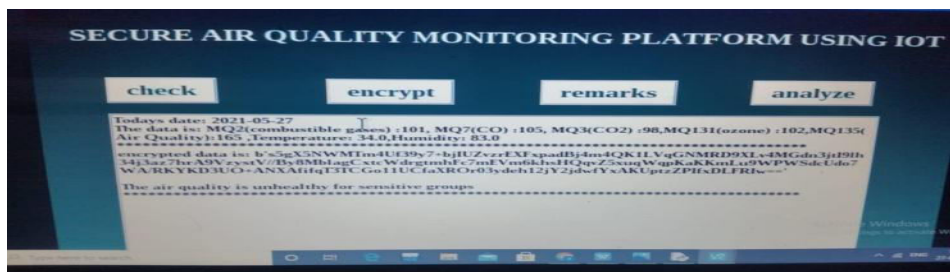


Fig 6: Output for indoor air quality

Case3: Indoors with polluted air: The quality was checked after spraying perfume MQ2 sensor was high a message was sent to the users stating that the particular gas was high. The concentration of the gases exceeded 250 which was more than the permissible limit and it is very hazardous to health. Spraying too much perfume causes migraine and allergic reactions.

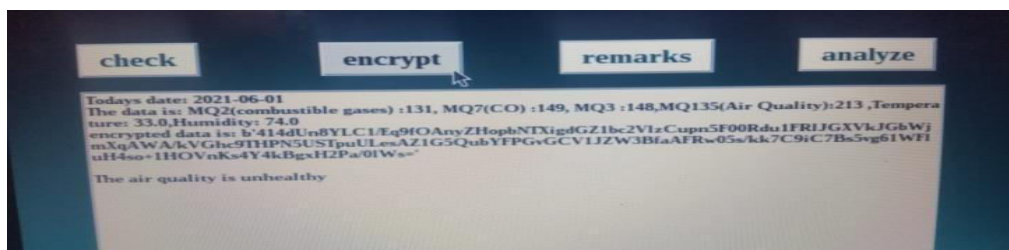


Fig7: Output for Indoor Air Quality with polluted air

All the data (concentration of gases) collected till now can be analyzed in the form of graphs with the help of matplotlib module in python.

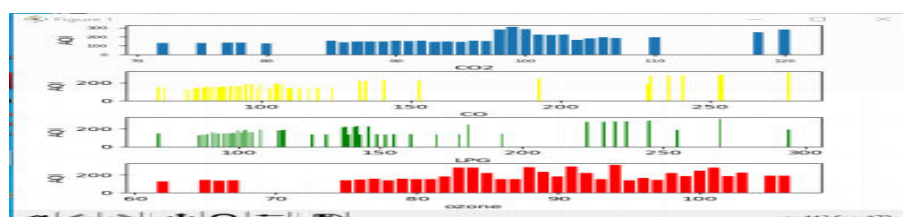


Fig8: Analysis of the data collected

- i. SMS alerts: SMS alerts are sent using the Twilio API.

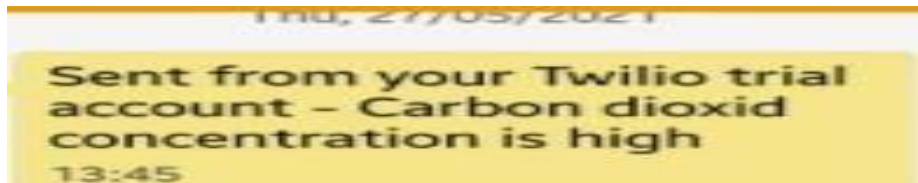


Fig9: SMS alert

- ii. The data is then stored in ThingSpeak cloud.

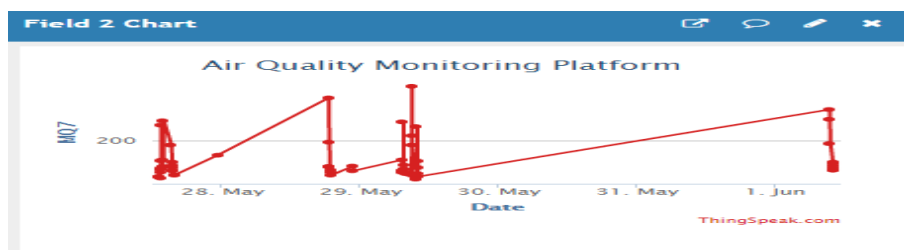


Fig 10: Graph for MQ7 sensor in Thingspeak

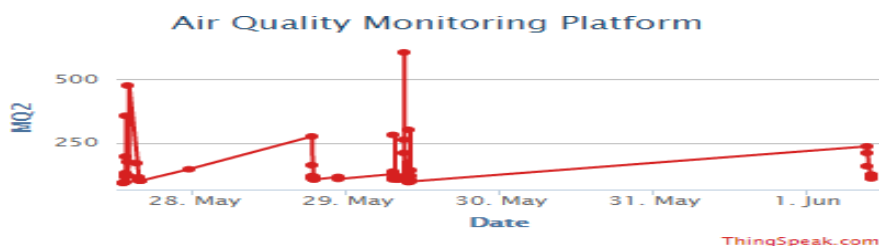


Fig 11: Graph for MQ2 sensor Thingspeak

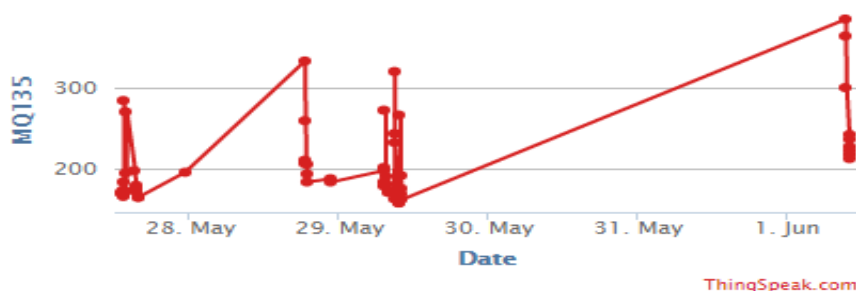


Fig12: Graph for MQ135 sensor in Thingspeak

V. CONCLUSION

In our system, we have used Raspberry pi 3B+ microcontroller along with different real time sensors to create a Secure Air Quality Monitoring Platform which helps in time-to-time detection of concentration of various pollutants in air. The information from the sensors is also encrypted to be sent through the internet so that data can't be tampered with. It is collected in an excel sheet and sent to the Thing speak cloud. The data is further analyzed and whenever the concentration of gases is high a sms alert is sent to the user. Advances in embedded systems and new gas sensors technologies provide an opportunity for a new generation of low-cost air quality monitoring systems to emerge [10]. Hence development of such air quality monitoring platform had been possible.



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