



IOT-BASED SMART INDUSTRIAL WORKER SAFETY SYSTEM

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Abstract : The IoT-Based Smart Industrial Worker Safety System is a wearable safety solution designed to improve the protection of workers operating in hazardous industrial, sewage, and confined environments. The system uses an ESP32 microcontroller as the central processing unit and integrates MQ-135 and MQ-2 gas sensors for detecting harmful gases, smoke, and combustible gases, while the DHT11 sensor monitors temperature and humidity. An MPU6050 motion sensor is used to identify sudden movements and possible fall incidents. In an emergency, the worker can also manually activate an SOS push button. The detected conditions are processed by the ESP32 and indicated locally through an OLED display, buzzer, and LED. At the same time, the system uses IoT connectivity and a Blynk dashboard to provide real-time monitoring and emergency notifications to the supervisor. This enables faster identification of hazardous conditions and worker accidents, allowing timely rescue and safety actions. The proposed system provides a compact, practical, and modular approach for enhancing industrial worker safety.

Index Terms: IoT, ESP32, Industrial Worker Safety, Gas Detection, MQ-135, MQ-2, DHT11, MPU6050, Fall Detection, SOS Alert, Blynk, Wearable Safety System.

I. INTRODUCTION

Industrial and sewage workers often perform their duties in environments where they may be exposed to toxic gases, smoke, high temperature, poor air quality, and other dangerous conditions. Workers in confined spaces may not always be able to identify hazardous gases or environmental changes before they become harmful. In addition, accidents such as slips, sudden falls, or loss of consciousness can occur without immediate assistance from supervisors. Therefore, continuous monitoring of both the worker and the surrounding environment is important for improving workplace safety.

Conventional safety equipment such as helmets, gloves, masks, and protective clothing mainly provides physical protection but generally does not provide real-time information about environmental hazards or the worker's physical condition. In an emergency, supervisors may

become aware of an incident only after the worker reports it or another person notices the accident. This delay can be critical, particularly in industrial and sewage environments where exposure to harmful gases or extreme conditions can rapidly affect a worker's health and ability to escape.

The proposed IoT-Based Smart Industrial Worker Safety System provides an additional layer of active monitoring by combining multiple sensors with an ESP32 microcontroller. The MQ-135 and MQ-2 sensors monitor changes in air quality, harmful gases, smoke, and combustible gases, while the DHT11 sensor measures temperature and humidity. The MPU6050 motion sensor continuously observes the worker's movement and can identify sudden changes in orientation or movement that may indicate a fall. An SOS push button is also provided so that the worker can manually request immediate assistance whenever required.

The ESP32 collects and processes the data received from the sensors and provides immediate local warnings through a buzzer, LED, and OLED display when an abnormal condition is detected. The system also uses Wi-Fi-based IoT communication to transmit important safety information to a Blynk IoT dashboard, allowing supervisors to monitor the worker's condition remotely. This makes it possible to receive alerts related to gas levels, temperature, fall detection, or manual SOS activation without depending entirely on verbal communication.

II. AIM AND OBJECTIVES

Aim:

To design and develop an IoT-Based Smart Industrial Worker Safety System that continuously monitors hazardous environmental conditions and worker movement, detects emergencies such as harmful gas exposure, excessive temperature, and falls, and provides immediate local and remote alerts for faster safety and rescue response.

Objectives:

- To monitor harmful gases and air quality around industrial workers using MQ-135 and MQ-2 gas sensors and identify potentially hazardous conditions.
- To measure environmental temperature and humidity using the DHT11 sensor and provide warnings when working conditions become unsafe.
- To detect sudden falls or abnormal movements of workers using the MPU6050 accelerometer and gyroscope for quick identification of possible accidents.
- To provide a manual emergency alert facility through an SOS push button so that workers can request immediate assistance whenever they face danger.
- To provide real-time local warnings through a buzzer, LED indicator, and OLED display so that workers can immediately become aware of hazardous conditions.
- To enable IoT-based remote monitoring using the ESP32 and Blynk dashboard, allowing supervisors to receive emergency

notifications and monitor worker safety conditions in real time.

III. LITERATURE REVIEW

The development of IoT-based wearable safety systems has received increasing attention because conventional personal protective equipment mainly provides physical protection and does not continuously monitor the worker's environment or physical condition. Research on industrial wearables has identified applications such as hazard identification, fall detection, location tracking, activity recognition, and health monitoring. These systems demonstrate that wearable sensors combined with wireless communication can provide continuous safety information and support faster emergency response.

1. IoT-Based Worker Monitoring Systems:

Earlier IoT-based safety systems focused on collecting environmental parameters through sensors and transmitting the information to a remote monitoring platform. Temperature, humidity, air quality, and hazardous gas monitoring have become important applications because workers may be unable to recognize dangerous environmental changes immediately. IoT connectivity allows supervisors to receive safety information in real time and take preventive action.

2. Wearable Safety Systems for Industrial Workers:

Research into wearable technologies has demonstrated the usefulness of integrating sensors directly into helmets, vests, bands, and other personal protective equipment. Such systems can continuously monitor worker-related and environmental parameters without

requiring the worker to operate a separate device. Surveys of industrial wearables highlight hazard detection, worker monitoring, location tracking, and emergency notification as important functions of connected wearable safety technologies.

3. Gas and Environmental Hazard Detection:

Gas detection has become an important part of safety systems for workers in confined spaces, sewage areas, mining, chemical industries, and oil and gas facilities. IoT-enabled gas sensors can continuously identify changes in air quality and hazardous gas concentrations and generate alerts when unsafe conditions occur. Connected personal gas detectors also demonstrate the advantage of sending information beyond the local alarm to off-site safety managers.

4. Fall and Abnormal-Movement Detection:

Motion sensors such as accelerometers and gyroscopes are widely used for detecting falls and sudden changes in body movement. Recent wearable research has demonstrated the combination of ESP32 and MPU6050 sensors for automatic fall detection and emergency notification. Such systems can provide local buzzer/LED alerts and transmit an emergency notification to a designated person, demonstrating the suitability of low-cost embedded hardware for real-time safety monitoring.

5. Manual SOS and Emergency Alert Systems:

Automatic detection alone may not identify every emergency, particularly when a worker encounters a hazardous situation while remaining physically stable. Therefore, modern wearable safety systems commonly include manual SOS or panic-button

functionality. Commercial connected safety wearables combine manual SOS with automatic fall or no-motion detection and remote monitoring, showing the importance of providing both automatic and worker-initiated emergency alerts.

6. IoT Dashboard and Remote Monitoring:

The integration of cloud or IoT dashboards enables supervisors to observe safety parameters remotely instead of depending only on information available at the worksite. IoT safety systems can provide real-time alerts, historical data, and centralized monitoring of workers. This approach improves situational awareness and can support faster emergency response, particularly when workers are operating alone or in difficult-to-access locations.

7. Research Gap and Proposed System:

Existing research shows that gas monitoring, temperature sensing, fall detection, SOS alerts, and IoT communication are individually effective safety features. However, there is a need for a low-cost, compact, and integrated wearable system that combines these functions into a single worker safety platform. The proposed system addresses this requirement by integrating ESP32, MQ-135, MQ-2, DHT11, MPU6050, SOS button, OLED display, buzzer, LED, and Blynk IoT monitoring. This combination provides both environmental and movement-based monitoring with immediate local and remote emergency alerts.

IV. METHODOLOGY

The proposed IoT-Based Smart Industrial Worker Safety System is developed as a wearable safety

unit that combines environmental sensing, motion monitoring, emergency signaling, and IoT communication. The system uses an ESP32 as the main controller because it provides sufficient processing capability along with built-in Wi-Fi for remote monitoring. The methodology is divided into hardware integration, sensor data acquisition, hazard detection, local alert generation, IoT communication, and system testing.

1. System Requirement and Component Selection:

The major hazards faced by industrial and sewage workers are first identified, including harmful gases, smoke, excessive temperature, sudden falls, and emergency situations. Based on these requirements, ESP32, MQ-135, MQ-2, DHT11, MPU6050, SOS push button, OLED display, buzzer, LED, and rechargeable lithium-ion battery are selected.

2. Hardware Integration:

All sensors and output devices are interfaced with the ESP32. The MQ-135 and MQ-2 sensors are connected to monitor surrounding air quality and hazardous gas conditions. The DHT11 measures temperature and humidity, while the MPU6050 provides acceleration and gyroscope data for movement and fall detection. The OLED, buzzer, and LED provide local information and warnings.

3. Environmental Monitoring:

The ESP32 continuously collects readings from the gas sensors and DHT11. The measured values are compared with predefined safety limits. If the gas concentration or temperature reaches an

unsafe level, the controller identifies the condition as a potential hazard and activates the appropriate warning.

4. **Fall Detection:**

The MPU6050 continuously monitors the worker's movement and body orientation. A sudden change in acceleration or orientation followed by an abnormal stationary condition is treated as a possible fall. The system then generates a fall alert so that the incident can be communicated to the supervisor.

5. **Emergency and IoT Communication:**

A dedicated SOS push button allows the worker to manually generate an emergency signal. When an emergency condition is detected, the ESP32 activates the buzzer and LED and sends the relevant information through Wi-Fi to the Blynk IoT dashboard. The supervisor can therefore monitor the worker's safety status remotely.

6. **Testing and Validation:**

The complete system is tested under simulated gas leakage, increased temperature, sudden movement/fall conditions, and manual SOS activation. The response of the sensors, local warning devices, ESP32 processing, and Blynk notifications is checked to verify reliable operation.

V. WORKING

The system starts when the rechargeable battery supplies power to the ESP32 and all connected sensors. After initialization, the ESP32 continuously reads data from the MQ-135, MQ-2, DHT11, and MPU6050 sensors.

The MQ-135 monitors changes in air quality and harmful gases, while the MQ-2 detects smoke and combustible gases. The DHT11 provides temperature and humidity readings, and the MPU6050 monitors the worker's movement and orientation

The collected information is displayed locally on the OLED display and processed by the ESP32.

During normal operation, the ESP32 compares the sensor readings with predefined threshold values. If the environmental conditions remain within the safe range and no abnormal movement is detected, the system continues monitoring. If harmful gas, smoke, or excessive temperature is detected, the buzzer and LED are activated to warn the worker. Similarly, when the MPU6050 detects a movement pattern indicating a possible fall, the system generates a fall warning. The worker can also press the SOS button at any time to manually request immediate assistance.

Whenever a hazardous or emergency condition occurs, the ESP32 uses its built-in Wi-Fi connectivity to transmit the alert information to the Blynk IoT dashboard. The supervisor can view the worker's safety parameters and receive an emergency notification remotely. This enables the supervisor to become aware of dangerous conditions without waiting for the worker or another person to report the incident. Thus, the system provides continuous monitoring → hazard detection → local warning → IoT notification → emergency response, creating an additional active safety layer for industrial and confined-space workers.

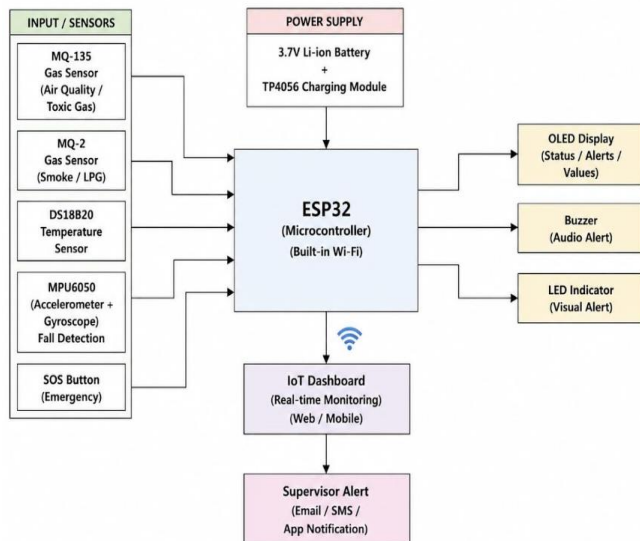
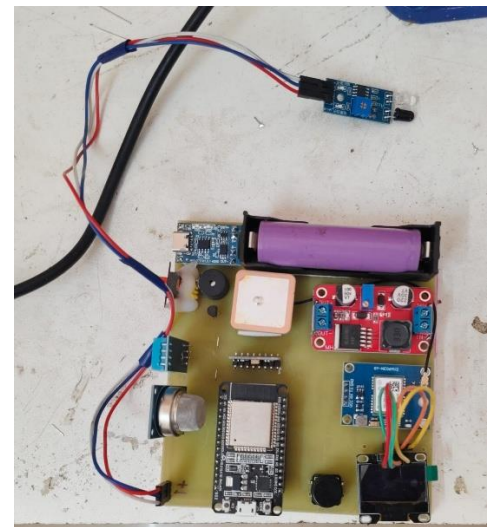


Fig 1: Block Diagram of the proposed system

VI. RESULTS

The developed IoT-Based Smart Industrial Worker Safety System successfully monitored important safety parameters such as harmful gases, smoke, temperature, humidity, and worker movement in real time. The MQ-135 and MQ-2 sensors provided continuous environmental monitoring, while the DHT11 measured temperature and humidity and the MPU6050 detected sudden movement and possible fall conditions. The SOS push button allowed the worker to manually trigger an emergency alert. During simulated hazardous conditions, the buzzer and LED provided immediate local warnings, while the ESP32 transmitted the safety status and emergency notifications to the Blynk IoT dashboard. The results demonstrate that the proposed system can provide continuous worker monitoring and support faster identification of hazardous and emergency situations.



VII. CONCLUSION

The IoT-Based Smart Industrial Worker Safety System provides an effective and practical approach for improving the safety of workers operating in industrial, sewage, and confined environments. By integrating gas detection, temperature monitoring, fall detection, manual SOS, local alerts, and IoT-based remote monitoring into a single system, it provides an additional safety layer beyond conventional protective equipment. The ESP32 enables real-time processing and wireless communication with the Blynk dashboard, helping supervisors receive timely information about hazardous conditions or worker emergencies. The system is compact, modular, and can be further improved by adding GPS location tracking, additional gas sensors, heart-rate monitoring, and advanced emergency communication for wider industrial applications.

VIII. REFERENCES

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