Smart Helmet System for Construction Workers

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Abstract. Smart helmet system is designed to improve the safety and health of construction workers by integrating various IoT-based system and communication technologies The system continuously monitors the worker's body temperature using the MLX90614 sensor, heart rate and SpO_2 with the MAX30102 sensor, and detects harmful gases using the MQ-135 gas sensor These health and environmental data are transmitted wirelessly to the ThingSpeak cloud via the ESP8266 Wi-Fi module, allowing real-time remote monitoring by supervisors through mobile devices. If a fall is detected by the MPU6050 sensor, the GPS NEO-6M provides the worker's coordinates, which the SIM900A GSM module transmits via SMS to the supervisor. If the worker has breath alcohol, the alcohol sensor activates a buzzer and automatically makes a call to notify the responsible team. All components are powered by a 5 V high-capacity rechargeable power bank (≥10,000 mAh) with appropriate voltage regulation, while the internal connections are implemented using soldered joints or locking connectors to ensure reliable operation in harsh working environments. The system offers a practical and affordable solution for construction sites by combining real-time health monitoring with automatic emergency alerts, helping to reduce workplace accidents and improve overall worker safety.

Keywords: alcohol sensor, automatic emergency alerts, body temperature, construction workers, gas sensor, heart rate & SpO2, IoT-based system, smart helmet, worker safety.

INTRODUCTION

Construction sites involve high-risk working conditions, and ensuring the safety of workers is a major concern. To improve this, a smart helmet system has been developed using IoT technology and microcontroller-based sensors. The helmet monitors the worker's health status and environmental safety conditions in real time. It includes sensors for body temperature, heart rate, oxygen level, gas detection, accident detection, and alcohol level. If abnormal conditions occur such as the worker falling, inhaling toxic gases, or being under the influence alerts are sent to supervisors via GSM message or phone call. The system also shows live data on the ThingSpeak cloud platform, making remote monitoring possible. Powered by a portable power bank, the helmet operates wirelessly and can be used throughout the working day. This smart helmet helps to reduce accidents and health risks, offering a practical solution for enhancing worker safety at construction sites.

PROBLEM

Construction workers face many safety risks on site, including accidents, health issues, and exposure to dangerous environments. Traditional safety measures often fail to provide immediate alerts or real-time monitoring. Many existing safety systems are also expensive, hard to install, and complicated to use, making them less practical for everyday use at

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construction sites. This project aims to solve these problems by creating a smart helmet system that monitors worker health and environment continuously. It sends real-time alerts to supervisors via mobile apps if any danger or abnormal condition is detected. The system is affordable, easy to set up, and user-friendly. By combining sensors for temperature, heart rate, gas detection, fall detection, and alcohol detection with wireless communication, the helmet improves safety with fast response time and simple remote management.

APPROACH

The system combines multiple sensors and modules to ensure the user safety and enable remote monitoring. A MPU6050 sensor detects accidents while an alcohol sensor checks for alcohol consumption. A GPS module determines the user's location, and a GSM module sends alerts and sounds alarms when necessary. The MLX90614 sensor measures body temperature, and the heart rate sensor monitors both heart rate and oxygen levels. Additionally, a gas sensor detects harmful gases in the surrounding environment. All collected data can be sent via the ESP8266 module to the Thingspeak cloud platform, allowing remote monitoring through a Wi-Fi connection.

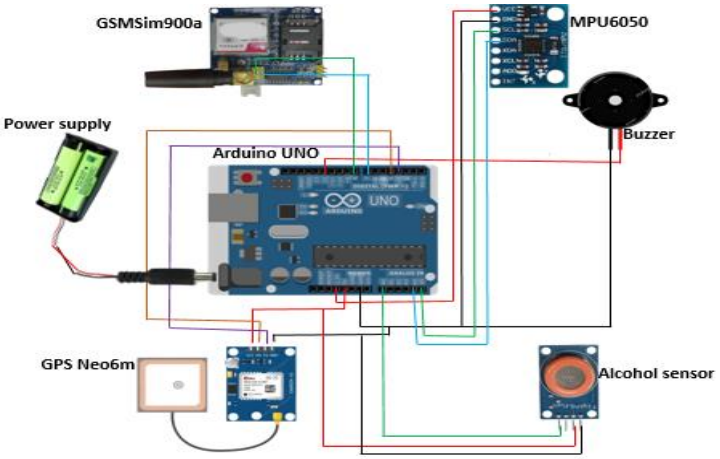

Figure 1: Circuit Diagram of Smart Safety and Alert System

The Arduino board acts as the main controller with the Arduino IDE used for programming. When the system starts, it checks the user through these sensors. If an accident is detected, the alarm sounds and the location is sent via SMS to the controller. If alcohol consumption is detected, the alarm sounds and a call is made to the controller. This integrated approach ensures real-time and accurate monitoring, and prioritizes the user's safety through effective, automated actions.

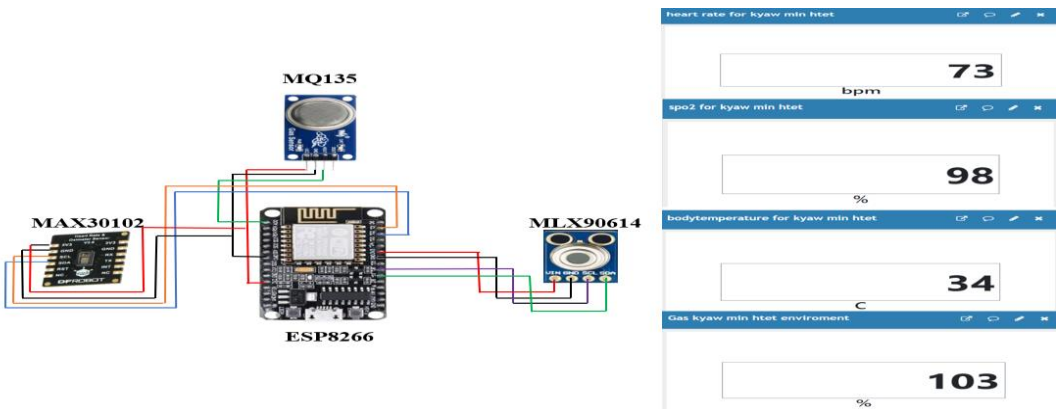

Figure 2: Circuit Diagram of IoT Health Monitoring System

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The system starts by checking whether the Wi-Fi is turned on. It uses a MLX90614 sensor to measure the user's body temperature and also uses a MAX30102 sensor to measure heart rate and oxygen levels. A MQ135 sensor is used to detect harmful gases in the surrounding environment. All the collected data is displayed on the ThingSpeak cloud platform, enabling remote monitoring. This process uses IoT technology to provide real-time health information, enhancing both safety and convenience for the user.

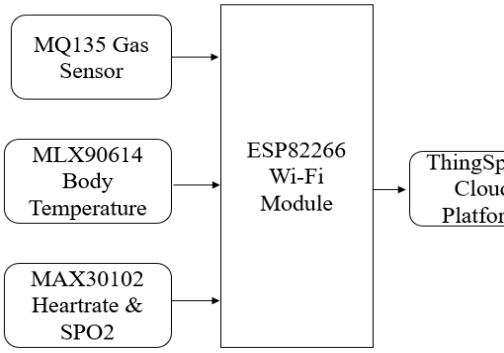

Figure 3: Block Diagram of Smart Safety and Alert System

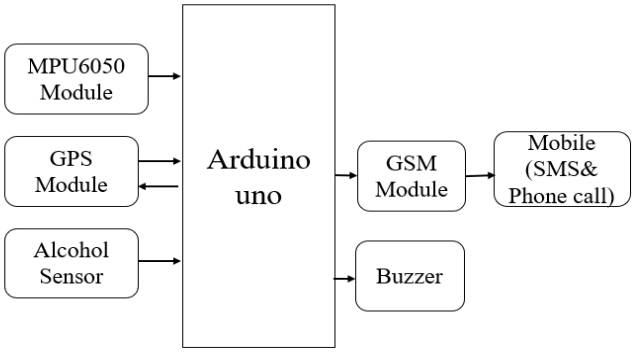

Figure 4: Block Diagram of IOT Health Monitoring System

Figure 3 illustrates the block diagram of the Smart Safety and Alert System. In this system, GPS module, Alcohol sensor and MPU6050 are input devices and GSM module and Buzzer are output devices.

Figure 4 illustrates the block diagram of the IOI-based healthy monitoring system. In this system Gas sensor, MAX30102(heartrate & spo2) sensor and MLX90614(body temperature) sensor are input devices, and ThingSpeak cloud is output platform.

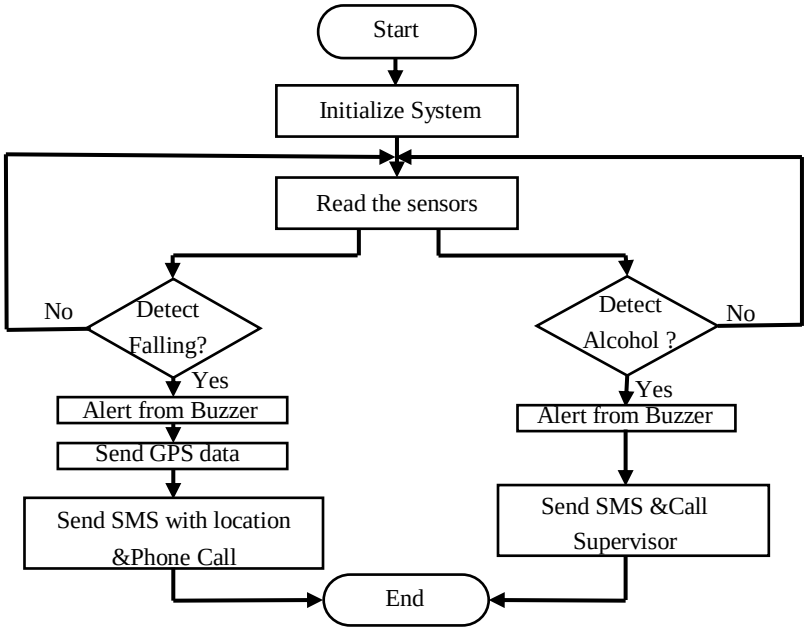

Figure 5: Flow Chart for Smart Safety and Alert System

The process begins with the start of the system. Once activated, the first step is system initialization, during which all components and sensors are set up and made ready for operation. After initialization, the system proceeds to read the sensors by gathering input data from the fall detection sensors and the alcohol detection sensor. The system then checks whether a fall has been detected. If a fall is detected, the system immediately retrieves the GPS data of the

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user's location. Using this location data, it then sends an SMS message containing the exact position of the individual to the designated contact. Once the message has been sent, the process moves to the end state. If no fall is detected, the system continues to the second decision point: alcohol detection. If alcohol is not detected, the system simply concludes the process and ends. However, if alcohol is detected, the system initiates an SMS alert and simultaneously makes a phone call to the supervisor in order to notify them of the situation. After the communication is complete, the system moves to the end state. The flow of the system ensures that falls trigger a location-based SMS alert, alcohol detection triggers both an SMS and a phone call, and normal conditions allow the process to end without unnecessary alerts.

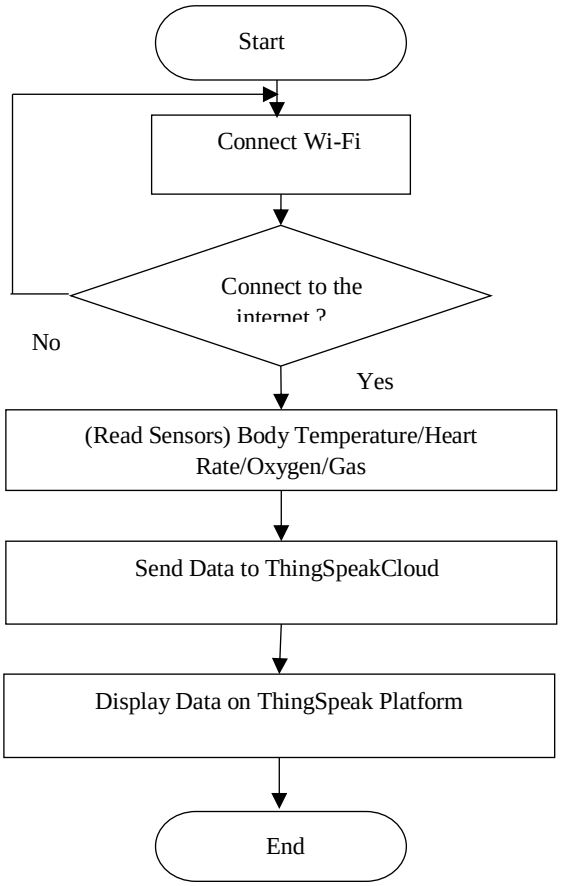

Figure 6: Flow Chart for IoT Health Monitoring System

When the system starts, it first establishes a Wi-Fi connection. After connecting to Wi-Fi, it checks whether the internet connection is successful. If the system fails to connect to the internet, it will continuously retry connecting to Wi-Fi until a successful internet connection is established. Once the internet connection is successful, the system will read data from various sensors. This system includes body temperature, heart rate, oxygen level, and gas-related information. The collected data is then sent to the ThingSpeak Cloud. After that, the users can easily view the information on the ThingSpeak Platform. Finally, the system completes all tasks and reaches the End stage, remaining in a state where it can be restarted again.

RESULTS

This system integrates Arduino with ESP8266, MPU6050, MQ3 alcohol sensor, GPS module, GSM module, MQ135 gas sensor, MAX30102 (heart rate and oxygen), and MLX90619 body temperature sensor, connected to the ThingSpeak Cloud Platform. It can

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monitor the user's health and environmental data while controllers can easily access the information through the cloud. The sensors measure heart rate, oxygen level, body temperature, gas levels, alcohol consumption, and then detect accidents while the GPS provides location, and the GSM module enables SMS alerts and phone calls. Although the system performs well, it sometimes faces network delays, higher-than-expected power consumption from ESP8266 and GSM, and minor electromagnetic interference during SMS transmission, which was improved by adjusting component placement.

Figure 3: Implementation of this system

CONCLUSION

The developed Smart Helmet system successfully integrates sensors and communication modules to enhance the user safety and health monitoring. In the event of an accident, the helmet immediately triggers an alarm and sends the user's location via SMS. Additionally, it can detect alcohol consumption, and in such cases, the system activates an alarm and makes an emergency phone call. The system also continuously measures body temperature, heart rate, oxygen level, and environmental gases through sensors and transmits the data to the cloud for real-time monitoring. Overall, this project presents a reliable IoT-based solution for rapid emergency response, health monitoring, and improved safety after accidents, making it a valuable contribution to personal safety systems.

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