E-Yantra Project Report

M S Dheeraj Murthy
IMT2023552
IIIT Bangalore

Mada Hemanth
IMT2023581
IIIT Bangalore

Dedeepya Avancha
IMT2023006
IIIT Bangalore

Lesin
IMT2023565
IIIT Bangalore

***Abstract*—This project presents a scalable air quality monitoring system designed to provide real-time environmental data to the general public in an accessible and understandable manner. Utilizing an ESP32 board, the system integrates multiple sensors, including temperature, humidity, dust, and gas sensors, to collect key environmental parameters. These sensors continuously monitor air quality, detecting pollutants and environmental conditions that contribute to air pollution and affect human health. The collected data is processed and displayed in real-time through a user-friendly interface, enabling individuals to make informed decisions about their surroundings. This low-cost, efficient solution is particularly relevant in urban and industrial areas, where air quality issues are a growing concern. By making air quality information easily available, the system empowers individuals to take preventive actions to mitigate the effects of pollution on health and the environment.**

***Index Terms*—ESP32, ESP8266, DHT11, ATmega328, MQ131, MQ135, GP2Y1010AU0F, I2C, UART**

I. INTRODUCTION

Air pollution has increasingly become a major concern in urban and industrial areas, contributing to respiratory diseases and environmental degradation. However, access to real-time air quality data for the common populace remains limited, making it difficult for people to understand the condition of their environment and take appropriate actions.

This project aims to bridge that gap by developing an affordable and scalable air quality monitoring system using an ESP32 microcontroller and a variety of environmental sensors. This system is designed to monitor temperature, humidity, dust, and harmful gases, providing real-time data through a user-friendly interface.

By making air quality information easily accessible, this project empowers individuals to make informed decisions about their health and surroundings, while also raising awareness about the importance of environmental monitoring.

II. SYSTEM OVERVIEW

The proposed system utilizes an ESP32 microcontroller connected to multiple environmental sensors, each responsible for measuring different atmospheric parameters. The sensors will collect data across various categories, which will be processed by the ESP32. The microcontroller will decode the incoming sensor data and transmit it to the ThingSpeak cloud platform. Once stored in ThingSpeak, the data will be imported into a web application accessible via mobile devices, allowing end users to monitor real-time air quality information.

The following sensors will be employed:

- DHT11 (Digital): Measures temperature and humidity.
- MQ131 (Analog): Monitors ozone (O_3) levels in the atmosphere.
- MQ135 (Analog): Detects harmful gases such as ammonia (NH_3), nitrogen oxides (NO_x), alcohol, benzene, smoke, and carbon dioxide (CO_2).
- GP2Y1010AU0F (Analog): Measures particulate matter (PM), providing insights into dust concentration in the air.

This setup ensures comprehensive air quality monitoring, covering key environmental factors relevant to public health.

III. RELATED WORK

This work draws inspiration and guidance from two significant papers in the field of IoT-based air quality monitoring:

- ”Development of a low-cost IoT device using ESP8266 and Atmega328 for real-time monitoring of Outdoor Air Quality with Alert” – This paper provided valuable insights into the design of low-cost IoT devices for real-time air quality monitoring, specifically focusing on the use of ESP8266 for data transmission and alert mechanisms.
- ”Development of a Movil IoT System Using ESP8266 for the detection of pollutants in the environment” – This paper offered guidance on the integration of IoT systems with ESP8266 for detecting environmental pollutants, highlighting techniques for mobile data transmission and sensor integration.

These papers played a crucial role in shaping the methodology and approach of this project, particularly in terms of selecting suitable hardware and communication protocols for real-time air quality monitoring.

IV. SYSTEM DESIGN

A. Microcontroller: ESP32

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth.

ESP32 is created and developed by Espressif Systems, a Chinese company based in Shanghai, and is manufactured by

Identify applicable funding agency here. If none, delete this.

TSMC using their 40 nm process. It is a successor to the ESP8266 microcontroller. [1]

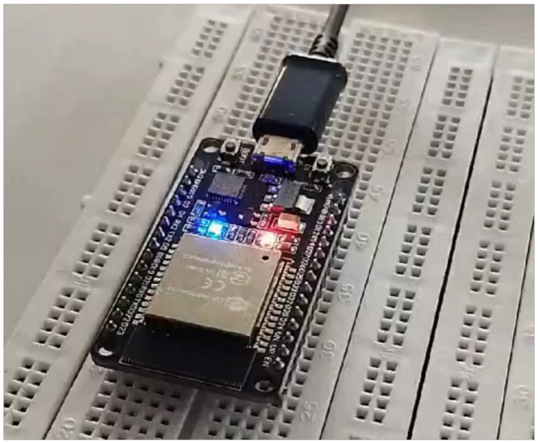

Fig. 1. ESP32 microcontroller in use

The ESP32 communicates with ThingSpeak via the HTTP protocol, ensuring reliable transmission of sensor data over Wi-Fi.

B. Sensors

- DHT11: A low-cost digital sensor for sensing Temperature and Humidity.

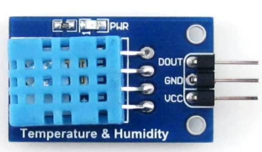

Fig. 2. DHT11 sensor

- MQ131: The MQ131 is a low-cost semiconductor sensor designed to detect Ozone (O_3) in the air. It is widely used for air quality monitoring due to its high sensitivity to O_3 and its ability to detect other gases like NO_2 (Nitrogen Dioxide) and Cl_2 (Chlorine). [2]
  - **Working Principle**: The MQ131 sensor works based on the principle of changes in resistance when exposed to ozone. The sensor element is made of SnO_2 (tin dioxide) semiconductor material that exhibits reduced electrical conductivity when exposed to O_3. As the concentration of ozone increases, the sensor's resistance decreases, allowing for the measurement of gas concentration.
  - **Specifications**:
    * Operating Voltage: 5V DC
    * Load Resistance: 10kΩ (recommended)
    * Detectable Concentration Range: 10 ppb to 2 ppm for O_3
    * Preheat Time: 24 hours (for optimal accuracy)
    * Operating Temperature: -10°C to 50°C
    * Humidity Range: 33% to 85% RH

Fig. 3. MQ131 sensor

- MQ135: The MQ135 gas sensor is widely used in air quality control equipment for buildings and offices. It is suitable for detecting or measuring NH_3, NO_x, alcohol, benzene, smoke, CO_2, etc. [3]
  - **Working Principle**: The MQ135 sensor uses a SnO_2 (tin dioxide) semiconductor layer that exhibits changes in conductivity when exposed to various gases. The resistance of the sensor decreases as the concentration of target gases increases, allowing for gas concentration measurement.
  - **Specifications**:
    * Operating Voltage: 5V DC
    * Load Resistance: 20kΩ (recommended)
    * Detectable Concentration Range: 10 ppm to 1000 ppm for NH_3, NO_x, alcohol, benzene, CO_2, etc.
    * Sensitivity: High sensitivity to NH_3, benzene, and smoke
    * Preheat Time: 24 hours for stable readings
    * Operating Temperature: -10°C to 50°C
    * Humidity Range: 20% to 90% RH

Fig. 4. MQ135 sensor

- GP2Y1010AU0F: This dust sensor "GP2Y1010AU0F" is the device to detect house dust, cigarette smoke, etc., and designed as a sensor for automatic running of application like air purifier and air conditioner with air purifier function. [4]

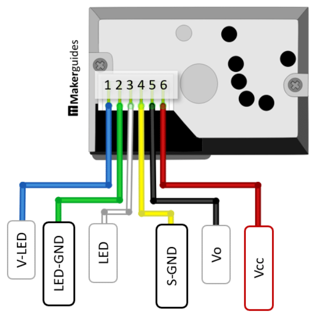

Fig. 5. GP2Y1010AU0F sensor

C. Software

- C/C++: C/C++ language has been used along with the Arduino IDE in order to program the ESP32 board to decode the data from the sensors and upload it to the ThingSpeak cloud.
- JavaScript: JavaScript, along with frameworks like React.js and Node.js, is used to handle the data exported from ThingSpeak and illustrate it in a webpage.

D. ThingSpeak

ThingSpeak™ is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. With the ability to execute MATLAB® code in ThingSpeak, you can perform online analysis and processing of the data as it comes in. [5]

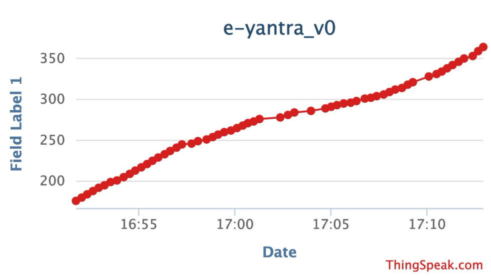

Fig. 6. Graph of values sent to ThingSpeak from ESP32

We have used ThingSpeak to store data from the sensors and visualize them as charts which we can export to the webpages as iframes. Data is visualized using line and bar charts, providing trends over time for each pollutant. Future versions will include threshold-based alerts, notifying users when harmful gas levels exceed safe limits.

V. Web Application and Data Flow

The system features a React-based web application designed to display real-time air quality data collected from the sensors. The following data flow highlights the process:

1) **ESP32 Microcontroller**: The ESP32 collects environmental data from four sensors:
   - **DHT11**: Measures temperature and humidity.
   - **MQ131**: Monitors ozone levels.
   - **MQ135**: Detects harmful gases, including CO_2 and NH_3.
   - **GP2Y1010AU0F**: Measures particulate matter (PM) concentration.
2) **Wi-Fi Connectivity**: The ESP32 connects to a Wi-Fi network and sends the collected sensor data to the ThingSpeak cloud platform using the HTTP protocol.
3) **ThingSpeak Channel**: Data is stored and visualized in real-time on a ThingSpeak channel, which acts as a bridge between the sensors and the web application.
4) **React Web Application**: The React-based website fetches real-time data from the ThingSpeak channel using its REST API. The data is then visualized as charts and gauges, providing users with an intuitive view of current air quality metrics.

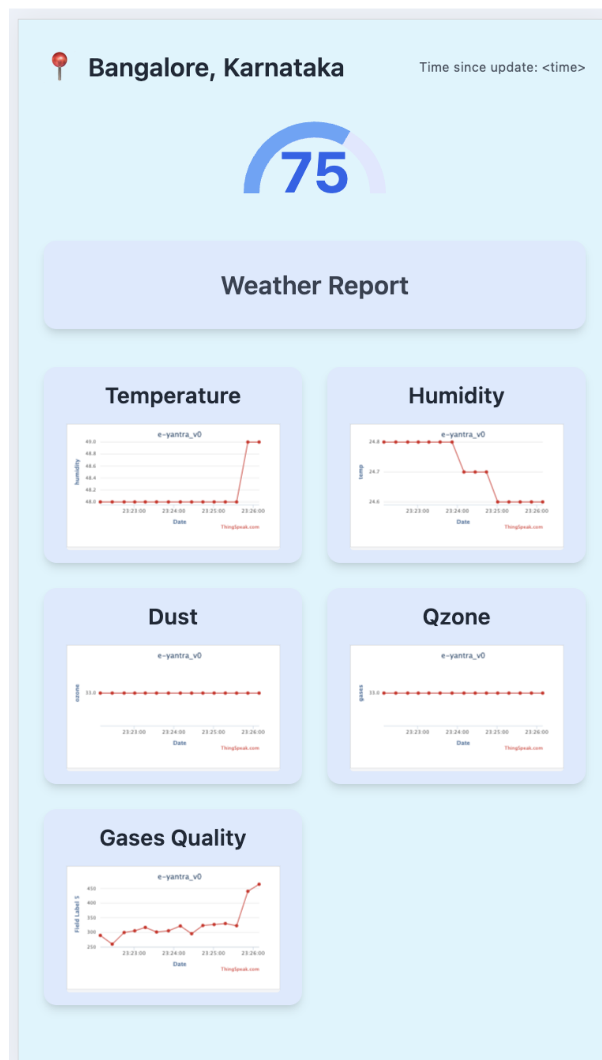

Fig. 7. React-based Web Application Showing Real-Time Air Quality Data

VI. Conclusion

The air quality monitoring system developed in this project harnesses the capabilities of the ESP32 microcontroller and a variety of environmental sensors to provide real-time data on atmospheric conditions. By integrating the system with the ThingSpeak cloud platform, users can access vital air quality information via a mobile-friendly web application, empowering them to make informed decisions about their health and environment. This project not only addresses the need for accessible air quality data but also contributes to raising public awareness about the importance of monitoring pollution levels. Future enhancements may include the integration of additional sensors and features to further improve the system's accuracy and functionality, promoting proactive measures for better air quality management in urban and industrial settings.

References

[1] https://en.wikipedia.org/wiki/ESP32
[2] https://www.winsen-sensor.com/sensors/ozone-sensor/mq131.html
[3] https://www.winsen-sensor.com/sensors/gas-sensor/mq135.html
[4] https://global.sharp/products/device/lineup/data/pdf/datasheet/gp2y1010au_appl_e.pdf
[5] https://thingspeak.com/pages/learn_more
[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.