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Air quality sensing and monitoring

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Abstract

With growing transportation and population density, increasing global warming, and sudden climate change, air quality is one of the critical measures that need to be monitored closely on a real-time basis in today's urban ecosystems. This paper examines the issues, infrastructure, information processing, and challenges of designing and implementing an integrated sensing system for real-time indoor and outdoor air quality monitoring. The system aims to detect the levels of gases, carbon monoxide (CO), carbon dioxide (CO_2), temperature, and humidity on a real-time basis and provides an overall air quality alert. The development of the system for real-time monitoring and alerting is validated and supported through conducted experiments.

Keywords: Real-time; Urban ecosystems; Indoor and outdoor; Gases; Monitoring Alerting

1 Introduction

One study shows that 50,000 to 100,000 people die prematurely each year due to air pollution in the United States alone. This number is 300,000 in the EU and over 3,000,000 worldwide. IoT-based air monitoring uses the Internet to monitor air quality (carbon dioxide, smoke), airborne alarm, alcohol, benzene, NH3, LPG and NOx from a network server. It shows the air quality in PPM on the LCD screen and on the web page, so you can easily monitor it. An LPG sensor is added to this system and is mostly used in domestic applications. The system will display temperature and humidity. The system can be installed anywhere but is typically installed in commercial and residential areas where gases are most likely to be detected and the system will send an alarm when it exceeds the threshold. Recent data shows that many urban and rural air pollutions occur using smart sensor networks and wireless systems. Ambient air temperature measurement of CO, NO_2 and SO_2 is reported. The system is based on smart sensor microinverters equipped with a network-enabled application processor that downloads the virus to a PC for further processing. A wireless sensor system has been developed for instant monitoring of organic compounds in the biological environment. A pollution network consisting of 24 sensors and 10 routers was deployed to monitor various pollutants. The system provides alerts based on the type of pollution found on site. High-definition surveillance network cameras are used to monitor the quality of the Internet. Pollution is an important factor affecting the quality of life of millions of people. Most air pollution comes from emissions from cars, factories, and natural disasters such as volcanic eruptions and forest fires. When people breathe dirty, they face many dangers such as cancer, premature death and asthma. In industry, pollutants are released into the atmosphere, causing temperature increases and global warming. In addition, machines in the industry produce pollutants such as noise and electricity. Air pollution needs to be monitored and controlled to ensure a better and healthier future for everyone. The Internet of Things (IoT) is growing in the space due to its simplicity and low cost. With the development of cities and industries comes pollution. In this paper, we propose a pollution monitoring and control system that allows us to monitor and control pollution from different industries in a single area using GSM and IoT. The system uses sensors to detect the presence of pollution in the market and continuously transmit

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this information. The sensor interacts with the Arduino Uno, which processes the data and sends it via GSM. This allows authorities to monitor and make decisions regarding smoke, electricity, temperature and various types of pollution in different industries. Authorities can also control pollution by cutting off polluting energy sources. Therefore, we can control pollution. Due to the continuous increase in transportation and population density, global warming and rapid climate change efforts, the air quality of many major cities around the world often falls below environmental quality. Many countries have developed their own infrastructure, processes and standards to monitor and provide information to their citizens. For example, the United States Environmental Protection Agency (US EPA) is responsible for monitoring and protecting human health and the environment in the United States. They established U.S. National Outdoor Air Quality Standards based on six air pollutants, proposing the use of Air Quality Index (AQI) to measure air quality and set limits for human health. During the process of industrialization and industrialization, many countries in the world experienced severe weather problems. Air pollution has become an important factor that threatens public health and affects people's daily activities. In major cities of developed countries with air pollution problems, such as Beijing and Delhi, people are generally required to wear masks before going out. Outdoor activities are also limited due to the weather conditions of the day.

2 Structure and content

2.1 Processes and materials

With the development of today's economy, the carbon dioxide content produced by these industries has also increased, which causes global warming, destruction of the ozone layer, and also affects human health. Current systems cannot provide effective and efficient control of these parameters and they may be overlooked due to the use of human labor. Pollution from different sectors such as the paper industry is increasing. The cement industry is dangerous and pollutes air and water. The approach presented here uses IoT technology to solve these problems. Using IoT technology, we follow the details of the work and also monitor the pollution. If the pollution exceeds the limit, our state-of-the-art system activates an alarm and ensures that the business does not exceed the limit. This approach not only ensures the sustainability of the environment, but also encourages urgent interventions to make crop production more efficient by encouraging it. and plays an important role in processing good information. The integration of different components such as MQ-2 CO sensor, ESP32 controller, 16x2 LCD, buzzer, Arduino ATmega328P microcontroller, DHT11 sensor and MQ series CO_2 sensor forms the backbone of the energy monitoring system. Integrations

2.2 MQ-2 CO Sensor

MQ-2 CO Sensor is an important gas detection application, especially in carbon monoxide (CO) monitoring from various environmental aspects. It works by the reaction of CO gas and the material in the sensor, resulting in a change in conductivity. These changes are then converted into electrical signals that can be interpreted by the microcontroller for further processing. The MQ-2 sensor is very sensitive to CO gas; This makes it an important tool for ensuring the safety of environments where CO increases risk, such as industrial facilities, homes with gas appliances, and motor vehicles. Its compact size, low cost and ease of integration make it the first choice of researchers and engineers designing CO solutions. The MQ-2 CO sensor forms the basis for detecting carbon monoxide (CO) levels in the environment. The sensor uses tin dioxide (SnO_2) semiconductor and exhibits high sensitivity to CO gas; This makes it ideal for applications requiring CO monitoring. Its integration involves connecting sensors to microcontrollers to convert analog signals to digital data, facilitating monitoring and analysis over time.

ESP32 Controller: ESP32 controller is a versatile microcontroller unit known for its high performance and powerful features, making it the foundation of IoT (Internet of Things) and the world of technology. It is powered by the dual-core TenSi LX6 processor, which can provide computing power to solve difficult tasks while maintaining low power consumption. ESP32 comes with built-in Wi-Fi and Bluetooth capabilities for seamless connectivity to the internet and other devices, enabling easy data exchange and remote control. Their rich hardware, which includes GPIO pins, ADCs, DACs, and communication interfaces, gives researchers the flexibility to interact with a variety of sensors and actuators, making them ideal for everything from home automation to business monitoring. Known for its versatility and performance, the ESP32 controller is the brain of the body. ESP32 leverages its dual-core architecture and built-in Wi-Fi capabilities to orchestrate seamless communication between sensors, peripherals, and the cloud. Integration involves programming and configuring GPIO pins to create connections with other devices while ensuring power efficiency and data transfer efficiency. Review This device is known for its simplicity, reliability and ease of use. It consists of 16 lines and 2 lines of alphanumeric characters and provides compact yet relevant information for presenting information in the system. The working principle of LCD is to control the light display by controlling the liquid crystal with an electric motor so that it can easily display text and images. Its compatibility with a variety of microcontrollers and ease of use make it a popular choice for scientists looking for instant visual feedback in their work, such as temperature, nature

layers, and user interface for various applications. The 16x2 LCD acts as the interface between the system and the user, providing real-time visual information. Its integration requires connection to a microcontroller via a communication link or communication link that displays important characteristics such as temperature, humidity, CO level and CO_2 concentration. Customized algorithms optimize LCD usage, reducing power consumption without affecting reading. These are silent sounds and are useful for creating alarms and messages. It usually consists of a coil and diaphragm that vibrates in response to an electric current and produces sound at the desired frequency. There are different types of buzzer modules, including passive buzzers and active buzzers, with different driving and control interfaces. Researchers often integrate audio alerts into their projects to provide feedback such as alarms, alerts, and status reports to improve user experience and interaction, all the way to interactive models in applications such as security systems. The addition of an audible alert increases the functionality of the system by providing audible alerts upon preset or abnormal conditions. Its integration involves configuring GPIO pins to create special sounds or patterns that alert users to critical events such as dangerous oil levels or malfunctions. Using pulse width modulation (PWM) technology, the intensity and duration of the ringing sound can be adjusted to suit different viewing environment.

2.3 ArduinoATmega328P

The Arduino ATmega328P microcontroller board is a popular platform for designing and building embedded systems and IoT applications. It is powered by the ATmega328P microcontroller unit, which provides a balance between computing power and processing power, making it suitable for many tasks. The Arduino ecosystem provides users with a comprehensive development environment, including an integrated development environment (IDE) and a large library of pre-written scripts, making it easy to create work and methods suitable for researchers and hobbyists. With widespread support and compatibility with a wide range of sensors and actuators, the Arduino ATmega328P board allows researchers to rapidly prototype and iterate their ideas, enabling innovation in areas such as home automation, robotics, and environmental monitoring. The Arduino ATmega328P microcontroller serves as a versatile platform for sensor interaction and data processing. Its integration involves writing firmware code to initialize the sensor module, obtain sensor readings, and complete preprocessing steps for data analysis and decision making. By leveraging the Arduino ecosystem and rich library support, developers can speed up the development process while making code reusable and scalable. Sensors used in many areas are temperature and humidity sensors. The capacitive humidity sensor and the thermistor for temperature measurement are combined in a single package with digital features. This sensor works by detecting changes in potential and resistance corresponding to changes in temperature, providing accurate readings within a certain range. Its simple interface and low power consumption make it suitable for battery-powered applications and environments where resources are limited. Scientists are actively incorporating DHT11 sensors into environmental monitoring, climate control, and weather forecasting programs, using their resources and confidence to collect valuable data for analysis and decision-making. The DHT11 sensor improves performance by measuring temperature and humidity. Its integration requires the use of a single-wire interface or digital communication such as I2C to connect to the microcontroller to provide synchronized data transfer. Advanced calibration procedures reduce sensor drift and ensure long-term reliability in different environmental conditions.

MQ Series CO_2 Sensor: MQ Series CO_2 Sensor is a device specially designed to detect the level of carbon dioxide (CO_2) in the air and ensure optimum air quality and environment. The MQ CO_2 sensor uses a sensitive semiconductor element that responds to changes in CO_2 concentration by changing its conductivity, which can be measured and interpreted by a microcontroller. These sensors are particularly useful in indoor air monitoring, ventilation control and greenhouse monitoring applications. With the ability to provide instant and contract CO_2 measurements, MQ Series CO_2 sensors enable researchers to measure environmental impact, optimize energy efficiency and user comfort in many locations, thereby supporting the stability and health of public utilities. MQ Series CO_2 sensors complement CO sensors by providing more information about indoor air quality and ventilation performance. Its integration involves setting up UART or I2C communication protocol to facilitate connection with the microcontroller. Instant analysis of carbon dioxide allows timely intervention to reduce health risks and increase energy efficiency in the indoor environment.

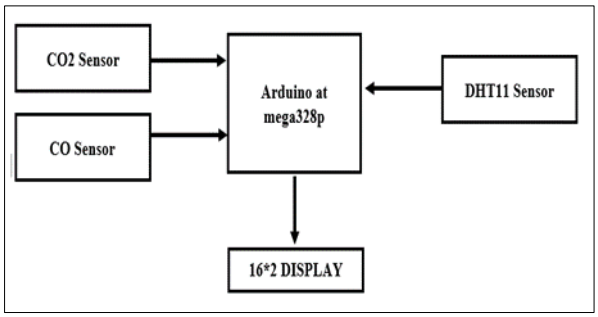

Figure 1 Block diagram of Air Quality Sensing and Monitoring

Arduino software: Commonly known as Arduino IDE (Integrated Development Environment), it is an open software platform for programming Arduino microcontrollers. Developed by the Arduino community, this software offers users an easy way to write, write and send code to the Arduino board. It simplifies the process of creating embedded projects, allowing both beginners and experienced developers to create a variety of electronic devices and projects. Arduino IDE provides a simple programming environment and a simple editor that allows users to write code using the Arduino programming language (a simplified version of C/C++). The language is designed for the Arduino board and allows the user to easily interact with the hardware without going through complex programming process. Additionally, the IDE includes a large collection of pre-written and functional templates (called libraries) that simplify the process from ready-to-use code to interfacing with sensors, actuators, displays, and other peripherals. Embedded C Language: Embedded C is a programming language designed for programming embedded systems, which are the integration of computer hardware into larger systems or products to perform specific tasks. Unlike general-purpose programs such as C or C++, Embedded C focuses on resource efficiency, runtime performance, and low-cost interoperability; This makes it ideal for developing software for microcontrollers, microprocessors and other embedded devices. Embedded C inherits many aspects of the C programming language, including syntax, data types, and control structures. However, it also offers additional features and limitations that are addressed according to the specific requirements of system development. For example, embedded C often relies on bitmap operations, bitmap operations, and direct memory access to manage hardware and interact with hardware devices under the house.

3 Methodology

Table 1 The Design specification

S/N	Components Required	Quantity
1	MQ2 (CO & CO_2) sensor	2
2	(16x2) LCD Display	1
3	PCB	1
4	RMC	1
5	Arduino-uno Atmega328	1
6	DHT11 Sensor	1
7	Voltage Regulators	1
8	Buzzer	1
9	Node-mcu esp8266	1

The method is crucial to establish good air quality measurement and monitoring using MQ2 to capture CO, CO_2 sensors and DHT11 to measure temperature and humidity. Initially, the project requires a good understanding of the sensor characteristics, including operating model, sensitivity and feedback data. Hardware configuration then involves integrating the sensor into a microcontroller platform such as Arduino. Calibration involves exposing the sensor to known target gas concentrations or ambient conditions and adjusting the sensor's response accordingly. This step is necessary for reliable data interpretation. Data collection is continuous, with recorded data being read at regular intervals. Additionally, real-time monitoring capabilities can be used to provide rapid feedback on adverse weather

conditions. Raw data is processed to convert readings into air quality content such as temperature and humidity, as well as CO and CO_2 concentrations in parts per million (ppm). Statistical analysis can be used to identify trends, patterns, and inconsistencies in data. Additionally, the project's integration with the Internet of Things (IoT) platform provides real-time remote access to data and facilitates automatic notifications or report notifications compared to the previous procedure. system over time. Perform regular sensor inspections, calibration updates, and hardware maintenance procedures to prevent sensor drift or degradation. Understanding, calibration, hardware integration, data acquisition, processing, analysis, visualization and maintenance. This approach ensures the effectiveness and reliability of monitoring in analyzing and solving air quality problems.

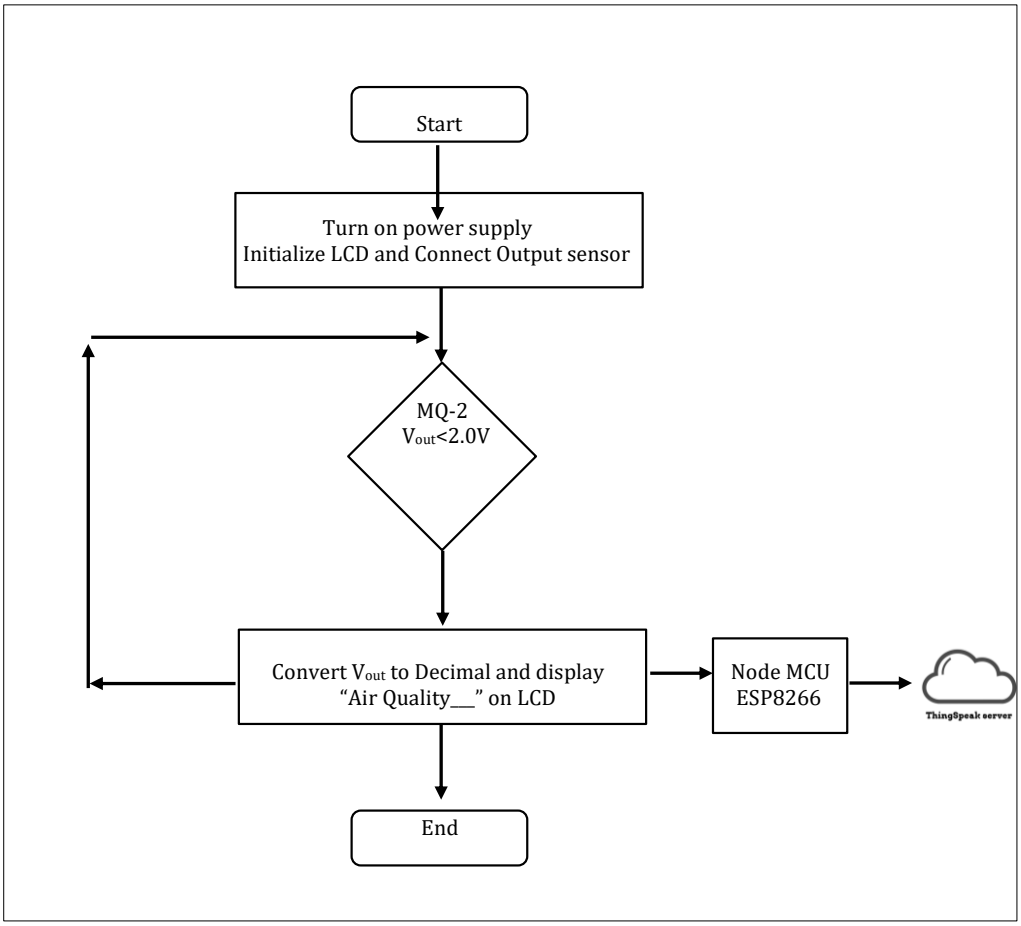

Figure 2 Flow-chart of the proposed system

4 Results and Discussion

The results of integrating MQ 2 CO sensors, buzzers, DHT11 sensors and MQ Series CO_2 sensors into air quality and monitoring projects provide an overview of gas badness and environmental perception. The MQ 2 CO sensor effectively instantly detects carbon monoxide and shows the difference in the environment. In areas with heavy traffic and industry, carbon dioxide concentration is particularly high, so the sources of pollution are identified. A buzzer in the system provides an audible alarm that sounds when carbon dioxide levels exceed a predetermined threshold. The proposal now raises public awareness and encourages measures to reduce air pollution. Integration of various sensors and microcontrollers into these systems provides a comprehensive approach to data collection and analysis that helps make effective air quality management decisions. In this section, we take a look at the results obtained from air quality measurement and monitoring systems and discuss their effectiveness in identifying various pollutants and environmental contaminants in terms of their effectiveness and impact. The main aim of our research is to improve the ability to measure and monitor air quality parameters including carbon monoxide (CO), carbon dioxide (CO_2), temperature and humidity. By integrating MQ-2, MQ series CO_2 and DHT11 sensors with Arduino ATmega328P microcontroller, ESP32 controller, 16x2 LCD and buzzer, we provide real-time monitoring of indoor air quality. The system performs well in detecting pollutants, protecting the indoor environment well. Carbon monoxide is a colorless, odorless gas that is especially dangerous at high concentrations and causes serious harm to those exposed. By

connecting MQ-2 and MQ Series CO_2 sensors, our system can measure CO levels and alert users to dangerous situations. Additionally, the addition of temperature and humidity sensors increases the functionality of the system, allowing a comprehensive evaluation of the indoor.

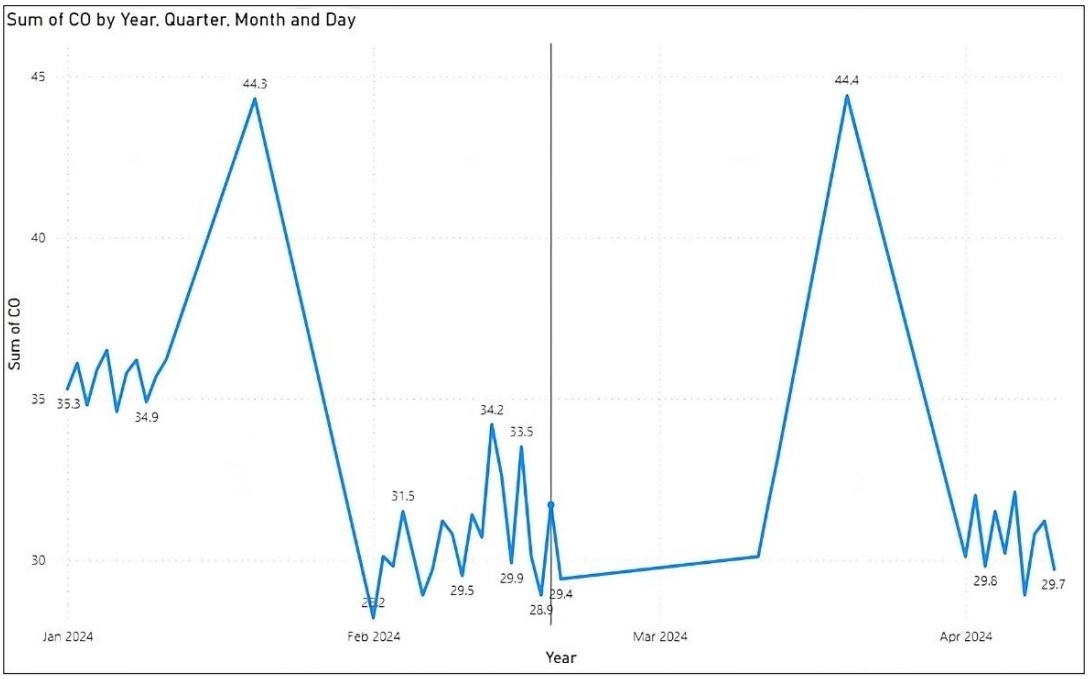

Figure 3 Year-Monthly range of CO

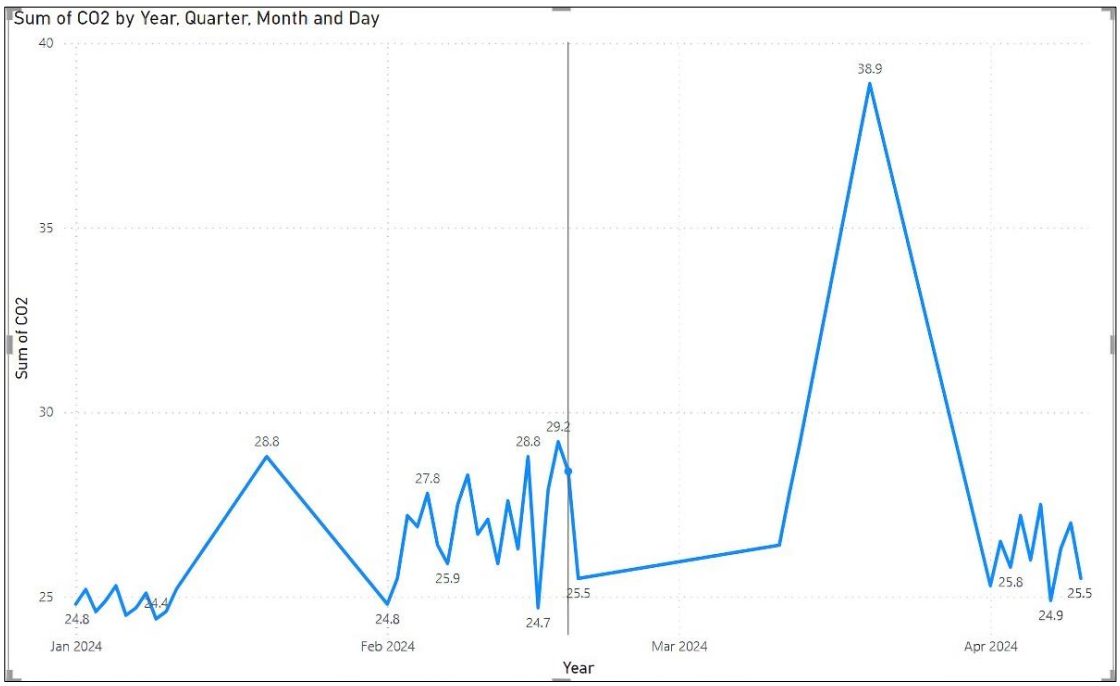

Figure 4 Year-Monthly range of CO_2

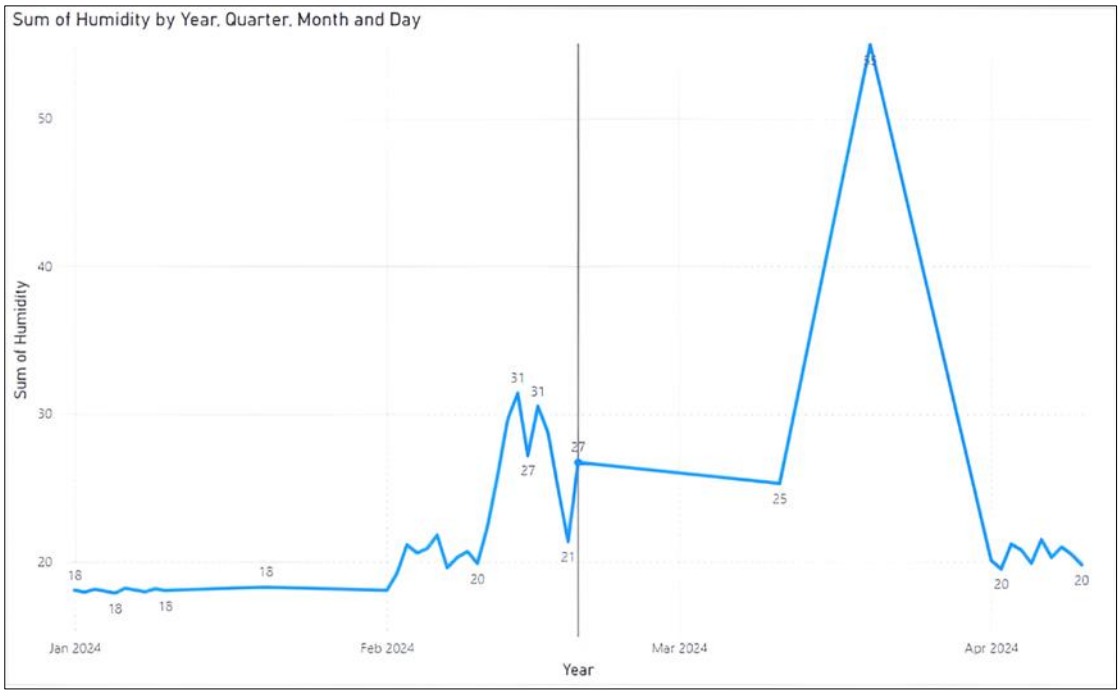

Figure 5 Year-Monthly range of Humidity

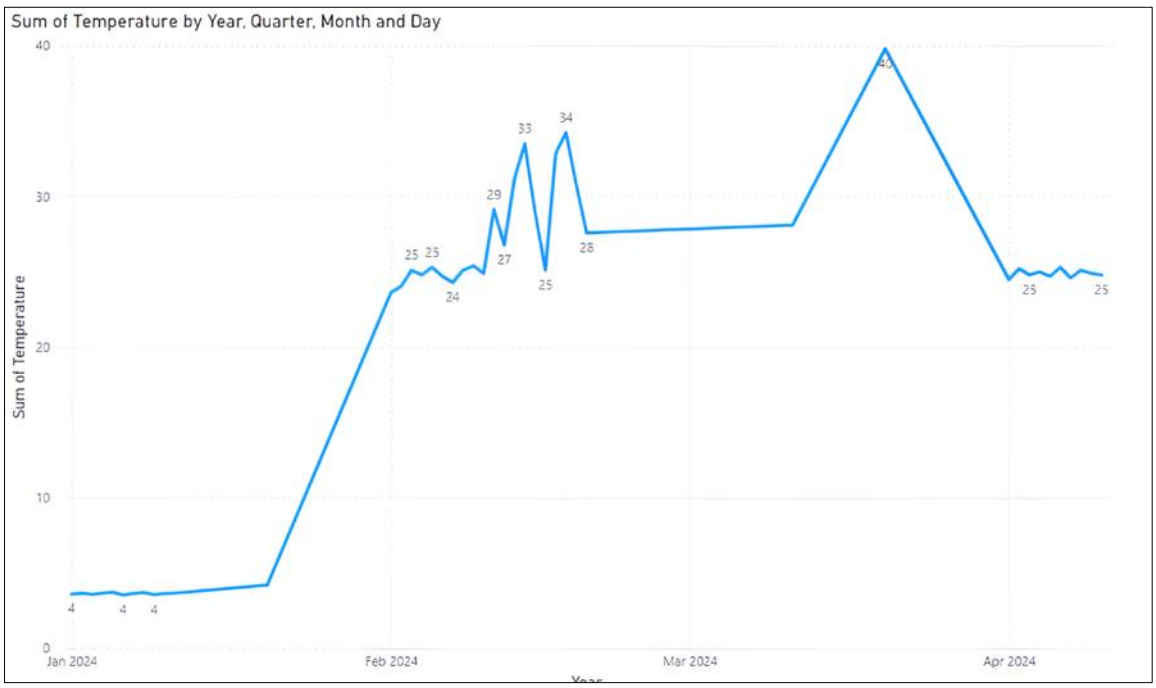

Figure 6 Year-Monthly range of Temperature

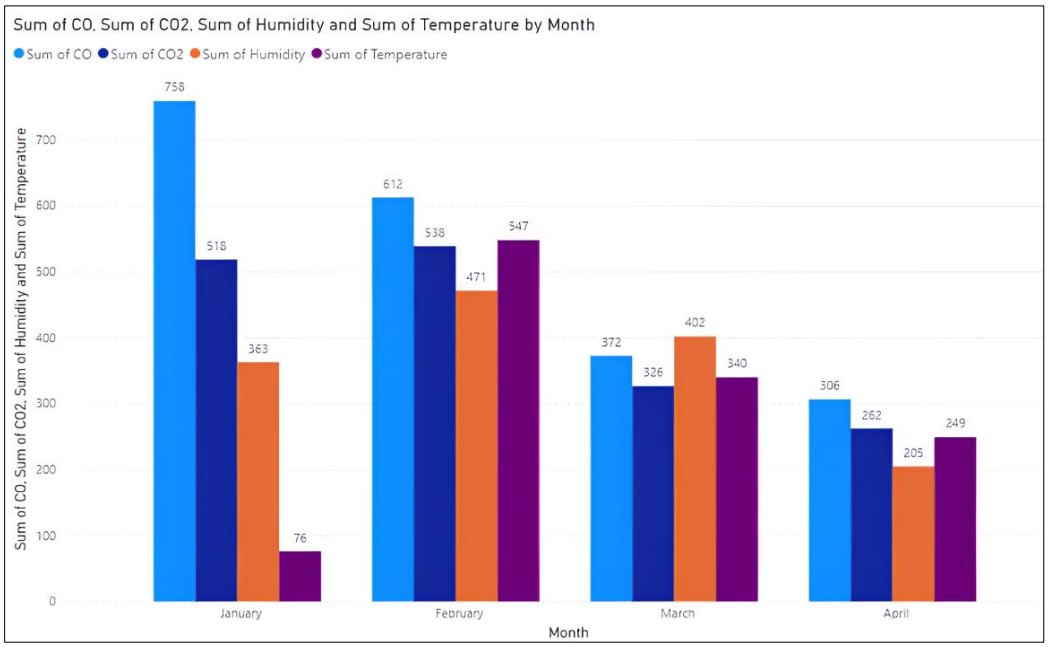

Figure 7 Sum of CO,CO_2, Humidity, Temperature

Displaying real-time data on the LCD screen provides users with an easy way to monitor air quality levels. Clear and understandable instructions provide access to important information, allowing timely intervention to improve indoor air quality. Additionally, the integration of voice warning strengthens the user's safety by increasing the warning time in bad weather conditions. In situations requiring immediate action, such as CO_2 pressure, the buzzer can serve as an important warning mechanism, enabling people to take the necessary steps to reduce the risk. Its strong and efficient power makes it ideal for use in many areas, including residential, commercial and industrial areas. Unlike traditional air quality monitors, which are often fixed and costly to install, our systems offer a simple and affordable solution for continuous monitoring of the home's indoor air quality.

The design and wireless connection used by the ESP32 controller can be integrated into existing systems and made available to many users. with remote control. The data is analyzed and printed to the channel in the form of exploded graphs or graphs. Weather conditions corresponding to these channels.

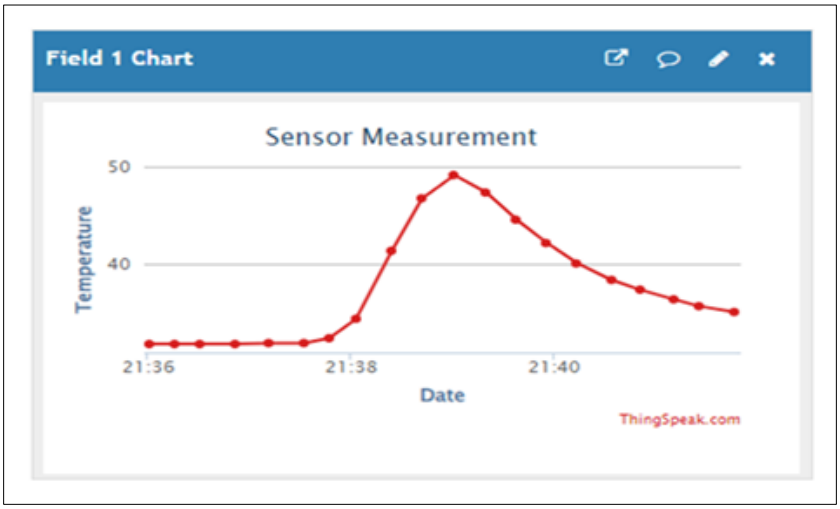

Figure 8 Air quality measurement as seen online of Temperature

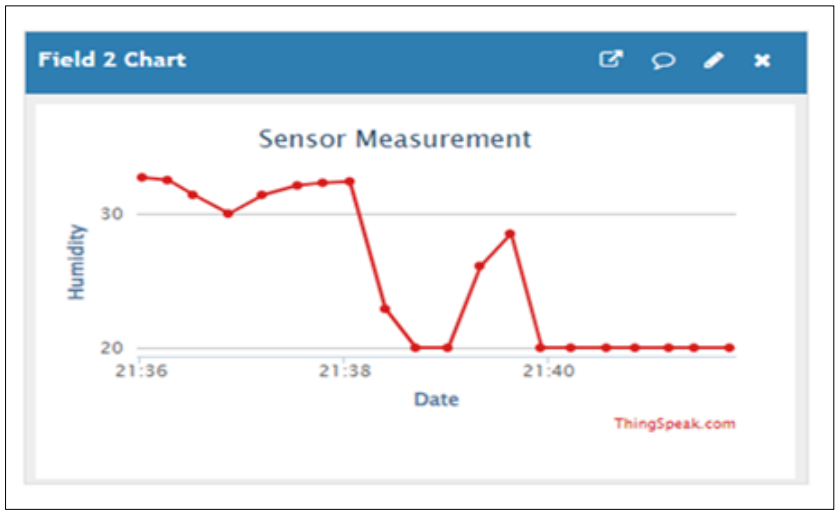

Figure 9 Air quality measurement as seen online of Humidity

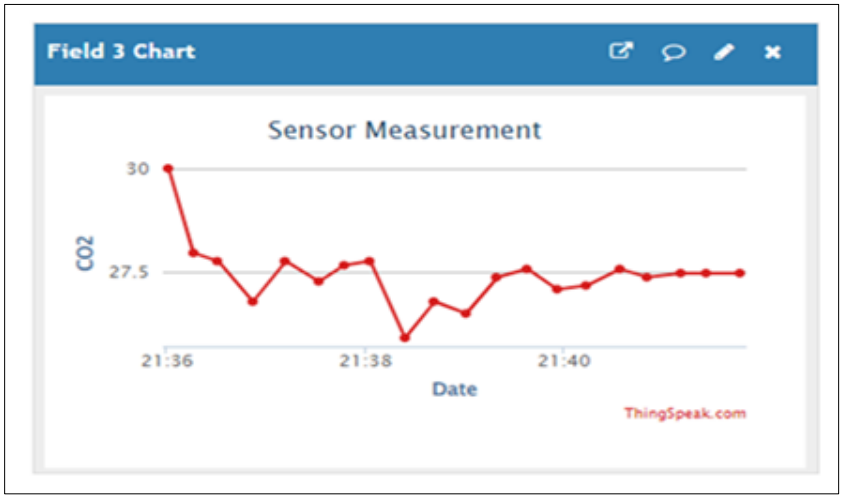

Figure 10 Air quality measurement as seen online of CO_2

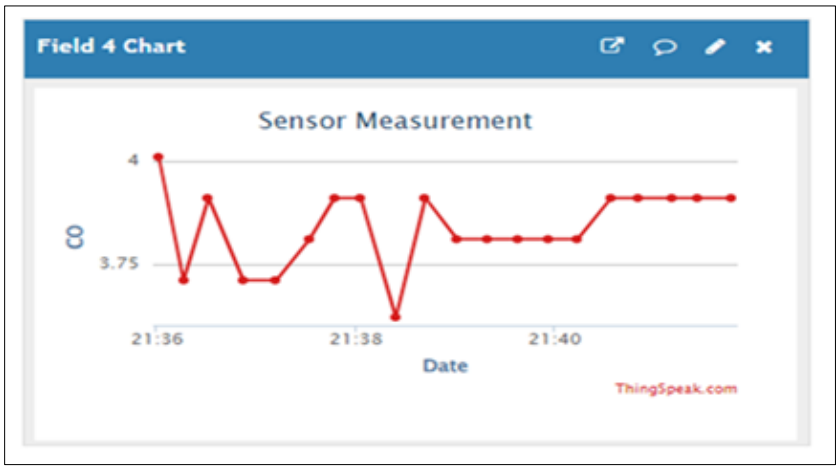

Figure 11 Air quality measurement as seen online of CO

The potential applications of our air quality measurement and monitoring systems are diverse and farreaching. The system can help homeowners maintain a healthy environment by monitoring pollution in residential areas and adjusting ventilation accordingly. In business and industry, it can improve workplace safety and productivity by identifying and reducing indoor air pollution. Additionally, data collected from the system can provide policymakers and environmental organizations with better information on developing expanded climate protection and management strategies. The system consists of components such as MQ sensor, DHT11 sensor, ESP32 controller, LCD screen, buzzer and Arduino ATmega328P microcontroller. The body's ability to detect many types of pollutants and environmental contaminants makes it useful in measuring indoor air quality and supporting a healthy environment. Future work will include integration with cloud- based platforms for remote monitoring and data analysis, as well as optimization for specific applications. Overall, our research contributes to the advancement of air quality monitoring technology and is expected to solve environmental problems associated with air pollution. Monitoring air quality. Data now provides a better understanding of air pollutants and the environment and helps make informed decisions about air quality management. Authorities can use this information to identify pollution hotspots, implement response plans, and develop policies to improve air quality. Complete data collection and analysis. The smart system ensures optimum indoor air quality by detecting various pollutants such as CO, CO_2, temperature and humidity. Displaying real time data on the LCD screen allows users to easily monitor air quality. Additionally, the buzzer increases user safety by providing timely warning of critical weather conditions. Overall, the proposed system provides a cost-effective, cost-effective solution for air quality monitoring applications, offering potential for deployment across geographies, industries, and industries.

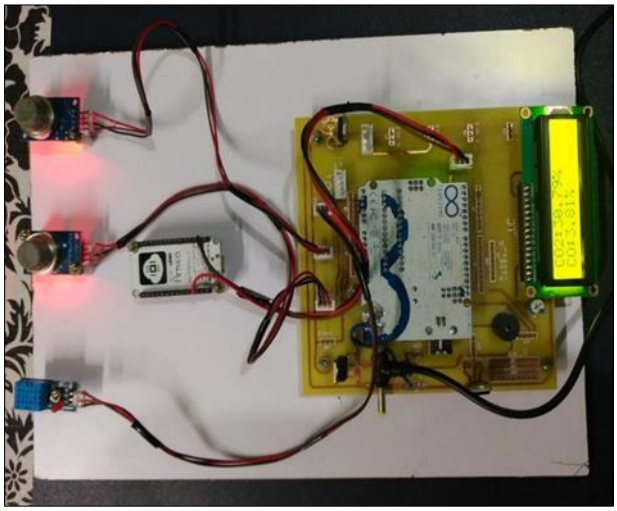

Figure 12 Prototype of our project

5 Conclusion

The integration of different products and processes forms the basis of good environmental care. By leveraging unique capabilities of all kinds, scientists and experts can create effective solutions to reduce environmental harms, protect public health, and improve safety in many areas. A specialized programming language for software development for embedded systems. Its focus on resource efficiency, fast processing, and low cost interoperability makes it a musthave for developers developing a variety of applications including automotive systems, electronics, business auto mation, and IoT devices. By mastering embedded C programming, developers can unlock the full potential of embedded systems and create powerful, reliable and high-performance solutions.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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