

IOT-Based Smart Helmet for Industrial Workers

Aishwarya M. P. (3BR21EE003), **Dheeraj Prasad** (3BR21EE008), **Jeevitha P. V.** (3BR21EE036), **Nalini** (3BR21EE063)

Department of Electrical and Electronics Engineering
Ballari Institute of Technology and Management, Ballari, Karnataka, India

ABSTRACT

Industrial workers, particularly those employed in mining and other hazardous environments, are continuously exposed to risks such as toxic gases, abnormal temperature and humidity conditions, falls, and emergency situations. This paper presents an **IoT-Based Smart Helmet for Industrial Workers** designed to improve worker safety through continuous environmental monitoring and emergency communication. The proposed system is based on an Arduino Uno microcontroller integrated with an MQ2 gas sensor, DHT11 temperature and humidity sensor, emergency switch, GPS module, GSM communication module, ESP8266 Wi-Fi module, 16×2 LCD, and buzzer. Sensor information is continuously monitored to identify potentially hazardous operating conditions. When an unsafe condition or emergency is detected, the system provides a local warning through the buzzer and supports emergency notification using GSM communication. GPS provides location information to assist in locating the worker, while IoT connectivity enables the concept of remote monitoring. The developed smart helmet provides an economical and practical approach for improving industrial worker safety by combining sensing, location tracking, warning, and communication functions in a wearable safety system.

Keywords— Internet of Things (IoT), Smart Helmet, Industrial Safety, Arduino Uno, MQ2 Sensor, DHT11, GPS, GSM, ESP8266.

INTRODUCTION

Industrial environments such as mining operations, construction sites, and manufacturing facilities involve numerous occupational hazards. Workers may be exposed to toxic gases, high temperatures, excessive humidity, falling objects, accidental falls, and other dangerous conditions. Conventional personal protective equipment provides physical protection but generally lacks the capability to continuously monitor environmental parameters or automatically communicate an emergency. Therefore, integrating sensing and communication technologies into personal protective equipment can significantly improve industrial safety.

The Internet of Things provides a suitable platform for developing intelligent wearable safety equipment capable of sensing, processing, and communicating information in real time. The proposed smart helmet integrates multiple sensors and communication modules with an Arduino-based controller.

The MQ2 sensor detects hazardous gases, while the DHT11 sensor monitors temperature and humidity. GPS supports worker location tracking, GSM provides emergency messaging, and the ESP8266 module enables IoT communication. An LCD provides system information and a buzzer generates an immediate local warning when unsafe conditions occur.

LITERATURE SURVEY

Faizan Manzoor *et al.* [1] developed a smart helmet integrating a microcontroller with GPS, GSM, Wi-Fi, vibration, pressure, and accelerometer sensors. When the measured sensor values exceed predefined thresholds, the system identifies a possible accident and transmits GPS coordinates and time information to family members and a server through GSM and Wi-Fi. D. P. B. Devkar *et al.* [2] proposed a low-cost intelligent helmet for accident prevention using GPS and GSM technologies. The system detects an accident and generates an alert to support rapid emergency response and improve user safety.

Prem Kumar M. and Rajesh Barreca [3] presented an IoT-based smart helmet for accident detection and notification using sensors, a Wi-Fi-enabled processor, and RF communication. The system incorporates an accelerometer for accident detection, a piezoelectric buzzer for speed-related warning, an ALCHO-LOCK function to prevent drink-and-drive situations, and a fog sensor to improve safety under poor visibility conditions. The work discussed in [4] focuses on an intelligent smart helmet for industrial and mining environments that monitors hazardous gases, light levels, humidity, helmet usage, and worker location. IoT-based wireless communication transfers information between underground workers and the base station, while a buzzer alerts the worker or supervisor whenever sensor readings exceed predefined threshold values. These studies [1]–[4] demonstrate the effectiveness of integrating sensing, IoT communication, accident detection, and location tracking to improve worker safety and emergency response.

PROBLEM STATEMENT

Industrial workers operate in environments where hazardous gases, unfavorable environmental conditions, and unexpected emergencies may threaten their safety. Traditional helmets primarily provide mechanical protection and do not continuously monitor environmental parameters or automatically communicate emergency information. Furthermore, practical IoT-based wearable systems face challenges involving sensor performance, wireless communication, battery life, data security, and reliable operation under harsh conditions.

OBJECTIVES

The main objectives of the proposed system are:

1. To design and implement an IoT-based smart helmet capable of monitoring hazardous environmental conditions and providing real-time alerts to industrial workers and supervisors.
2. To improve emergency response using GPS-based location tracking and GSM/IoT communication so that worker location and emergency information can be communicated during dangerous situations.

PROPOSED SYSTEM

The proposed system uses an **Arduino Uno** as the main processing and control unit. Various sensing and communication devices are interfaced with the controller to form an integrated worker-safety system. The smart helmet incorporates an MQ2 gas sensor for detecting hazardous gases, a DHT11 sensor for monitoring temperature and humidity, and an emergency switch that allows a worker to manually request assistance. The sensed information is processed by the controller and relevant operating information is displayed using the LCD.

The communication section consists of GPS, GSM, and ESP8266 Wi-Fi modules. GPS is employed for obtaining the worker's location, while GSM provides SMS-based emergency communication. The ESP8266 supports IoT connectivity for remote monitoring applications. A buzzer provides an immediate audible warning whenever a dangerous condition is identified. The integration of sensing, processing, warning, location tracking, and communication functions enables the helmet to provide more comprehensive protection than a conventional industrial safety helmet.

BLOCK DIAGRAM

Fig. 1 shows the Arduino Uno receiving inputs from the MQ2 gas sensor, DHT11 temperature and humidity sensor, and emergency switch. The controller processes these inputs and interfaces with the ESP8266 Wi-Fi module, 16×2 LCD, buzzer, GSM, and GPS modules for real-time monitoring, hazard alerts, and emergency communication.

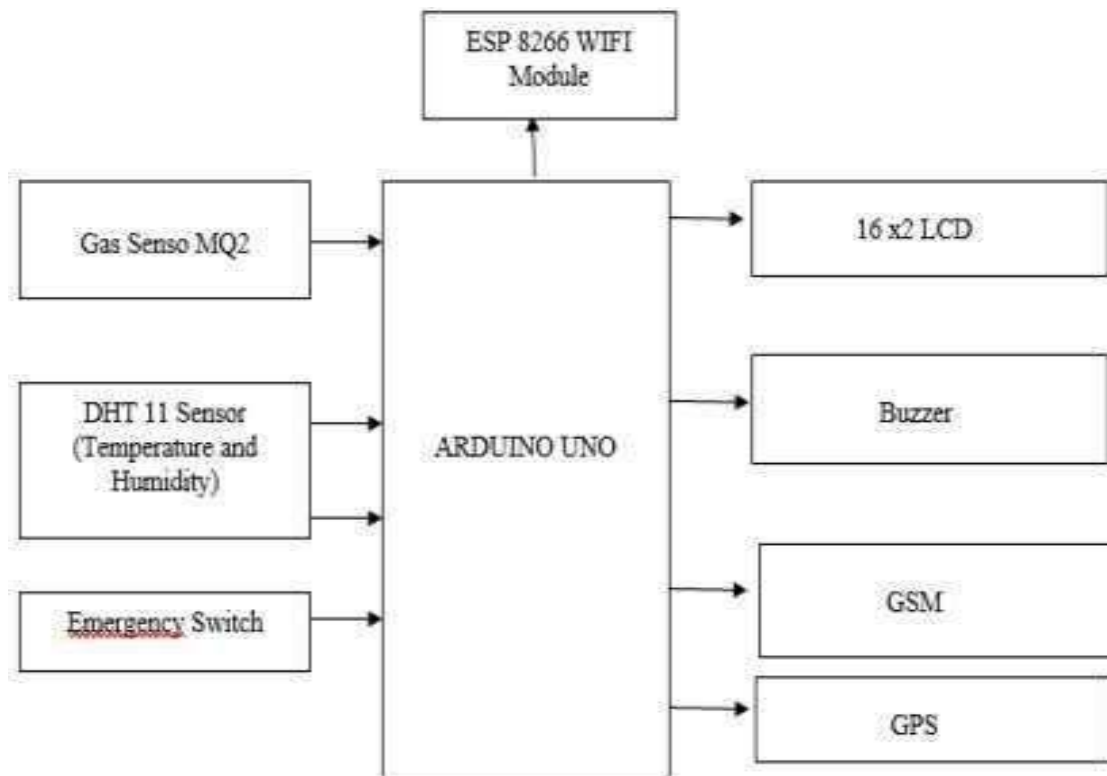


Fig 1Block diagram of IOT based smart helmet

CIRCUIT DIAGRAM

Fig. 2 shows the circuit connections of the smart helmet system, integrating the Arduino controller with the 16×2 LCD, GPS module, gas sensor, GSM module, DHT11 sensor, and buzzer. The circuit enables environmental monitoring, location tracking, display of sensor information, and emergency alert communication.

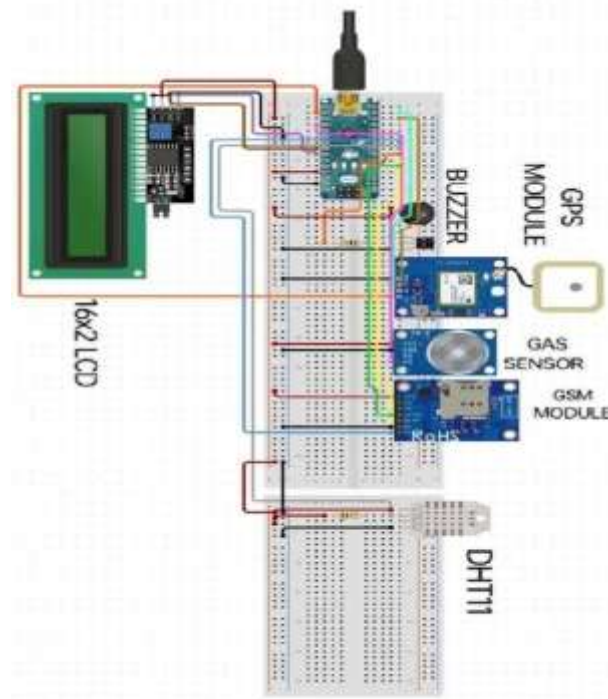


Fig: 2 Circuit diagram of Iot based smart helmet

METHODOLOGY

The methodology begins with integration of the sensing, processing, display, and communication modules with the Arduino Uno. The GPS and GSM modules are connected through serial communication for location tracking and emergency messaging, while the LCD provides system-status information. A regulated power supply is used to provide the required operating voltage. The controller program is developed using the Arduino IDE and uploaded to the Arduino Uno. During initialization, the required sensors and communication modules are configured before continuous monitoring begins.

During operation, environmental parameters are continuously monitored and processed by the Arduino. The MQ2 sensor is used to identify hazardous gases and the DHT11 measures temperature and humidity. When a dangerous condition is detected, the buzzer provides an immediate warning. In an emergency, GPS location information can be obtained and the GSM module is used to transmit the necessary emergency information to predefined contacts. The LCD continuously indicates the operating condition of the system, while ESP8266 connectivity extends the system toward IoT-based remote monitoring.

RESULTS AND DISCUSSION

The Fig. 3 developed IoT-based smart helmet demonstrates the successful integration of environmental monitoring, hazard warning, location tracking, and emergency communication into a wearable industrial safety system. During normal operation, the system continuously monitors sensor data and displays the corresponding information on the LCD. The MQ2 sensor detects the presence of hazardous gases, while the DHT11 sensor measures temperature and humidity. When potentially dangerous environmental conditions are detected, the buzzer is activated to provide an immediate warning to the worker.

The communication subsystem enhances the usefulness of the helmet during emergency situations. GPS provides location information, while GSM supports transmission of emergency messages to predefined contacts. The

emergency switch allows the worker to manually request assistance when required. The overall implementation demonstrates how an Arduino-based IoT system can improve the speed of hazard identification and emergency response compared with a conventional helmet. The report also recognizes limitations and future improvement areas involving battery life, data security, comfort, weight, and reliable performance under challenging environmental conditions.



Fig:3 Hardware Setup

CONCLUSION

The IoT-Based Smart Helmet for Industrial Workers provides an integrated approach to improving worker safety in hazardous environments. The proposed system combines an MQ2 gas sensor, DHT11 temperature and humidity sensor, emergency switch, Arduino Uno, LCD, buzzer, GPS, GSM, and ESP8266 Wi-Fi communication. These components enable environmental monitoring, immediate warning, location tracking, and emergency communication within a single wearable safety platform.

The system demonstrates the potential of IoT technology to transform conventional personal protective equipment into an intelligent safety device. The emergency switch allows workers to request assistance, while the LCD and buzzer provide local information and warnings. Further development focusing on improved battery life, data security, comfort, reduced weight, and reliable operation under harsh industrial conditions can make the proposed smart helmet more suitable for practical industrial deployment.

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