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Design and Implementation of a Smart Air Quality Monitoring System Using Blynk and IoT Technology

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Abstract -Air quality monitoring is very important, not only in general, but of course in urban and industrial areas, where being on the part of pollution that is one of the problems that is growing. It is on the bases of that, research in this case is presented in the design and implementation of a smart air quality monitoring system using the IoT technology. The wireless connects along with the DHT11 sensor for temperature and humidity reading and MQ-135 gas sensor module to sense various air pollutants including CO2, CO & VOC. The Blynk app is used to analyze and visualize data in real time, with users able to have an intuitive user interface of the air quality trend. The system was tested under different weather conditions and was found to deliver reliable and accurate feedback of air quality. It also provided real time feedback for users through a serial monitor. The results indicate successful integration between hardware and software components and the Blynk app provides a relatively user-friendly way of displaying, analyzing and interacting with the data output from the sensor. However, the current study demonstrates the feasibility of IoT based air quality monitoring systems for real time environmental monitoring. Future efforts will focus on improving system accuracy; improving sensor calibration; and the development of more capable large scale, urban air quality monitoring application.

Key Words**:** Air Quality Monitoring, IoT-based Systems, Environmental Monitoring, Sensor Networks, Real-time Data Analysis

Ⅰ. INTRODUCTION

A major global concern is its impact on the environment and human health and that one is air quality. Urbanization and industrialization speed up concentration of pollutants in the atmosphere that causes serious health problem. As this challenge cannot be addressed without effective air quality monitoring systems, it is urgent that they are available. The monitoring of air quality involves determining and analyzing different pollutants such as particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide and ozone. The source of these pollutants can be all different: vehicular emissions, industrial activities, natural processes. Prolonged exposure to bad air quality may lead to serious health problems, ranging from respiratory disease to cardiac disease and cancer.

Satisfactory air quality monitoring is critical for a number of reasons, including. It allows us to find outplaces where the air quality is not that good, to take immediate actions and give out public health advisories. Through monitoring air quality trends air quality can be assessed for the changes in the environment due to human activities and strategies for mitigation put into place. Furthermore, reliable air quality data contributes to decisions about and regulation of emissions and of air quality standards.
The purpose of this research paper is to develop and implement an IoT based air quality monitoring system. This system utilizing the power of the IoT provides a cheap and efficient solution to real time air quality monitoring and analysis.

Ⅱ. LITERATURE REVIEW

With the growing concern for the problems of air pollution and its health and environment impact the area of air monitoring with the Internet of Things (IoT) is an area of research. IoT based systems provide real time, complete, and scalable solutions for the air quality monitoring in different settings, including urban, industrial and indoor.

Together, fixed and mobile IoT sensors can offer complete picture of the air quality in a region. Fixed sensors are generally supplemented by mobile sensors located on moving vehicles which can provide full spectrum analysis of air quality spatial and temporal variations while covering areas not detected by stationary sensors. [1]. The modular IoT platforms facilitate the integration of various sensing technologies — and hence wireless sensor networks — from within the same commercial edge provider. We adapt these systems for indoor air quality

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monitoring (IAQM) systems, for example, for measuring CO2 CO, SO2, NO2, O3, as well as temperature and humidity. [3] [5]. Industrial air quality monitoring using IoT enabled devices consist of sensors like MQ-135 equipped in monitoring devices for propagating the contaminated data in real time through smart devices. These systems are crucial for monitoring air quality in industrial settings with more concentrated pollutants. [7]. Most IoT based air quality monitoring systems use various sensors for pollutant detection. Parameters measured by common sensors such as MQ135, CCS811, PMS5003, BME280 can measure CO2, PM2.5, PM10, VOCs and more. Node MCU and ESP32 micro controllers have been used for wireless transmission and data processing [2] [6] [9]. Wi-Fi modules or LTE modems are used to send sensor data to cloud services. It enables real time air quality data use and remote access. In many ways, cloud computing is integrated to store, analyze and visualize data that gives users actionable insights. [4] [8]. Mobile applications and web interfaces user friendly to carry out real time sensor data, configure alerts and visualize trends. They support informed user decision making about environment and also realize proactive pollution management. [2] [4]. Current air quality monitoring systems frequently encounter difficulties in precision and sensitivity. Existing systems could be improved to have a higher accuracy and reliability with improved sensor technologies and calibration methods [4]. As IoT based systems are at first glance modular, they are well suited in their Samsung enabling deployment in different settings ranging from residential to industrial. But it's hard to ensure seamless integration of these systems and their maintenance [3] [5]. Environmental sustainability is improved through real time data from IoT based air quality monitoring systems that allow for monitoring and reducing pollution. Future work should further develop low cost, energy efficient systems to further enhance their environmental benefits. [6] [10].

Ⅲ. PROBLEM STATEMENT

Effective monitoring solutions for the ever-rising levels of air pollution and its health and environment impacts are in an urgent need. Traditional air quality monitoring techniques typically do not provide real time capability, and do not constitute complete vertical and horizontal spatial coverage. Real time, scalable and flexible monitoring for a range of diverse settings including urban, industrial and indoor, is a promising opportunity that can be achieved by using IoT based systems. The systems take advantage of a mixture of fixed and mobile sensors to create a detailed representation of air quality and their spatial and temporal variations. However, applications of IoT air quality monitoring suffer from the limitations against high accuracy and sensitivity. The performance is also sensitive to sensor precision, environmental conditions as well as the reliability of data transmission. Improved system accuracy requires enhancement of the calibration methods as well as the advanced sensor technologies. In addition, there are additional problems in the integration and maintenance of modular IoT platforms, which should be done seamlessly, in various settings from household to industry. Data analysis and visualization are made easy by cloud computing, but securing data and saving energy continue to be an issue. the need for future advancements is clear: energy efficient, robust and affordable IoT systems that preserve environmental sustainability. The objectives are to measure, display temperature, humidity and gas level of the environment. Capable of producing an air quality sensing system with advanced capabilities that provides low-cost comprehensive monitoring through the combination of advanced detection technology technologies. Sensed data can be displayed in format that can be displayed in serial monitor by the user.

Ⅳ. PROPOSED METHODOLOGY

1. Block Diagram

The air quality monitoring system measures the concentration of gases using MQ135 sensor and temperature, and humidity using DHT11 sensor as shown in fig.1. Data obtained from the sensors are analyzed by the ESP8266 Wi-Fi module and can be sent to the cloud platform or other server. This can be done by either through the Blynk app or through the serial monitor, although this will be from the local interface.

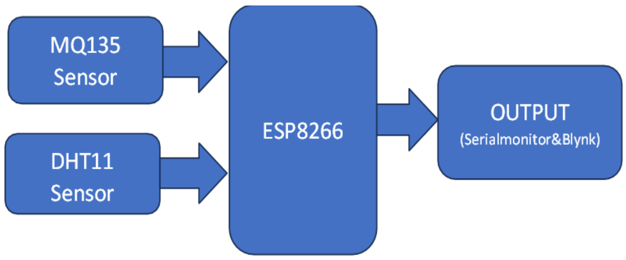


Fig 1. Block Diagram of air quality monitoring

2. Components / Tools Involved

a) NodeMCU ESP8266: It is an affordable development board based on the ESP8266 Wi-Fi system. This board is convenient to program through Arduino integrated development environment, consumes little power and is suitable for many applications like industrial uses.

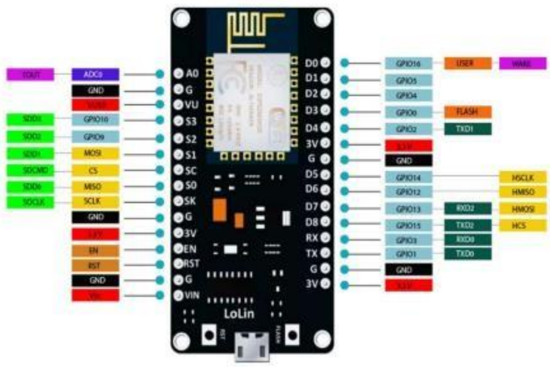
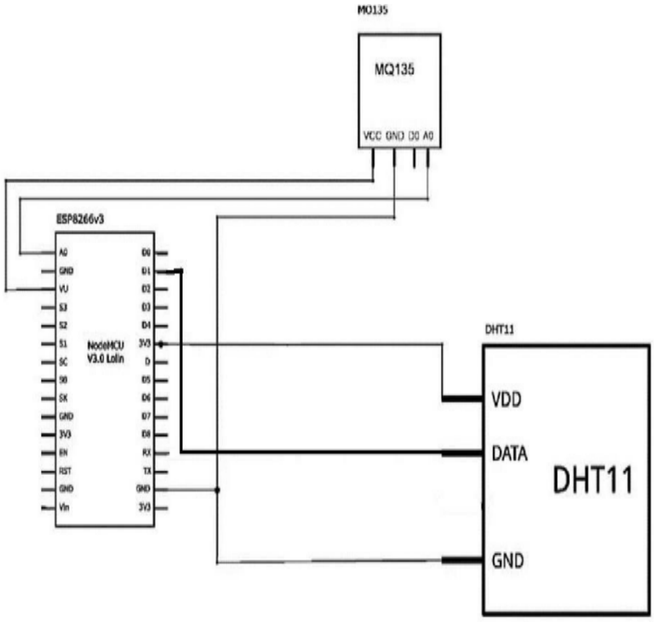


Fig 2. NodeMCU ESP8266

b) DHT11 Sensor Module: The air quality monitoring system involves an ESP8266 Wi-Fi module and incorporates DHT11 temperature and humidity sensors and MQ135 gas sensors. Much of this data is then sent to a cloud-based platform to allow remote analysis for trends.



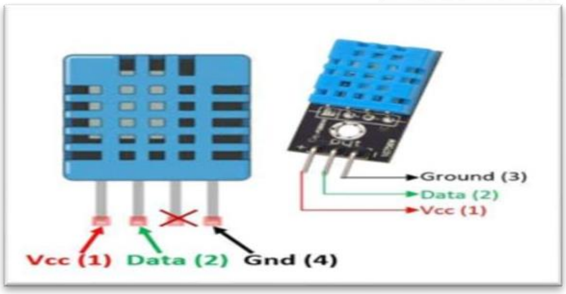


Fig 3. DHT11 Sensor Module

c) MQ-135 Gas Sensor Module: The MQ-135 gas sensor detects various air pollutants. It's easy to use and affordable, but its accuracy can be affected by environmental factors.

Fig 4. MQ-135 Gas Sensor Module

d) Arduino IDE: The Arduino IDE is open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++.

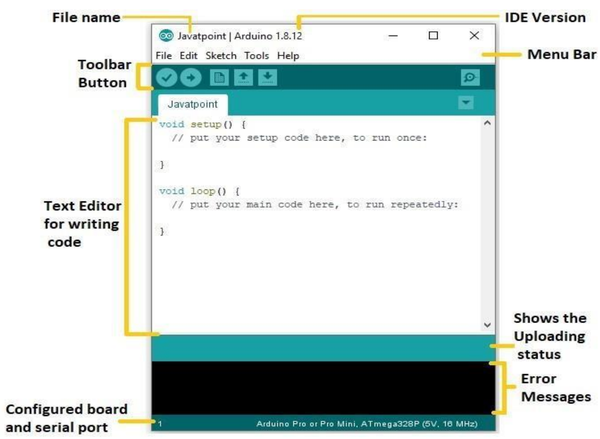


Fig 5. Arduino IDE Interface

3) Circuit Diagram

Fig 6. Circuit Diagram

An air quality monitoring system is depicted in fig 1. It uses an ESP8266 Wi-Fi module to collect data from two sensors: It used an MQ-135 gas sensor and a DHT11 temperature and humidity sensor. Sensor data is processed with ESP8266, and then it is wirelessly sent to cloud platform or local server for further analysis and visualization.

4) Working Model

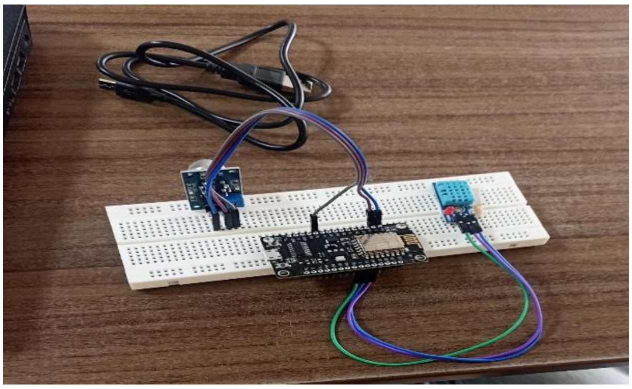


Fig 7. Working Prototype

The DHT11 temperature and humidity sensor is connected as follows: In the DHT11 the OUT pin is connected to the D1 pin of the ESP8266, the IN pin of the DHT11 is connecting to 3V and the GND pin of DHT11 is connecting to GND pin of ESP8266.

The MQ123 gas sensor is connected as follows: The ESP8266 will be connected to the A0 pin of the ESP8266, the GND of the ESP8266 will be connected to the GND of MQ123 and VCC of MQ123 will be connected to 3V to the ESP8266.

Table 1 Pin Configuration for Circuit Diagram

DHT11	D1
OUT	GND
IN	3V
MQ123 SENSOR	ESP8266
A0	A0
GND	GND
VCC	3V

V. WORKING OF THE SYSTEM

1) Sensor Data Acquisition: The temperature and humidity measured by the DHT11 sensor and the gas concentration in the air surrounding will be detected by MQ-135 sensor.
2) Data Processing: ESP8266 is the module that read analog signals from the sensors and convert it to digital value.
3) Wi-Fi Connectivity: The ESP8266 module is used to send the processed data to a cloud Platform or local server over Wi Fi.
4) Data Storage and Visualization: After receiving data, we store our data in a database and display our data on a web interface or even mobile app.
5) Alert System: The system can send alerts for predefined temperature, humidity and gas levels.
6) Remote Monitoring: The web interface or mobile app gives users a view on air quality data remotely.

The parameters are monitored continuously, which provides valuable insight into the air quality as well as some means for preventive action.

VI. RESULTS AND DISCUSSION

We have shown that our device has capability of making accurate measurements of temperature, humidity and gas concentration. The data can be observed in two formats: via the Blynk app and through the Serial Monitor.

1) Blynk app visualization

Air quality monitoring using the IoT platform Blynk is advantageous. It gives real time monitoring, remote access and customizable dashboards. Critical thresholds can be set up by users and historical data stored for analysis. Blynk has other services integration allowing it to do more and enable data driven decisions through improving air quality.

Figure 8 illustrates three separate gauges within the Blynk app, each dedicated to monitoring a specific parameter:

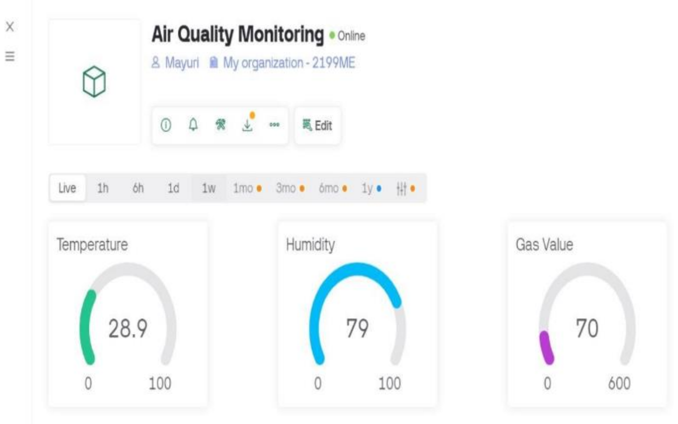


Fig 8. Blynk visualization

a) Temperature Gauge: It shows the air temperature around it. The temperature levels are read from the DHT11 sensor, which gives very accurate reads.
b) Humidity Gauge: Returns the humidity value of surrounding air. Lastly, the DHT11 sensor is used to measure what this current moisture content is, using this also.
c) Gas Value Gauge: It the concentration of air pollutants. This gas sensor reading is amounted from the air that carries various gases and pollutants.

2) Blynk App Analysis

Blynk App offers an air quality parameter monitoring interface using Blynk app. It displays three key metrics in a clear and intuitive manner as shown in below fig 8.

Fig 8. Blynk app analysis

The Blynk app uses circular gauges to display three key air quality parameters:

a) Temperature: Current temperature is indicated on the green gauge. This is a higher number so it's warmer.

b) Humidity: The cylinder gauge shows the humidity at the moment. The higher the number, the more humid.

c) Gas Value: The air pollution level is represented with the purple gauge. The more pollution, the higher the number.

A variety of weather conditions have been used to test the performance and reliability of the air quality monitoring system. some of the samples have been depicted below to analysis the key observations. They relied in capturing and creating the real time data, largely because they used the Blynk app, built for data visualization.

Fig 9. Sample 1

Fig 10. Sample 2

3) Key Observations from Blynk App Testing

a) Temperature Readings: Temperature Fluctuations across Different Seasons and Weather Events were measured accurately by the system. This was visualized in the Blynk app view with a circular gauge, where a number indicating a higher temperature represented that this temperature was warmer.
b) Humidity Readings: It worked well in monitoring humidity levels (especially during monsoon) and drought. On the Blynk app, I showed humidity data in a circular gauge with more showing more moisture in the air.
c) Gas Concentration: We show that the system was able to detect variations in gas concentration, particularly in urban and industrial areas. The Blynk app was used to display this data using a circular gauge; the higher the value, the higher the concentration of the polluting agent.

4) Serial Monitor Output

Real-time data of temperature, humidity, and gas concentration is reported via the serial monitor output. These parameters are constantly being monitored and classified as 'Good air' if current readings are good as shown in below fig. This means that the air quality is OK and takes no serious risks.

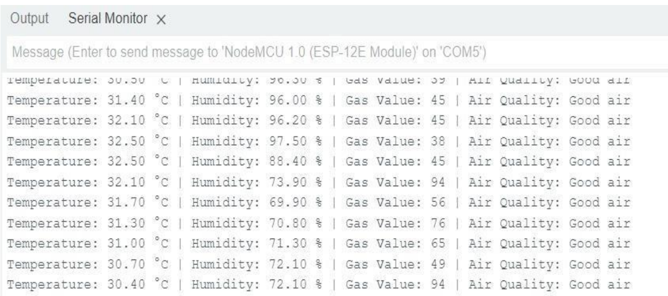


Fig 11. Real time analysis

5) Advantages of Using Serial Monitor

Real-time Data: The system provides immediate feedback about the sensor readings and the behaviour of the system.
a) Debugging Tool: Identifying and troubleshooting code and hardware issues can be achieved with it.
b) Data Logging: This can be used to log data later for offline analysis and visualization.
c) Flexibility: It supports the formatting and display of custom data.
d) Accessibility: It has minimal setup and can simply be hooked up directly from the microcontroller's development environment.

Seeing what the serial monitor has to say is incredibly valuable, and we can take that to make educated decisions on how the system can run better.

VI. CONCLUSION

This research paper has demonstrated the development and implementations of an IoT based air quality monitoring system. Local real time environmental data could be collected and transmitted by the system through the aide of an ESP8266 Wi-Fi module, DHT11 temperature and humidity sensor and MQ-135 gas sensor. This allows you to visualize and monitor the data you collect through the Blynk app, which is obviously very user friendly.

We have experimentally shown that the system can perform temperature, humidity, and gas concentration measurement. This data is presented using the Blynk app in an eye-catching way, and is therefore easy for the users to read and understand. The testing conducted under different environmental conditions has been shown to validate the system reliability and accuracy.

IoT technology has helped integrating the monitoring of the air quality, letting users observe and make decisions about what to do. Additional sensors can additionally be incorporated into the system, like particulate matter sensor, to provide a more detailed air quality analysis.

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