IoT-Based Environmental Monitoring and Early Warning System for Residential Safety

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Abstract: This project presents an Internet of Things (IoT)-Based Environmental Monitoring and Early Warning System for Residential Safety for improving human safety through real-time environmental monitoring and automatic emergency response. The system uses MQ2, MQ4, DHT11, and Flame sensors to detect gas leakage, smoke, methane gas, temperature, humidity, and fire conditions. The detected conditions are classified into three states: Safe, Warning, and Danger. Traffic light LEDs, a buzzer, and a DC fan provide automatic visual, audible, and safety responses. Sensor readings and system status are displayed on an LCD and uploaded to the ThingSpeak cloud platform for remote monitoring. Telegram notifications are sent to family members and rescue personnel during emergency conditions. When fire is detected, the system activates the buzzer, opens an emergency exit door using a servo motor, and uses the SIM900A GSM module to send an SMS containing the alert and a predefined home address, as well as make an emergency phone call. The proposed system provides a low-cost and efficient solution for early hazard detection, accident prevention, and rapid emergency response.

Keywords: Internet of Thing (IoT), human safety, accident warning, rescue system, environmental monitoring, gas detection, fire detection, emergency communication

INTRODUCTION

Human safety is an important concern in residential, workplace, and industrial environments, where gas leakage, methane, high temperature, and fire may occur unexpectedly. Conventional safety systems often depend on manual monitoring, which can delay hazard detection and emergency response. IoT technology enables continuous environmental monitoring and automatic warning systems. Therefore, this project develops an IoT-Based Environmental Monitoring and Early Warning System for Residential Safety that monitors hazardous conditions in real time and provides appropriate warnings and automatic safety actions. The system classifies environmental conditions as Safe, Warning, or Danger, while ThingSpeak provides remote monitoring and Telegram provides emergency notifications. The system also activates a ventilation fan and automatically opens the emergency door to support rapid response during hazardous conditions**.** These features help reduce response time and improve safety during emergency situations. For critical situations, the SIM900A GSM module sends an SMS and makes a phone call to the designated emergency contact.

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PROBLEM

Gas leakage, smoke, methane, fire, and excessive temperature, high humidity level can cause serious injuries, property damage, and loss of life if not detected promptly. Manual monitoring may result in delayed detection and response, while conventional systems may not provide real-time monitoring, remote notification, or automatic emergency actions. Therefore, an intelligent IoT-based system is required to continuously monitor hazardous conditions, provide early warnings, notify responsible persons, and support rapid emergency response.

APPROACH

The proposed system uses an ESP8266 and Arduino Uno microcontroller with MQ2, MQ4, DHT11, and Flame sensors to continuously monitor environmental conditions. The sensor data are processed by the ESP8266 and classified into Safe, Warning, and Danger states. According to the detected state, traffic light LEDs, a buzzer, and a DC fan provide visual, audible, and automatic safety responses. Sensor values and system status are displayed on an LCD and uploaded to ThingSpeak for remote monitoring, while Telegram sends notifications during important conditions. When a fire is detected, the system activates the buzzer, automatically opens the emergency exit door using a servo motor, and uses the SIM900A GSM module to send an emergency SMS containing the predefined home address and make a phone call to the designated contact. Thus, the system integrates environmental monitoring, automatic warning, safety control, cloud monitoring, and emergency communication into a single low-cost solution.

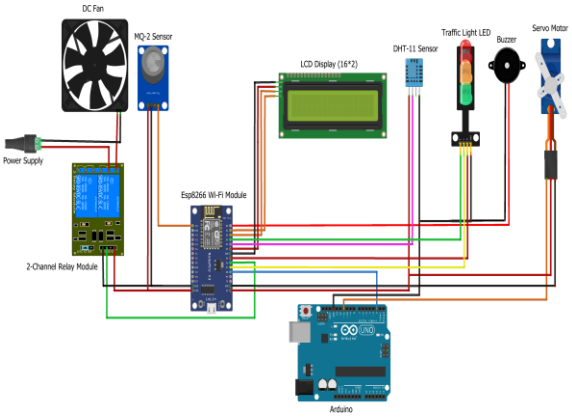


Figure 1. Circuit Diagram of Home Environmental Monitoring and Alert System

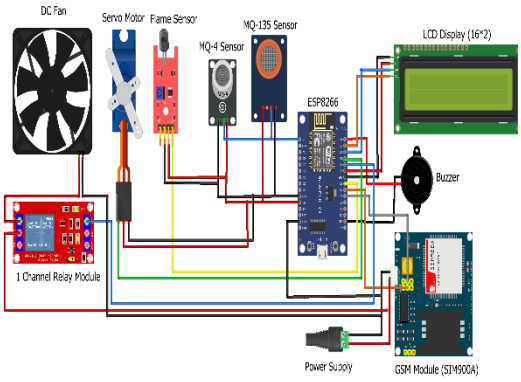


Figure 2. Circuit Diagram of Fire Emergency Alert System

Figure 1 illustrates the circuit connections of the ESP8266-based system with the MQ-2 gas sensor, DHT11 sensor, 16×2 LCD, traffic light LEDs, buzzer, 2-channel relay module, DC fan, and power supply. The ESP8266 processes the sensor data, displays the system status on the LCD, and controls the output devices. The relay module automatically controls the DC fan according to the detected environmental conditions. An Arduino UNO is also integrated with the ESP8266 to control the servo motor, which operates the window-opening mechanism during emergency conditions.

Figure 2 presents the circuit connections of the ESP8266-based system with the MQ-4 smoke sensor, flame sensor, 16×2 LCD, buzzer, 1-channel relay module, DC fan, servo motor,

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SIM900A GSM module, and power supply. The ESP8266 processes the sensor data, displays the system status on the LCD, and controls the output devices. The relay module automatically controls the DC fan according to the detected environmental conditions. The servo motor operates the designated mechanism during emergency conditions, while the SIM900A GSM module sends alert messages to the user when an emergency condition is detected.

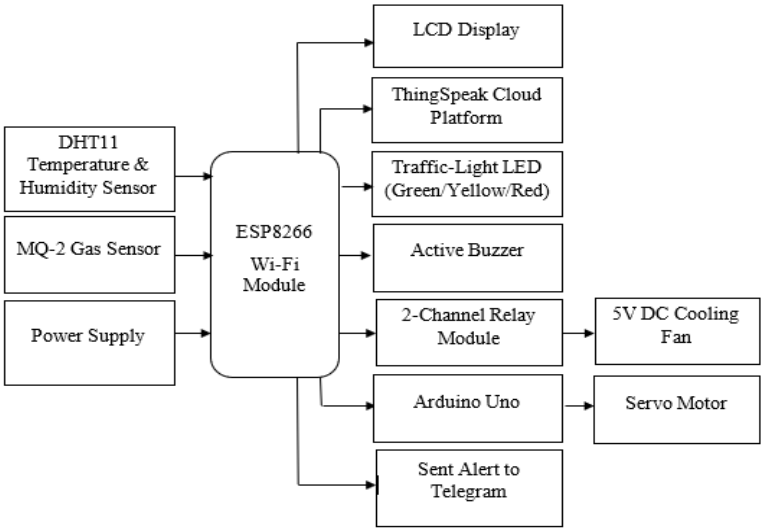


Figure 3. Block diagram of Home Environmental Monitoring and Alert System

Figure 3 outlines the block diagram of IoT-based home environmental monitoring and alert system. The ESP8266 collects data from the DHT11 and MQ-2 sensors and processes it based on predefined thresholds. The system provides local alerts through the LCD, traffic-light LEDs, buzzer, and cooling fan, while environmental data are uploaded to ThingSpeak. The ESP8266 is also connected to an Arduino Uno, which controls the servo motor to open the window during danger conditions. Telegram Bot API is also used to send real-time alerts to the family and team.

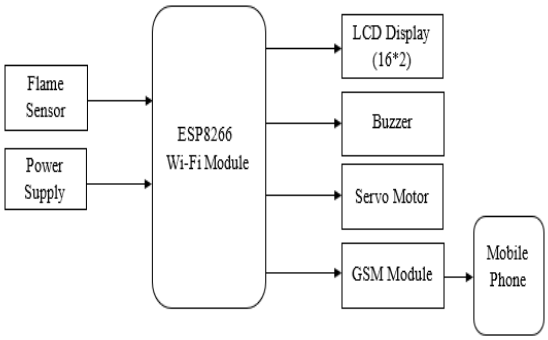


Figure 4. Block diagram of Fire Emergency Alert System

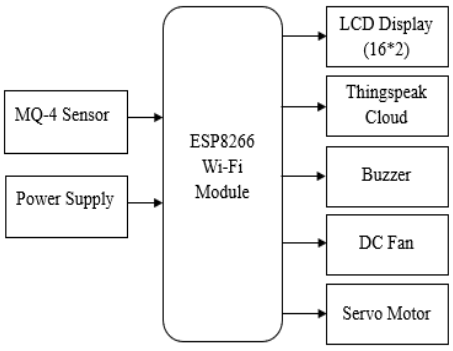


Figure 5. Block diagram of Methane Gas Monitoring System

Figure 4 represents the block diagram of fire emergency alert system. The ESP8266 collects data from the flame sensors and processes it according to predefined conditions. The system provides local status and alerts through the 16×2 LCD, buzzer, and servo motor. A GSM module is also used to send real-time SMS alert and phone call to the user's Mobile Phone.

Figure 5 depicts the block diagram of the IoT-based methane gas monitoring system. The ESP8266 collects data from the MQ-4 sensor and processes it according to predefined

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conditions. The system provides local status and alerts through the 16×2 LCD, buzzer, DC fan, and servo motor while data are simultaneously uploaded to the ThingSpeak cloud.

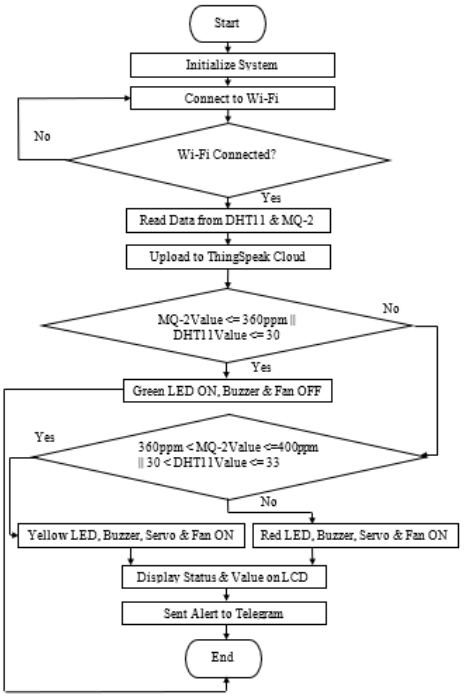


Figure 6. Flow Chart of Home Environmental Monitoring and Alert System

Figure 6 demonstrates the flow chart of the IoT-based home environmental monitoring and alert system. The system initializes the sensors, connects to Wi-Fi, and reads temperature, humidity, and gas data from the DHT11 and MQ-2 sensors. The data are uploaded to ThingSpeak and classified as Safe, Warning, or Danger based on predefined thresholds. The corresponding LED, buzzer, and fan are activated, while the Arduino Uno controls the servo motor during Warning and Danger conditions. The system displays the status and sensor values on the LCD and sends alerts to Telegram.

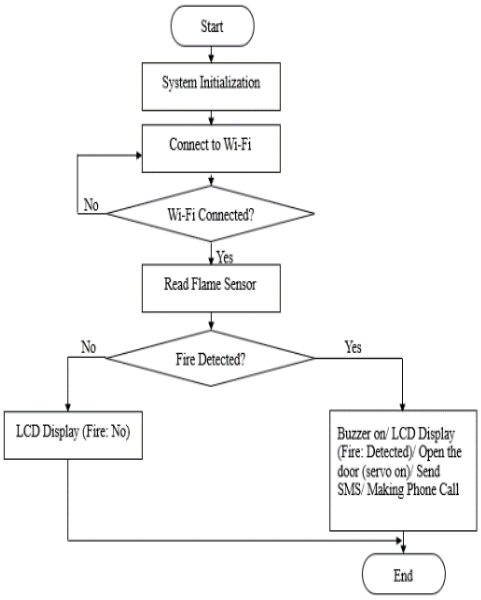


Figure 7. Flow Chart of Fire Emergency Alert System

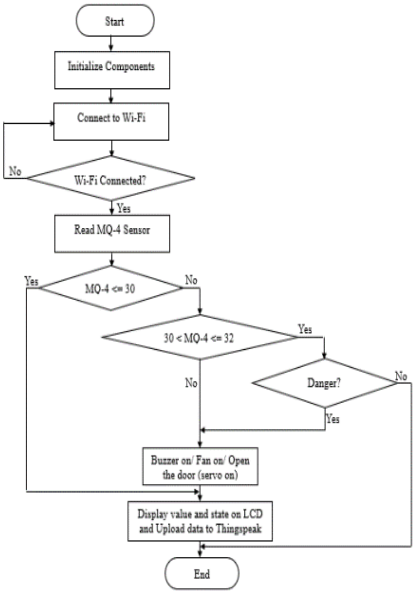


Figure 8. Flow Chart of Methane Gas Monitoring System

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Figure 7 describes the flowchart of ESP8266-based fire emergency alert system. The system initializes and connects to Wi-Fi, then reads the flame sensor data. If a fire is detected, the system displays a fire alert on the LCD, activates the buzzer, opens the door using the servo motor, and sends SMS and phone call alerts through the GSM module.

Figure 8 provides the flow chart of the methane gas monitoring system. The system initializes the components and connects to Wi-Fi before reading data from the MQ-4 sensor. Based on the predefined methane gas thresholds, the system determines the environmental condition and activates the buzzer, DC fan, and servo motor when a dangerous condition is detected. The sensor values and system status are displayed on the LCD and uploaded to ThingSpeak for remote monitoring.

RESULTS

The proposed IoT system was successfully implemented and tested under various environmental conditions. The system effectively detects gas, methane, air quality, temperature, humidity, and fire, classifying them into Safe, Warning, and Danger states. It displays sensor readings on the LCD, uploads data to ThingSpeak, and sends Telegram alerts during emergencies. Under fire conditions, it activates the buzzer, opens the emergency door using a servo motor, and sends SMS location notifications and makes phone calls through the SIM900A module. Overall, the system provides reliable hazard detection, automatic response, and rapid emergency communication to improve safety.



Figure 9. System Behavior Under Safe Condition



Figure 10. System Behavior Under Danger Condition

Figure 9 displays the system in a safe condition, where the gas level, temperature, humidity, and fire detection values are within the safe range. The green LED is illuminated, indicating that no hazardous condition is detected.

Figure 10 highlights the system operating under a danger condition. When gas is detected, the red LED indicates the danger status, the LCD displays the sensor values and system status, the ventilation fan is activated, and the door opens automatically. In case of fire, the door opens automatically to provide an emergency exit, and an alert message is displayed on the LCD.

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Figure 11. Methane Gas Detection Under Safe Condition



Figure 12. Methane Gas Detection Under Danger Condition

Figure 11 indicates the methane gas sensor under a safe condition. The LCD displays a safe methane gas level and indicates that no methane gas is detected. The door remains closed under normal conditions.

Figure 12 shows the system operating under a danger condition. When a high methane gas level is detected, the emergency door automatically opens, the fan is activated to remove the gas, and the buzzer provides an audible warning.

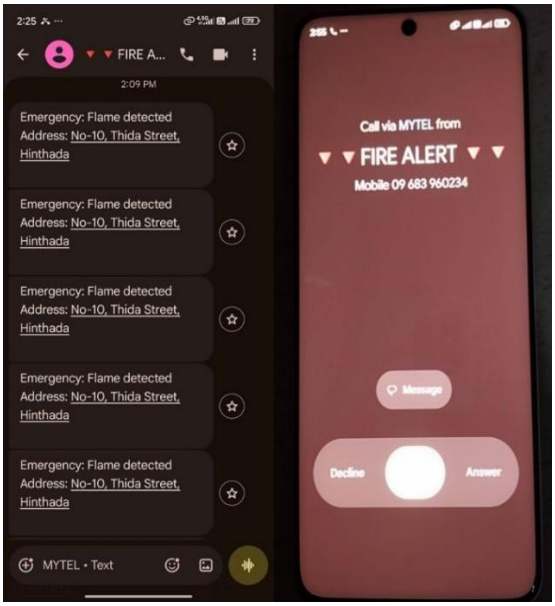


Figure 13. Fire Alert Call and SMS Notifications

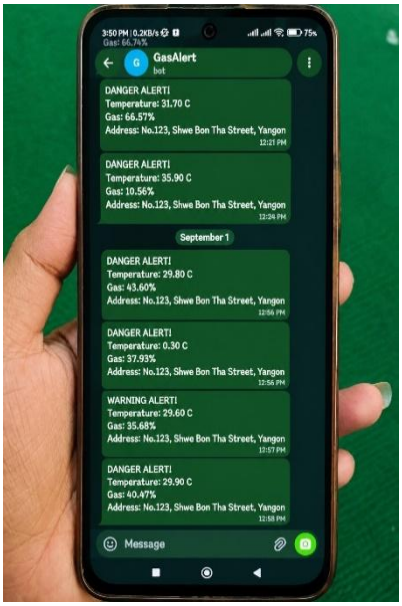


Figure 14. Telegram Alert Notification

Figure 13 details the system operating under a danger condition. When a fire or flame is detected, the system automatically sends an emergency SMS to the rescue team with the address and initiates an emergency phone call for notification.

Figure 14 reports Telegram alert notifications sent to the residents when the gas level or temperature reaches the warning or danger threshold. The notifications provide the temperature, gas concentration, and location information.

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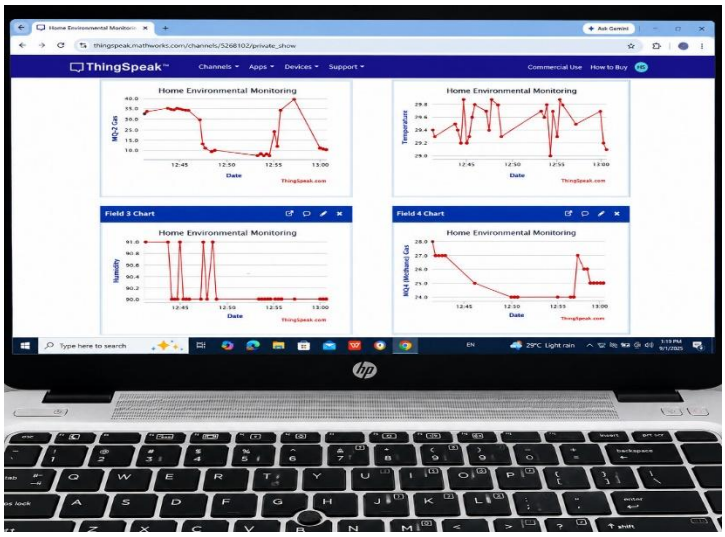


Figure 15. Real-Time Monitoring on ThingSpeak Cloud

Figure 15 reveals the real-time environmental data collected by the proposed system and uploaded to the ThingSpeak cloud platform. The graphs display MQ-2 gas, humidity, temperature, MQ-4 gas, and flame sensor readings over time. These results demonstrate that the system can continuously monitor home environmental conditions and visualize the sensor data remotely through the cloud platform.



Figure 16. Implementation Design of the System

CONCLUSION

This paper presents an IoT-based Automatic Human Accident Warning and Rescue System that enhances human safety through real-time monitoring and automated emergency responses. Equipped with multiple sensors, the system detects early signs of gas leaks, high temperatures, fire, and poor air quality. It provides local alerts via LEDs and a buzzer, while automatically activating a DC fan and opening emergency doors to mitigate hazards. By leveraging ThingSpeak, Telegram, and a SIM900A GSM module, the system enables remote data logging and facilitates rapid emergency communication through SMS location alerts and

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direct phone calls to designated contacts. Ultimately, this reliable and cost-effective system offers an automated safety solution that optimizes emergency responses and prevents severe accidents.

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