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Design and assessment of a Real-Time Internet of Things based, cost-efficient air quality monitoring system

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Abstract
The effects of climate change are leading to an increase in the frequency and severity of the heatwaves.The combination of high temperatures, wildfires, and desert dust is already having a measurable effect on air quality, public health, and the planet. This paper offers a cost-effective air quality monitoring solution that assists in maintaining an awareness of air quality by detecting a range of pollutants in a variety of settings, particularly in offices , vehicles and busy areas without ventilation or reliant on air vents.thedevice is capable of detecting a variety of pollutants. In this device The MQ-series gas sensors are attractive candidates in the area of gas concentration sensing due to their high sensitivity and low cost.MQ135 and MQ7 have been considered .the MQ135 is capable of detecting the presence of a variety of substances, including ammonia, carbon dioxide, alcohol and smoke. The MQ7 sensor detects carbon monoxide.
The combination of these two sensors makes them appropriate for the intended application. Additionally, the DHT22 sensor is used in measuring temperature and humidity.The system is linked to the internet through Wi-Fi by using esp32 chip which is perfect for IoT applications. The gathered data from the sensors are displayed in an IoT platform ThingSpeak and displayed in an LCD as well. The entire installation can be constructed in a slim and cost-effective manner, and can be utilized as a convenient carry-on device.Such that awareness is brought among the people of the air quality level of the area surrounded by the person either indoor or outdoor or in public vehicles. The objective of this work is to observe the air quality in a particular locality and alert the user when the readings exceed the normal level.

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I. Introduction

The prevalence of air pollution is rapidly becoming a major issue in many countries, driven by a variety of factors such as industrialization, urbanization, population growth, vehicle emissions and deforestation. The air quality index is steadily deteriorating.air quality can be measured in any location. Cost-effective sensors have been taken into account.

The Internet of Things (IoT) facilitates the transmission of data to the cloud, and the data can be read from any location on the internet.The Air Pollution units used are the PPM (parts per million). The raw sensor data is converted to the PPM values in the corresponding code in the Arduino IDE platform, while the necessary information is extracted from the Sensor Data Sheets. The development kit board used in the project are cost-effective and reliable which is NodeMCU ESP 32 kit.

II. Literature Review and Related work

The Air Quality Index, or AQI, is a daily indicator of air quality. It indicates the level of clean or polluted air in an area, as well as the potential health consequences associated with breathing polluted air [1]. The focus of the AQI is on the health effects that an individual may experience within hours or days of inhaling polluted air.High levels of air pollution can lead to immediate health issues, such as aggravation of cardiovascular and respiratory conditions, increased stress to the heart and lungs, as they must work harder to provide oxygen, and damage to the respiratory system [2]. Long-term exposure to contaminated air can have long-term consequences, such as accelerated lung aging, loss of lung capacity and function, and the development of diseases such as asthmatic and bronchitis, as well as emphysema and possibly cancer[3]. The

Purpose of the AQI is to assist you in comprehending the impact of local air quality on your health. A higher AQI indicates a higher concentration of air pollutants, which in turn implies a higher level of health risks.

Range (PPM)	**Status**
0-50	Good
51-100	Moderate
100-150	Unhealthy for sensitivegroups
151-200	Unhealthy
201-300	Very Unhealthy
301-500	Hazardous

Table 2.1. Air Quality Index

Table2.1 explains the air quality index ranges, It is generally accepted that a concentration of 0 to 50 parts per million (PPM) is safe, 51 to 100 PPM is moderate, 100 to 150 PPM is poor and unhealthy for individuals with health conditions and complications associated with lung diseases, and 200 PPM or higher is considered highly unhealthy and hazardous [4]. Gautam et al. [5] implemented a similar concept with the use of MQ2 gas sensors and the Raspberry Pi. The data from the sensor was presented in the IoT platform, which serves as a cloud web server called "Thingspeak". The limitation of the research lies in the fact that the Raspberry Pi requires a necessary component analog-to-digital converter, as the MQ2 Gas Sensor is an analog device. As the MQ Series sensors are analog, an additional chip is required for digital to analog conversion, which defeats the purpose of the project in terms of cost effectiveness. Additionally, the MQ2 Sensor is has high sensitivity for Liquid Petroleum Gas (LPG), smoke, and has a limited detection range. And the proposed system did not include a temperature or humidity sensor.Iffikrul, M et al. [6]came up with a similar concept.which involved the use of MQ2 sensors and temperature sensor, with the data collected being transmitted to the IoT Blynk application. The previous prototype did not include an option to alert the user when there was a high concentration of hazardous gases in the vicinity. Additionally, the MQ2 Gas Sensor has a limited detection range. One of the most concerning issues with the Blynk application is that many users have mentioned that the platform only allows a certain number of devices to be connected to one Blynk account, which necessitates the creation of multiple accounts for IoT devices.It appears that the sensors used by [7] have not been calibrated correctly, as the indicated readings are in excess of 300 parts per million (PPM). As indicated in Table 2.1, this level of PPM is considered to be hazardous and dangerous.

III. Proposed System

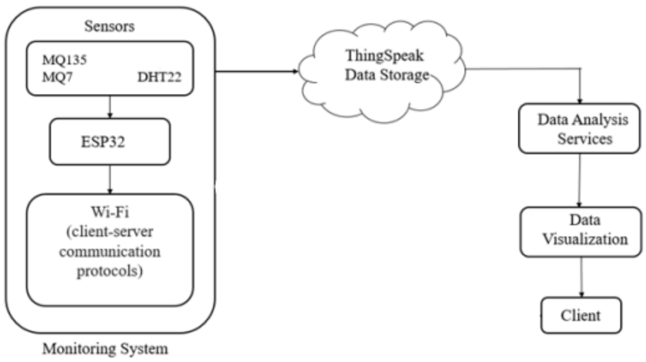

Figure 3.1. Proposed system

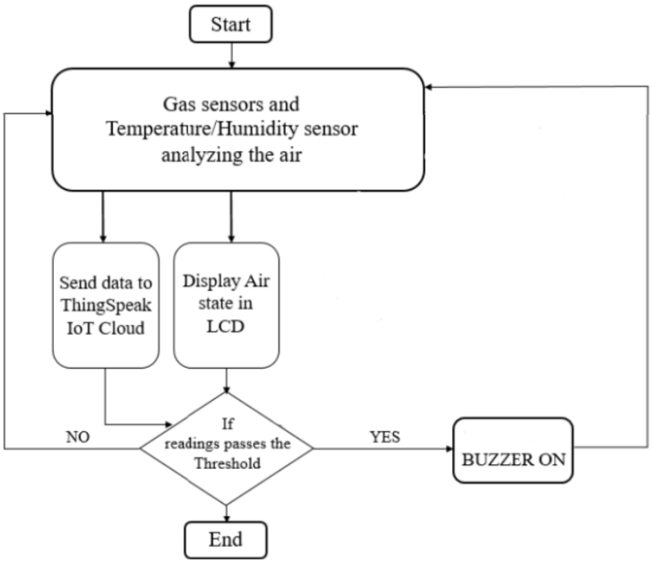

Figure 3.2. Flow chart of the system

The proposed system in figure 3.1 and Flow chart of the system in figure 3.2shows the system's architecture. the system is equipped with MQ7 sensor, MQ135 sensor, DHT22 temperature and humidity sensors, a buzzer, and a 16 x 2 LCD display which will display the current status of the air quality to the user.the system is intended to detect the presence of toxic gases in the surrounding environment and to inform the user of any time there are toxic levels of gases present. The sensor data is presented in the IoT platform ThingSpeak.

IV. Measuring the Accurate Parts per Million PPM.

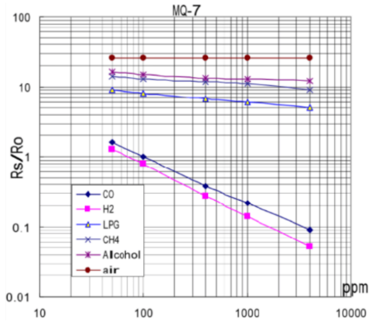

Figure 4.1. MQ7 sensitivity chart

From the datasheet of the sensor in figure 4.1. after choosing the desired line of the gas to be detected (CO) from the sensitivity chart. the points of the line are re-plotted using Excel.

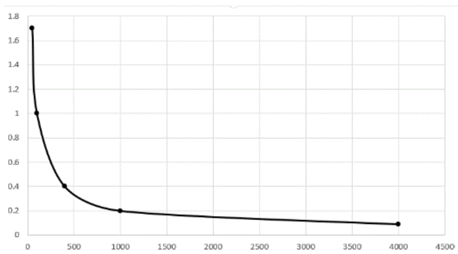

Figure 4.2. CO log-log scale

Figure 4.2 represents the re-plot of CO points in log-log scale, indicating the equation
logy=mlogx+b (4.1)
the constant m and bare the exponent and the intercept (scale factor), respectively, and can be calculated by choosing any two points from the sensitivity chart of MQ7 sensor.in this case points (100,1)and (1000,0.21) from the CO(Carbon monoxide) line.

$m=\frac{logy - logy0}{logx - logx0}$ (4.2)

$m=\frac{\log(\frac{y}{y0})}{log\frac{x}{x0}}$ (4.3)

Substituting the values of x,xo,y and y0 :

$m=\frac{\log(\frac{0.21}{1})}{\log(\frac{1000}{100})}$ = (4.4)

m= - 0.677 (4.5)

finding the y intercept by choosing a point from the CO line in the sensitivity chart point (100,1)

logy=mlogx+b(4.6)

b = log(1) – (-0.677)*log(100) (4.7)

b= 1.35 (4.8)

10^{b}=22.4 (4.9)

after finding m and b the gas concentration in ppm can be estimated as follows.

Rs/R0 =$ppm^{m} * 10^{b}$ (4.9)

ppm^{m}= Rs/R0/22.4 (4.10)

Ppm=$(\frac{Rs}{R0*22.4})^{\frac{1}{-1.477}}$ (4.11)

V. Experimental Setup

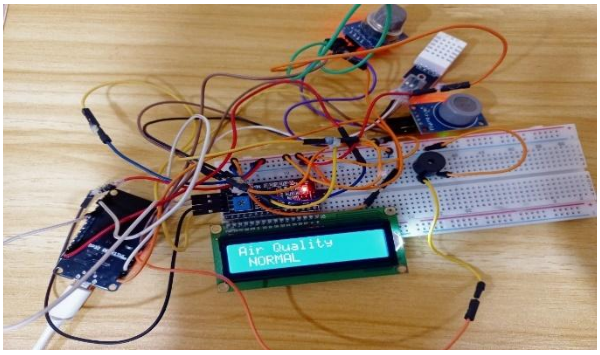

Figure 5.1. System Setup

Figure 5.1 illustrates the full system setup, which includes MQ7, QM135, DHT22, ESP32,LCD and a buzzer.

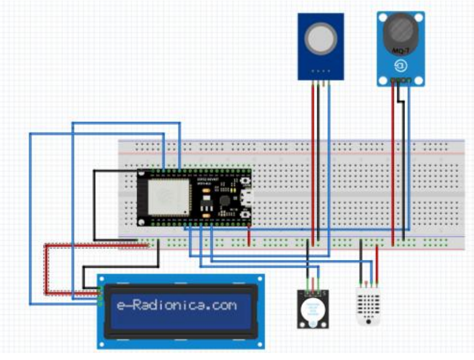

Figure 5.2. Circuit connection

Figure 5.2 shows the connection of the sensors and the buzzer in addition to the I2C LCD.

VI. Results and Findings

The air quality measurements were conducted in a laboratory setting and presented on the ThingSpeak platform. The X axis of each graph indicates the date and time while the Y axis indicates the parameter ppm.

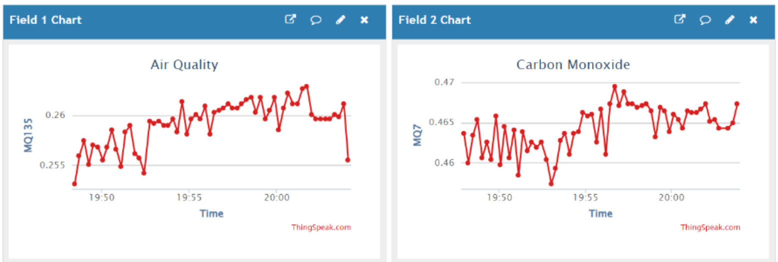

Figure 6.1. MQ7 and MQ135 readings

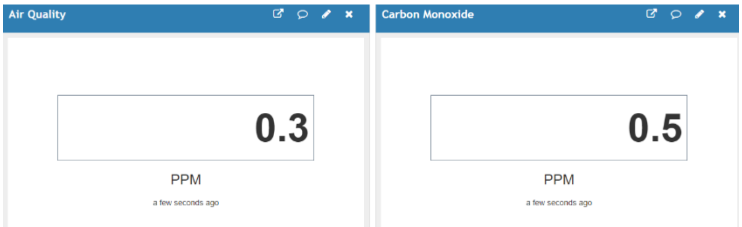

Figure 6.2. MQ7 and MQ135 numerical readings

The MQ135 and MQ7 readings are presented in Figure 6.1, with updates being made every 10 seconds. Additionally, Figure 6.2 provides an additional option of numerical readings from the sensors.

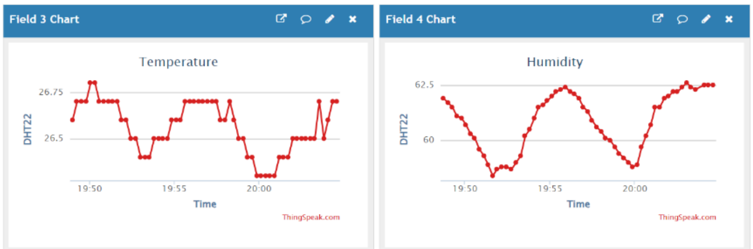

Figure 6.3. DHT22 readings of temperature and humidity

Figure 6.3 displays the values for the temperature and humidity of DHT22 sensor.

Date	Entry ID	MQ135 AirQuality	MQ7 CO	Temperature °C	Humidity %
2023-10-25	2060	0.34552	0.51579	27.9	57.4
2023-10-25	2061	0.34271	0.49199	28	57.8
2023-10-25	2062	0.33968	0.50757	27.9	57.2
2023-10-25	2063	0.34249	0.50627	28	56.8
2023-10-25	2064	0.34206	0.50735	28	56.8
2023-10-25	2065	0.33989	0.5067	28	56.6

Table 6.1.readings of the sensors

Table 6.1 illustrates the sample data of the sensors on October 25, 2023, providing an overview of each sensor and its respective values.

VII. Conclusion

This paper proposes a low-cost, energy-efficient and highly accurate system for real-time air quality monitoring on a small scale using specialized sensors. This system will alert users when the air quality levels exceed a certain threshold and display the data in an easy-to-understand manner. By leveraging the concept of the Internet of Things, users can monitor the air surrounding the system from any device or computer. By continuously updating the data, users will be able to take prompt action to reduce air pollution, which is a pressing concern. This system is cost-effective, energy-efficient, space-efficient, and can be deployed anywhere, offering great flexibility and effectiveness.

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