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Design and Development of an IoT-Based Integrated Multi-Hazard Detection System for Industrial Applications

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Abstract: ***The Smart Industry Safety: An IoT-Based Multi-Hazard Detection System for Fire, Gas, and Electrical Fault Detection is developed to provide real-time monitoring and effective management of hazardous conditions in industrial environments. Industrial workplaces are often exposed to risks such as fire outbreaks, gas leaks, electrical faults, and poor air quality, which can lead to property damage, injuries, or even loss of life. This system aims to reduce such risks by integrating smart sensors and IoT technology to continuously monitor critical safety parameters. When any hazardous condition such as fire, gas leakage, or electrical fault is detected, the system immediately sends alerts to responsible personnel, enabling quick action and preventing the situation from escalating. An integrated alarm system also provides audible alerts, and these alerts can be controlled remotely through a dedicated mobile application.***

In addition to hazard detection, the system monitors environmental parameters such as temperature, humidity, and air quality to maintain a safe and comfortable industrial environment. All collected data is transmitted to a cloud platform, allowing remote monitoring, data storage, and analysis for better safety management. The use of a secure cloud platform with a subscription plan ensures reliable and scalable storage of industrial data. By combining real-time hazard detection, environmental monitoring, automated alerts, and cloud-based data management, the proposed system provides an effective solution for improving industrial safety and operational efficiency.

Keywords: Internet of Things (IoT); Industrial Safety; Multi-Hazard Detection System; Fire Detection; Gas Leakage Monitoring; Electrical Fault Detection; Predictive Analytics

I. INTRODUCTION

Industrial safety plays a crucial role in modern manufacturing and production environments. With the rapid growth of industrialization, the scale and complexity of industrial operations have increased significantly. Industries often deal with high-temperature processes, flammable materials, toxic gases, and heavy electrical machinery. These factors increase the risk of workplace accidents such as fire outbreaks, gas leaks, and electrical faults. Traditional safety systems mainly rely on manual inspections and conventional alarm mechanisms, which may fail to provide immediate alerts and are prone to human error. Therefore, there is a strong need for an automated and intelligent safety monitoring system.

The integration of the Internet of Things (IoT) in industrial environments provides an effective solution for improving safety management. IoT technology enables real-time monitoring, data collection, and remote access to industrial systems. By using connected sensors and smart devices, industries can continuously monitor critical parameters and receive instant alerts when abnormal conditions occur. This approach allows industries to move from reactive safety management to a more proactive and preventive safety strategy.

The proposed Industrial Safety System using IoT is designed to monitor multiple hazardous conditions within an industrial environment. The system detects fire incidents, harmful gas leaks, and electrical faults while also monitoring environmental parameters such as temperature, humidity, and air quality. Early detection of these hazards helps prevent accidents, reduces operational risks, and ensures the safety of workers and industrial infrastructure. In addition, the system includes an alarm mechanism and a mobile application that enables remote notifications and control, ensuring quick response during emergency situations.

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All sensor data collected by the system is transmitted to the ESP RainMaker cloud platform, allowing real-time monitoring, remote accessibility, and historical data analysis. Cloud storage enables industries to analyze safety trends, perform predictive maintenance, and improve overall operational efficiency. By integrating real-time hazard detection, environmental monitoring, remote alerts, and cloud-based data management, the proposed system provides a reliable and intelligent solution for enhancing industrial safety.

II. LITERATURE REVIEW

Industrial safety has significantly evolved with the integration of Internet of Things (IoT) technologies, enabling real-time monitoring and early hazard detection. Recent studies emphasize the importance of multi-hazard detection systems that simultaneously monitor fire, gas leakage, and electrical faults to enhance industrial safety and reliability. Warkad et al. [1] proposed an IoT-based industrial safety system integrating fire, gas, and electrical fault detection, demonstrating improved response time and system reliability. Similarly, Doshi and Rai [2] developed an IoT-based fire and gas monitoring system that utilizes sensor networks for real-time alerts. Fire and gas detection form the foundation of industrial safety systems. Abdulsalam [6] demonstrated the effectiveness of IoT in detecting fire and gas leaks in industrial environments using sensor-based alert mechanisms. Gupta and Singh [4] proposed an intelligent safety system combining multiple sensors for hazard prevention. Recent advancements focus on improving detection accuracy and reducing false alarms. Babu et al. [11] evaluated MQ-series gas sensors and highlighted trade-offs between sensitivity, response time, and power consumption. Anwar and Hussain [16] compared MQ2 and MQ5 sensors, concluding that sensor selection significantly impacts system reliability. Morchid et al. [12] introduced NB-IoT-based architectures for large-area fire detection, improving scalability and energy efficiency. Park et al. [15] developed a pre-fire early warning system using multivariate temporal thresholds, enhancing early detection capabilities. Systematic reviews by Tripathi et al. [18] and bibliometric analysis by AlQahtani et al. [19] indicate a growing trend toward integrating AI and IoT for smarter fire safety systems. Practical deployment guidelines by NIDM [13] and sustainability-focused implementations [14] further strengthen real-world applicability. Electrical faults such as short circuits, overloads, and arc faults pose significant risks in industrial systems. Islam et al. [3] developed an IoT-based fault detection and diagnosis system capable of identifying abnormal operating conditions in real time. Advanced techniques for electrical fault detection include machine learning and signal processing. Chevtchenko et al. [8] applied anomaly detection using IoT devices and ML algorithms for industrial machinery. Villarreal et al. [23] proposed optimized SVM-based classification for electrical faults in noisy environments. Yang et al. [21] focused on IoT-enabled monitoring of power electronics systems using streaming analytics, improving predictive maintenance capabilities. Additionally, advancements in arc fault detection techniques have been extensively reviewed by Thakur et al. [9]. Distributed IoT architectures using LoRa technology for fault detection in smart grids were presented by Mnyanghwalo et al. [17], demonstrating improved communication efficiency and scalability. Wireless Sensor Networks (WSNs) play a crucial role in enabling IoT-based safety systems. Asif et al. [7] highlighted the importance of WSNs for real-time industrial monitoring, emphasizing low power consumption and scalability. Recent research explores advanced communication technologies such as NB-IoT [12] and LoRa [17] to support large-scale deployments. These technologies ensure reliable data transmission, even in harsh industrial environments. The integration of Machine Learning (ML) with IoT has enhanced the intelligence of safety systems. Chevtchenko et al. [8] demonstrated anomaly detection using ML, while GasGuard [25] introduced ML-based false alarm reduction techniques in gas monitoring systems. Abdullahi [20] proposed adaptive evacuation systems based on IoT data, improving emergency response. Zhang et al. [22] developed real-time public safety alert systems integrating IoT with emergency response mechanisms. Reliability analysis and redundancy strategies for IoT safety systems were explored by Singh [24], emphasizing the importance of fault tolerance in mission-critical applications. The effectiveness of industrial safety systems is guided by standards and frameworks. ISA TR84.00.07 [10] provides guidelines for evaluating fire and gas system effectiveness, ensuring compliance with safety regulations. NIDM [13] offers practical deployment strategies for IoT-based fire detection systems, particularly for retrofit applications in existing infrastructures.

III. SYSTEM ARCHITECTURE

A. Overview of the Proposed System

The proposed system is an IoT-based industrial safety and monitoring system designed to detect fire, gas leakage, and electrical faults in real time. In this system, different sensors are used to continuously monitor environmental and electrical conditions. The sensor data are collected and processed by the Arduino Uno microcontroller, which analyzes the readings and identifies any abnormal situation. If any dangerous condition such as fire, gas leakage, or electrical fault is detected, the system immediately triggers the safety mechanism to prevent possible accidents in industrial environments.

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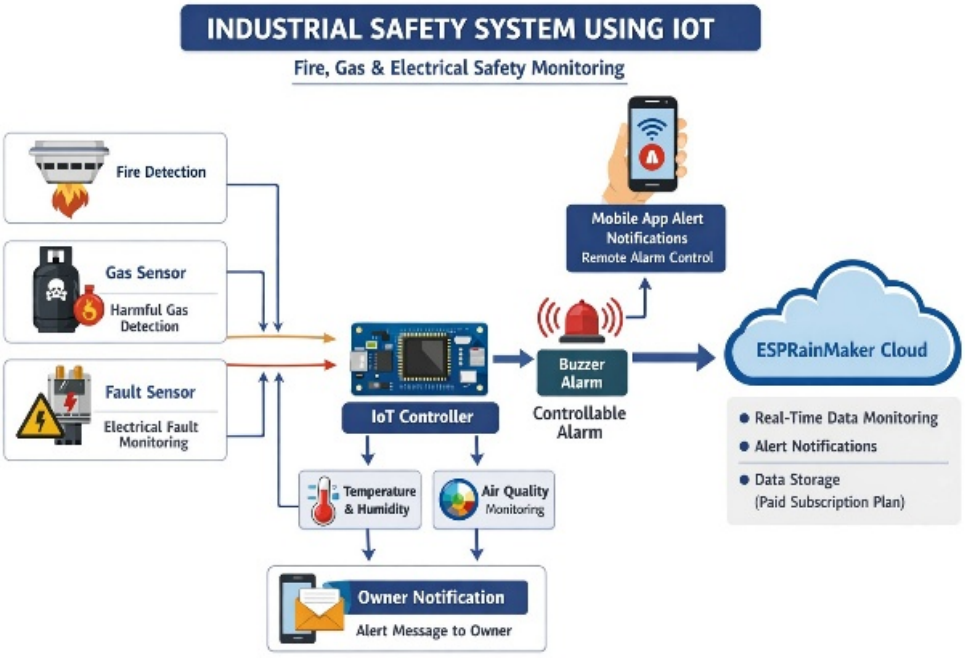
For cloud connectivity and remote monitoring, the ESP RainMaker platform is used with an active subscription. The ESP32 module is responsible for sending alert messages and system status to the cloud through the ESP RainMaker platform. When a fault is detected, the ESP32 sends an alert notification to the user and automatically shuts down the system by disconnecting the power supply to the loads using a relay module. This helps in protecting industrial equipment and ensures quick response during emergency situations. The system therefore provides a smart, reliable, and IoT-based solution for industrial safety and monitoring.

B. Block Diagram of the System

The system architecture as shown in Figure-1, consists of several interconnected components that work together to ensure industrial safety monitoring. The major components include sensors, microcontroller, communication module, cloud platform, and alert system. The flame sensor detects fire or flame presence in the environment. The MQ135 gas sensor measures harmful gas concentration and air quality levels. These sensors continuously send analog or digital signals to the ESP32 microcontroller.

The ESP32 processes the sensor data and compares it with predefined threshold values. If the system detects unsafe conditions such as high gas concentration or fire detection, it activates the relay module and alarm system. The ESP32 also transmits sensor data to the cloud platform through Wi-Fi connectivity. This data can be viewed in real time through a mobile application or web dashboard.

Figure-1: Industrial Safety system



C. System Architecture

The proposed system architecture is divided into three main layers:

1) Sensor Layer

The sensor layer is responsible for collecting environmental and safety-related data. It includes sensors such as a flame sensor, MQ135 gas sensor, DHT11 temperature and humidity sensor, and a current sensor. These sensors continuously monitor the surrounding environment and electrical conditions to detect hazardous situations. The flame sensor detects fire based on infrared radiation emitted by flames. The MQ135 gas sensor detects harmful gases such as ammonia, carbon dioxide, benzene, and smoke. The DHT11 sensor measures temperature and humidity levels to identify abnormal environmental changes. The current sensor monitors the electrical load and helps in detecting electrical faults or overcurrent conditions.

2) Processing Layer

The processing layer consists of the ESP32 microcontroller. The ESP32 acts as the central control unit of the system. It receives sensor data, processes the information, and decides whether the environment is safe or hazardous. The ESP32 also controls other devices such as LEDs and relay modules to indicate system status or activate alarms.

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3) Cloud Monitoring Layer

The cloud layer stores and processes all sensor data received from the ESP32. The system uses ESP RainMaker cloud platform for real-time monitoring and data storage. This layer allows users to monitor industrial conditions remotely using a smartphone or computer. It also provides historical data for analysis and predictive maintenance.

4) Working Principle of the System

The system works by continuously monitoring environmental and safety parameters using sensors. The sensors detect fire presence, harmful gases, temperature changes, and electrical faults in the industrial environment. When the system is powered on, the ESP32 initializes all sensors and begins collecting data. The flame sensor continuously checks for the presence of fire, while the MQ135 gas sensor measures the concentration of harmful gases in the air. The temperature sensor monitors the surrounding temperature and helps in detecting abnormal heat conditions that may indicate a potential fire hazard. In addition, the current sensor monitors the electrical current flowing through the connected industrial load to detect abnormal current conditions such as overload or electrical faults. The sensor data are processed by the Arduino Uno and analyzed according to predefined threshold values. If the readings remain within safe limits, the system indicates normal operation through LEDs. However, if any sensor value exceeds the safe threshold, the ESP32 immediately activates the alarm system, sends alert notifications through the IoT platform, and shuts down the power supply to the loads using the relay module to ensure safety.

5) IOT Communication Architecture

The IOT communication architecture enables the system to transmit sensor data from the industrial environment to the cloud platform. The ESP32 microcontroller has built-in Wi-Fi capability, which allows it to connect directly to the internet. Sensor data collected by the ESP32 is transmitted to the ESP RainMaker cloud platform. The cloud platform stores the data and provides real-time visualization through dashboards and mobile applications. This communication architecture enables remote monitoring of industrial conditions. Supervisors can check system status, sensor readings, and alerts from any location using their mobile devices.

6) Predictive Fault Detection Concept

Predictive fault detection is an important feature of modern industrial monitoring systems. Instead of responding only after a fault occurs, predictive monitoring helps identify potential problems before they become serious. The proposed system stores historical sensor data on the cloud platform. By analyzing this data, industries can identify patterns or trends in environmental conditions and equipment behavior. For example, gradual increases in temperature or gas concentration may indicate a developing problem. Detecting these patterns early allows industries to perform preventive maintenance and reduce the risk of accidents.

7) Data Acquisition and Processing

Data acquisition refers to the process of collecting sensor data from the industrial environment. In this system, sensors continuously measure environmental parameters and send electrical signals to the ESP32 microcontroller. The ESP32 reads these signals and converts them into meaningful digital data. The system software processes this data and determines whether the readings are within safe limits. If unsafe conditions are detected, the system triggers alarms and sends notifications to the IOT cloud platform. The processed data is also stored on the cloud for future analysis and monitoring.

IV. HARDWARE

This project has used following hardware components-

4.1 Microcontroller ESP32
4.2 Fire Sensor
4.3 Gas Detection Sensor (MQ135)
4.4 Current sensor
4.5 DHT11 Temperature and Humidity Sensor
4.6 Buzzer
4.7 LCD Display
4.8 AC to DC Power supply module
4.9 Relay Module 2 Channel
4.10 Arduino Uno
4.11 Buck Convertor (DC-DC Step down)
4.12 Exhaust Fan

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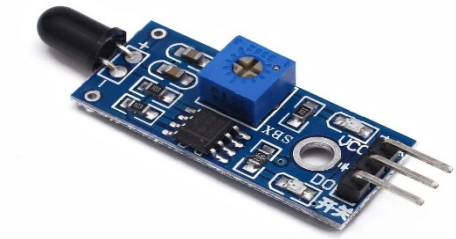
COMPONENTS

1) Microcontroller ESP32



The ESP32 acts as the central processing unit (CPU) of the proposed IoT-based industrial safety system, managing the overall operations of the embedded system. As a dual-core microcontroller, it can perform multiple tasks simultaneously, making it suitable for applications that require real-time monitoring and data processing. The ESP32 executes the programmed code, processes input from various sensors, and controls system responses based on predefined logic. One of its key advantages is its built-in Wi-Fi and Bluetooth connectivity, which enables seamless communication with cloud platforms and nearby devices for remote monitoring and control. Through Wi-Fi, the ESP32 can transmit sensor data to IoT platforms such as ESP RainMaker for real-time monitoring, while Bluetooth allows communication with local devices using technologies like Bluetooth Low Energy (BLE). In this system, the ESP32 continuously analyzes sensor data and compares it with predefined threshold values; if any parameter exceeds the limit, the system identifies it as a fault condition, activates the alarm, and sends notifications through the IoT platform, while normal readings allow the monitoring cycle to continue. Additionally, the ESP32 is designed with efficient power management features, including low-power modes such as deep sleep, which reduce energy consumption when the system is inactive. This capability helps extend the operational life of IoT devices, especially in remote monitoring applications. Due to its powerful processing capability, strong connectivity features, real-time data handling, and power efficiency, the ESP32 serves as the core component of the proposed industrial safety monitoring system.

2) Fire Sensor



A fire sensor is an important electronic component used to detect the presence of fire within its sensing range and plays a crucial role in safety monitoring systems. It operates by detecting specific wavelengths of infrared or ultraviolet radiation emitted during a fire event and converts these optical signals into electrical signals that can be processed by the microcontroller. In the proposed industrial safety system, the fire sensor continuously monitors the environment for any indication of flame or abnormal heat conditions. When a fire is detected, the sensor immediately sends a signal to the ESP32 microcontroller, which then activates the alarm system and sends a notification through the IoT platform for quick response. The sensor provides real-time monitoring, ensuring that fire incidents are detected at the earliest stage, allowing preventive actions to be taken before the situation escalates. Due to its ability to provide fast, reliable, and accurate fire detection, the fire sensor is widely used in industrial and domestic safety systems. Its integration into the proposed IoT-based industrial safety system enhances automation, improves reliability, and significantly increases the overall level of fire protection.

3) MQ135 Sensor



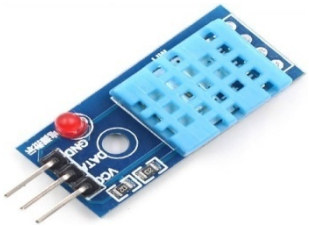
The MQ135 gas sensor is widely used for monitoring air quality by detecting the concentration of various harmful gases present in the environment. It is capable of sensing gases such as ammonia (NH_3), nitrogen oxides (NOx), benzene, alcohol, smoke, and carbon dioxide (CO_2), which are commonly associated with air pollution and potential health hazards. In the proposed IoT-based industrial safety system, the MQ135 sensor continuously monitors the surrounding air and measures the level of these gases to determine whether the air quality is safe or polluted. When the concentration of harmful gases exceeds the predefined threshold value, the sensor sends a signal to the ESP32 microcontroller, which then activates the alarm system and sends a notification through the IoT platform. This real-time detection helps identify gas leakage, pollution sources, or unsafe environmental conditions at an early stage. By integrating the MQ135 sensor with the air quality monitoring system, the collected data can also be used to analyze environmental conditions and take preventive measures such as improving ventilation or activating safety mechanisms. Therefore, the MQ135 sensor plays a crucial role in enhancing environmental safety, protecting human health, and maintaining safe air quality in industrial environments.

4) Current Sensor



The current sensor used in the Industrial Safety Monitoring System is designed to measure the flow of electrical current in a circuit and detect abnormal conditions that may indicate electrical faults. In industrial environments, electrical equipment operates under varying load conditions, and excessive current flow may occur due to faults such as overloads, short circuits, or malfunctioning equipment. These faults can cause overheating of wires, damage to electrical devices, or even fire hazards. The current sensor plays an important role in monitoring the electrical behavior of the system and ensuring that the current remains within safe operating limits.

5) DHT11 Temperature and Humidity Sensor



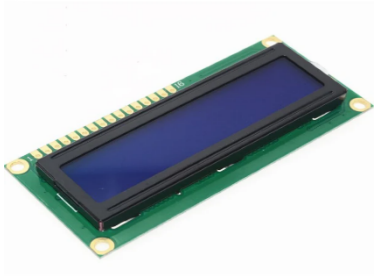
The DHT11 sensor is a digital temperature and humidity sensor commonly used in IOT and embedded monitoring systems. It is designed to measure the surrounding air temperature and humidity and send this data to a microcontroller such as the ESP32. In the industrial safety monitoring system, the DHT11 sensor helps in observing environmental conditions inside the industrial area. Monitoring temperature and humidity is important because abnormal environmental conditions can increase the risk of fire hazards, equipment malfunction, or unsafe working conditions for employees.

6) Buzzer



In this project, the buzzer is connected to the ESP32 microcontroller and is activated whenever the system detects abnormal sensor readings. When the flame sensor detects the presence of fire or when the gas sensor identifies dangerous levels of harmful gases, the ESP32 processes the sensor data and sends a signal to the buzzer. Upon receiving this signal, the buzzer generates a loud sound that alerts nearby workers about the emergency situation. This audible notification ensures that people in the surrounding area are immediately aware of the potential danger and can take necessary safety actions.

7) LCD Display



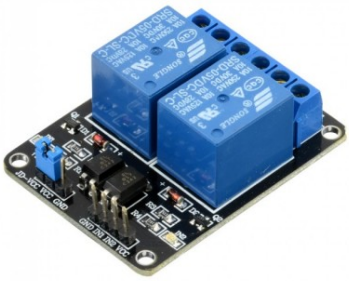
The LCD display is an important output device used in the Industrial Safety Monitoring System to visually present system information and sensor readings. A Liquid Crystal Display (LCD) is an electronic display module that uses liquid crystals to produce visible characters and symbols. In this project, a 16×2 LCD display is used, which means it can display two lines of text with sixteen characters in each line. The display provides a simple and effective way to monitor real-time data directly from the system without requiring additional devices such as computers or smartphones.

8) AC to DC Power supply module



The AC to DC power supply module works by first reducing the high AC voltage using internal switching circuits and then converting the alternating current into direct current using rectification and filtering stages. This conversion process ensures that the output voltage is stable and safe for sensitive electronic components such as the ESP32 microcontroller, sensors, and LCD display. Without this conversion, the electronic components would be damaged if connected directly to AC supply.

9) Relay Module 2 Channel



The 2 Channel Relay Module is an important switching component used in the Industrial Safety Monitoring System to control high-power electrical devices using low-power signals from the microcontroller. A relay module works as an electrically operated switch that allows the ESP32 controller to safely operate external devices such as alarms, fans, lights, or other electrical loads. Since microcontrollers operate on low voltage levels such as 3.3V or 5V, they cannot directly control high-voltage equipment. The relay module acts as an interface between the low-voltage control circuit and the high-voltage load circuit, allowing the system to safely manage electrical devices during hazardous situations.

The 2-channel relay module contains two independent relays on a single board, which allows the system to control two different electrical devices simultaneously. Each relay channel can be activated separately by sending a signal from the ESP32 microcontroller. When the controller detects a hazardous condition such as fire, gas leakage, or electrical fault, it sends a trigger signal to the relay module. The relay then switches its internal contacts, allowing electrical power to flow to the connected device. For example, one relay channel can be used to activate an alarm or buzzer while the second channel can be used to control a cooling fan or warning light.

10) Arduino Uno



In the real-time data processing stage, the system continuously monitors and analyzes the data collected from different sensors. The Arduino Uno receives the sensor readings and processes the data by comparing it with predefined threshold parameters. If the sensor values remain within the safe limits, the system continues normal monitoring and moves to the next cycle of data collection. However, if any sensor value exceeds the defined threshold, the Arduino Uno identifies it as a fault condition. The Arduino then sends a signal to the ESP32 module indicating that a fault has been detected. After receiving this signal, the ESP32 immediately activates the alarm system and sends an alert notification to the user's mobile through the IoT platform. This process ensures quick detection and immediate response to hazardous situations in the industrial environment.

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11) Buck Convertor (DC-DC Step down)



A buck converter, also known as a DC-DC step-down converter, is used to reduce a higher DC voltage to a lower DC voltage required by electronic components. In the industrial safety monitoring system, the buck converter helps regulate the voltage supplied to devices such as the ESP32 microcontroller, sensors, and display units. Since different components operate at different voltage levels, the buck converter ensures that each component receives the correct and stable voltage.

12) Exhaust Fan



The exhaust fan is used in the project as a safety load to remove harmful gases and smoke from the environment. It is connected to the control circuit through a relay module and connecting wires. When the gas sensor detects gas leakage or smoke in the surroundings, the microcontroller activates the relay. As a result, the exhaust fan turns ON automatically to ventilate the area. This helps in reducing the concentration of dangerous gases and improves air circulation. The exhaust fan plays an important role in maintaining a safe environment during emergency conditions. It also helps in preventing the spread of smoke or gas inside the room. Therefore, the exhaust fan acts as an important safety component in the system.

V. SOFTWARE

The proposed IoT-based industrial safety system is implemented using embedded programming and IoT technologies to ensure efficient monitoring and fault detection. The system is programmed using the Arduino IDE, an open-source development environment used for writing, compiling, and uploading code to microcontrollers such as Arduino Uno and ESP32. The embedded software is developed using the C/C++ programming language, enabling the microcontroller to interface with sensors and other hardware modules. During system initialization, all connected sensors and communication modules are configured, after which the system continuously collects sensor data such as temperature, gas concentration, and electrical parameters. The program operates in a continuous loop, allowing real-time monitoring of system conditions and ensuring that any abnormal situation is detected immediately.

The system uses a sensor data processing algorithm to analyze the raw signals obtained from different sensors. The microcontroller converts analog sensor outputs into digital values using an analog-to-digital converter (ADC) and applies filtering and calibration techniques to improve measurement accuracy. The processed values are then compared with predefined threshold limits to determine whether the system is operating under normal or abnormal conditions. If any parameter exceeds the safe limit, the fault detection logic identifies the situation as a hazardous condition and triggers warning signals or alarms. This early detection mechanism ensures that issues such as fire, gas leakage, overheating, or electrical faults are quickly recognized, preventing equipment damage and improving overall safety.

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To enable remote monitoring and user interaction, the system integrates with the ESP RainMaker IoT cloud platform through the ESP32 module. When a fault condition is detected by the Arduino Uno, the information is transmitted to the ESP32, which then updates the device status on the cloud platform. The system stores sensor data on cloud servers, enabling real-time monitoring, historical data analysis, and performance evaluation through dashboards. Additionally, the ESP RainMaker mobile application sends instant notifications to the user whenever a hazardous condition is detected, allowing quick response to emergencies. The use of cloud monitoring and predictive analysis also supports predictive maintenance, where historical data trends can help identify potential failures before they occur, thereby reducing downtime and improving the reliability of the industrial safety system.

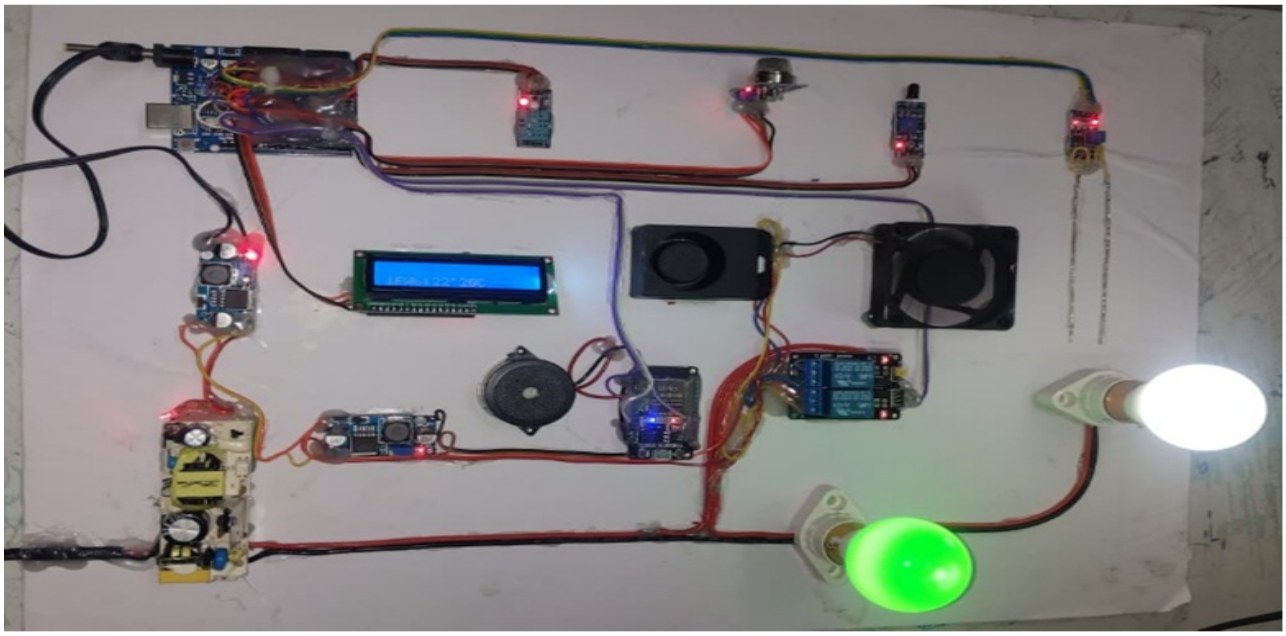


Figure-2: The experimental Setup

VI. RESULTS

A. Experimental Setup

The experimental setup of the proposed Industrial Safety System using IoT was developed to test and evaluate the performance of the system under different operating conditions. The system consists of a microcontroller-based IoT controller connected with multiple sensors such as flame sensors, gas sensors, and electrical fault detection modules. All components were properly connected using a powered using a regulated DC power supply. The microcontroller was programmed using the Arduino IDE to read sensor values, process the data, and transmit the information to the cloud platform. During the experiment, different conditions such as flame presence, gas leakage, and electrical variations were simulated to observe the system response. The experimental setup allowed testing of sensor accuracy, system response time, and reliability of the IoT communication system. The experimental setup is shown in Figure-2.

B. Sensor Response Analysis

Sensor response analysis was conducted to evaluate how effectively the sensors detect environmental and electrical parameters. Each sensor continuously monitors the surrounding conditions and sends data to the microcontroller. The flame sensor responds quickly to infrared radiation generated by fire, while the gas sensor detects the presence of combustible gases in the environment. Similarly, the electrical fault sensor monitors voltage or current irregularities. The sensor outputs were observed through the serial monitor and IoT dashboard to verify correct operation. It was observed that the sensors provided stable and consistent readings during normal conditions and responded immediately when abnormal parameters were introduced. This confirms that the sensors used in the system are suitable for real-time safety monitoring applications.

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C. Detection Accuracy

Detection accuracy refers to the ability of the system to correctly identify hazardous conditions such as fire, gas leakage, or electrical faults. During testing, different scenarios were created to check whether the system accurately detects abnormal conditions without generating false alarms. The results showed that the sensors were able to detect fire, gas presence, and electrical faults with a high level of accuracy. The microcontroller successfully processed the sensor data and triggered alerts when the values exceeded the predefined safety limits. The overall detection accuracy of the system was found to be reliable for industrial safety monitoring purposes. Accurate detection ensures timely alerts and improves the overall safety of the monitored environment.

D. Fault Detection Time

Fault detection time is an important performance parameter of the system, as it determines how quickly the system can respond to dangerous situations. In the proposed system, the microcontroller continuously monitors sensor readings in real time. When an abnormal condition such as fire or gas leakage occurs, the sensor immediately detects the change and sends a signal to the controller. The microcontroller processes the data and activates the alarm system within a short time. During experimental testing, the system was able to detect faults within a few seconds of occurrence. This fast response time is crucial for preventing accidents and minimizing damage in industrial environments.

E. System Reliability

System reliability refers to the ability of the monitoring system to operate continuously without failure under normal operating conditions. The proposed system was tested for extended periods to verify stable performance of sensors, microcontroller, and communication modules. The results showed that the system maintained consistent monitoring and data transmission throughout the testing period. The sensors provided stable readings, and the microcontroller successfully processed the data without interruption. Additionally, the IoT communication system ensured that the collected data was continuously transmitted to the cloud platform. The overall reliability of the system demonstrates its suitability for long-term industrial safety monitoring applications.

F. IoT Monitoring Results

The IoT monitoring results were evaluated using the cloud platform dashboard where the sensor data was transmitted and displayed in real time. The cloud platform successfully stored and visualized system parameters such as gas levels, temperature, and fault detection status. The dashboard provided graphical representations of sensor readings, allowing users to easily analyze system behavior. Whenever abnormal conditions were detected, alert notifications were generated and sent to the user's mobile device. The IoT monitoring system enabled remote access to the system data, allowing users to monitor the safety status from any location. The results confirm that IoT integration enhances the efficiency, accessibility, and functionality of the industrial safety monitoring system.

The image shows the mobile application interface and notification system used in the IoT-based Industrial Safety System developed for monitoring fire, smoke, and electrical devices. The system is implemented using ESP RainMaker (ESP32-based IoT platform) and allows real-time monitoring and alerts through a smartphone.

The diagram consists of **four screenshots** demonstrating the operation of the Industrial Safety IoT system.

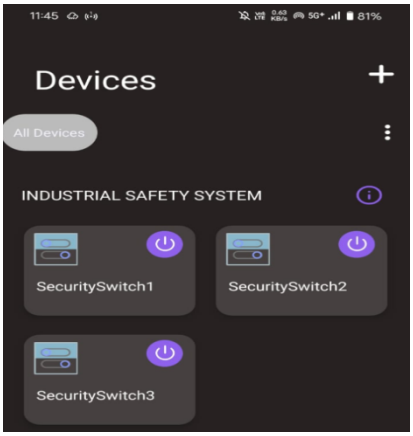


Figure-3: Result: Device Control Interface

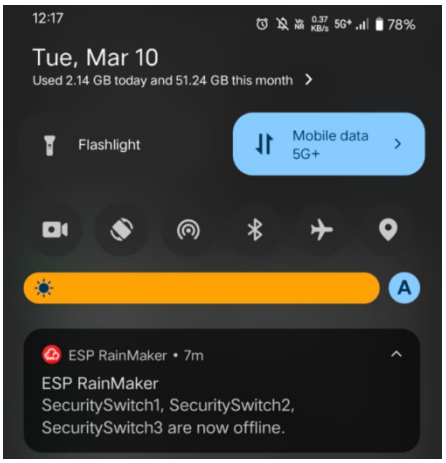


Figure-4: Result: Device Status Notification

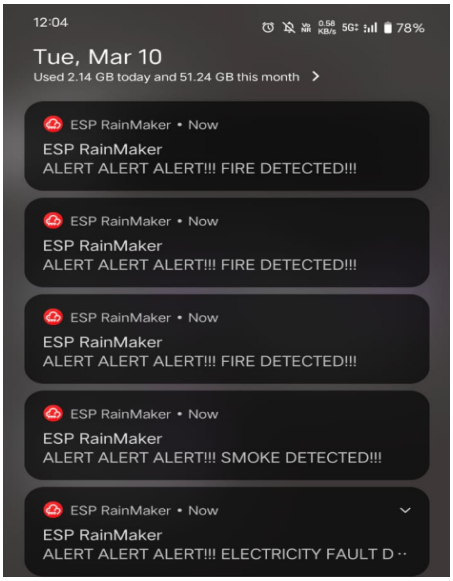


Figure-5: Result: Hazard Detection Alerts

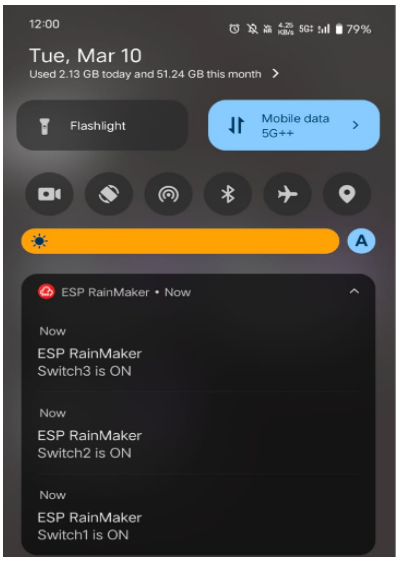


Figure-6: Result: Device Operation Status

1) Device Control Interface

- This screen displays the registered IoT devices connected to the industrial safety system.
- Three devices are shown:
  - SecuritySwitch1
  - SecuritySwitch2
  - SecuritySwitch3
- Each switch represents a connected electrical device or safety module (such as alarm, relay, or safety equipment).
- The power button icon allows the user to remotely turn the device ON or OFF using the mobile application.
- This interface enables remote control and monitoring of industrial safety equipment.

2) Device Status Notification

- This screenshot shows a system notification from ESP RainMaker.
- The notification indicates that:
  - SecuritySwitch1, SecuritySwitch2, and SecuritySwitch3 are offline**.**
- This occurs when:
  - The IoT device loses Wi-Fi connectivity, or
  - The ESP32 controller is powered off or disconnected.
- Such notifications help administrators quickly detect communication failures in the monitoring system.

3) Hazard Detection Alerts

- This screen displays emergency alerts generated by the system.
- The system sends instant notifications when hazardous conditions are detected.
- Example alerts include:
  - FIRE DETECTED
  - SMOKE DETECTED
- These alerts are triggered by sensors such as:
  - Flame sensor
  - Smoke or gas sensor (MQ series)
- Multiple alerts indicate continuous detection of dangerous conditions, prompting immediate action.

4) Device Operation Status

- This screenshot shows real-time device status updates.
- Notifications indicate that:
  - Switch2 is ON
  - Switch3 is ON
- This confirms that the industrial safety system can remotely activate safety devices, such as:
  - Alarm sirens
  - Ventilation systems
  - Emergency relays

5) Overall Function of the System

The diagram demonstrates how the IoT-based Industrial Safety System provides:

- Real-time monitoring of industrial hazards
- Instant alerts for fire and smoke detection
- Remote control of safety devices
- Automatic system status notifications
- Cloud-based connectivity using ESP RainMaker

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This system enhances industrial safety, rapid response to emergencies, and remote monitoring, thereby reducing risks and improving workplace safety management.

VII. CONCLUSION

The Industrial Safety Monitoring System using IOT provides an effective and reliable solution for monitoring hazardous conditions in industrial environments. The system is designed to detect potential dangers such as fire, smoke, and electrical faults by using multiple sensors connected to a microcontroller. By continuously monitoring environmental conditions, the system ensures early detection of hazardous situations and helps prevent accidents that may cause damage to equipment or risk the safety of workers. The integration of sensors with the microcontroller allows the system to analyze environmental data in real time and respond immediately when abnormal conditions are detected. When the sensors detect fire, smoke, or electrical faults, the system activates the buzzer alarm and generates alerts to notify workers and supervisors. This quick response mechanism improves industrial safety and helps prevent serious incidents in workplaces where hazardous materials or electrical equipment are present.

Another important feature of the system is the integration of IOT technology through the ESP RainMaker platform. This allows users to monitor the safety status of the industrial environment remotely using a mobile application. Real-time alerts and notifications enable supervisors to respond quickly to emergencies even when they are not physically present at the industrial site. The results obtained during testing demonstrate that the system is capable of detecting hazardous conditions accurately and generating immediate alerts. The system operates continuously and provides reliable monitoring of industrial environments. Therefore, the proposed Industrial Safety Monitoring System can be considered an efficient and cost-effective solution for improving workplace safety and reducing the risk of industrial accidents.

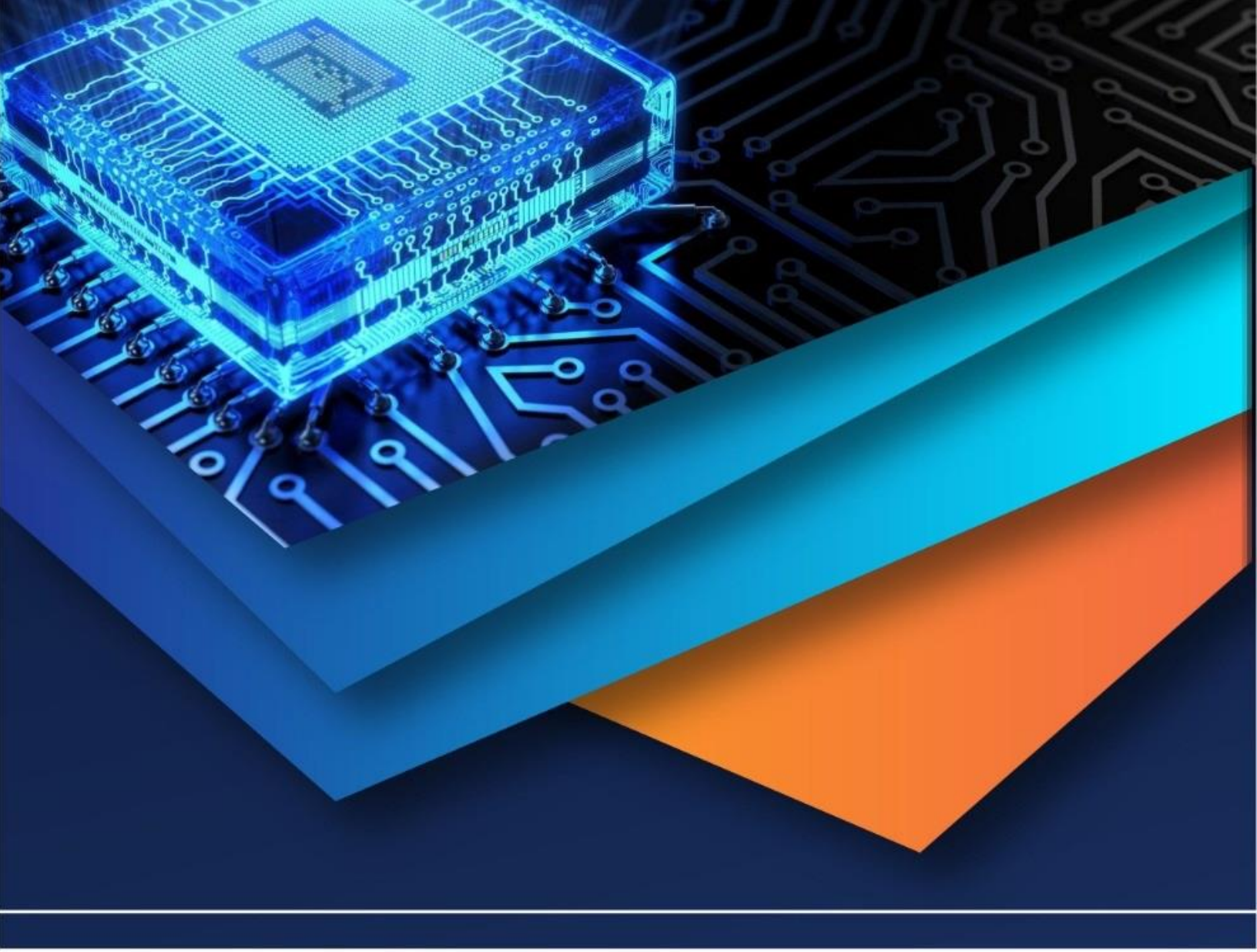
VIII. FUTURE SCOPE

Although the current system provides effective monitoring of fire, smoke, and electrical faults, there are several possibilities for future improvements and enhancements. In the future, Artificial Intelligence (AI) can also be implemented in the system to make it more intelligent and efficient. AI algorithms can analyze sensor data patterns and predict potential hazards before they occur. For example, AI can be used for predictive analysis to identify abnormal temperature rise, unusual gas concentration, or electrical load variations. It can also help in reducing false alarms by intelligently verifying sensor data and recognizing real hazards. Machine learning models can learn from past data and improve the accuracy of detection over time. Additionally, AI can be integrated with cloud platforms to provide smart notifications, automatic decision making, and advanced safety recommendations for industries. These enhancements would make the system more reliable, proactive, and suitable for large-scale industrial safety monitoring.

REFERENCES

[1] S. B. Warkad et al., "Industrial Safety System Using IoT for Fire, Gas, and Electrical Faults," *International Journal of Innovative Research in Technology*, Vol-12,Issue-8 pp.5430-5436, 2026.
[2] A. Doshi and Y. Rai, "IoT Based Fire and Gas Monitoring System," *International Journal for Research in Applied Science & Engineering Technology*, 2021, Vol-9, Issue-7 pp.3110-3117, July 2021.
[3] M. N. Islam et al., "Development of an IoT Based Industrial Fault Detection and Diagnosis System," *Asian Journal for Convergence in Technology*, Vol-9, Issue-1 pp.18-22, 2023.
[4] P. K. Gupta and M. K. Singh, "IoT-Based Intelligent Safety System for Fire, Gas, and Industrial Hazard Prevention," *Advanced International Journal of Multidisciplinary Research*, Vol-3, Issue-5 pp.1-5, 2025.
[5] "IoT Based Industrial Automatic Fault Monitoring System," *International Journal of Scientific Research & Engineering Trends*, Vol-11, Issue-2 pp.1247-1257, Mar-Apr-2025.
[6] K. Abdulsalam, "Application of IoT for Fire and Gas Leakage Detection in Industrial Environment," *World Scientific News 184*, pp.63-74, 2023.
[7] Muhammad Junaid Asif et al., "Wireless Sensor Networks for Real-Time Industrial Monitoring," 2025.
[8] Sérgio F. Chevtchenko et al., "Anomaly Detection in Industrial Machinery using IoT Devices and Machine Learning,", Vol-11,pp.128288-128305, 2023.
[9] Kriti Thakur et al., "Advancements in Arc Fault Detection for Electrical Distribution Systems,", 2023.
[10] ISA TR84.00.07, "Guidance on the Evaluation of Fire and Gas System Effectiveness," International Society for Automation, 2010.
[11] P. Babu, A. Jain, and S. Tiwari, "Performance evaluation and communication trade-offs for MQ-series gas sensors in IoT deployments," Procedia Engineering, vol. 220, pp. 102–111, 2024.
[12] I. Morchid, Y. Haddad, and S. Elmir, "Integrated IoT architecture for large-area early fire detection using NB-IoT and energy-optimized nodes," Energy & Systems, vol. 18, pp. 33–49, 2024.
[13] NIDM Working Group, "Practical guidelines and field notes for IoT fire detection retrofits," National Institute of Disaster Management Technical Report, 2024.
[14] A. Morchid and B. Elaziz, "Sustainable IoT fire-detection deployments for agriculture: field validations," Agricultural Systems and Safety, vol. 9, pp. 60–76, 2024.
[15] J. Park, H. Kim, and T. Cho, "Pre-fire early-warning system using multivariate temporal thresholds on ESP32 platform," AIP Advances, vol. 14, art. 085602, 2024.

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