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## Smart Helmet for Construction Workers

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### Abstract

Construction sites are risky, with dangers like falling objects, harmful gases and extreme weather. To improve safety, a smart helmet using IoT technology has been developed. It includes a DHT11 sensor for temperature and humidity, an MQ sensor for gas detection, an IR sensor for nearby obstacles, and GPS for location tracking all connected to an ESP32. The system monitors the worker's surroundings in real time and can detect falls with about 96% accuracy. If an issue occurs it immediately triggers a buzzer and sends an SMS alert to the compounder or boss and family so that help can arrive quickly and get immediate help. GSM support ensures alerts can still be sent even in low network areas. Overall, it's a practical and cost-effective solution that helps improve worker safety on construction sites.

**Keywords.** Smart helmet, Construction safety, worker protection, DHT Sensor, MQ135 gas sensor, IR sensor, GPS tracking, GSM alert system, IOT.

### 1. INTRODUCTION

Construction work is one of the most dangerous jobs, with many accidents happening every year. Falls into harmful gases and exposure to extreme weather conditions are common risks, particularly in remote and industrial locations where supervision is limited. Normal helmets only provide protection against physical impact and have no time-protection effect. To improve this a smart helmet system uses GSM, GPS, and Sensors to monitor conditions and detect hazards like falls or gas leaks. It can quickly send alerts and help workers communicate during an emergency. The idea is to provide a simple, low-cost solution that improves security on doing work on-site. It does not work all the time; it depends, but it works all the time it provides better protection than the normal helmets that are used during work.

## 2. LITERATURE REVIEW

Many researches have looked into smart helmets that use IoT to improve safety on construction sites for examples S. Fang [1] developed a system based on RFID to track worker on site. While it helps with location tracking it does not include feature to monitor environmental conditions like gas level or temperature. J. Teizer [2] studied wearable sensors that can track human activities but their system did not include GSM emergency communication technology. Li et al. [3] conducted research on environmental monitoring through gas humidity and temperature sensors which they used to track location data through GPS and their proposed solution uses a helmet as their monitoring device. The construction site developed by Kim et al. includes a one way alarm service that operates through partial GPS but the system lacks emergency connection functions.

Table 1. Comparative Analysis of Existing Systems and Proposed Approach

| Feature/<br>Aspect            | Teizer (2015) | Fang et al.<br>(2016) | Li et al.<br>(2019) | Kim et al.<br>(2020) | Proposed<br>System |
|-------------------------------|---------------|-----------------------|---------------------|----------------------|--------------------|
| <b>Target Application</b>     | Construction  | Construction          | Industrial          | Construction         | Construction       |
| <b>Fall Detection</b>         | Partial       | No                    | Yes                 | Yes                  | Yes                |
| <b>Gas Sensor (MQ Series)</b> | No            | No                    | Yes                 | Yes                  | Yes                |
| <b>Temperature (DHT)</b>      | YES           | No                    | Yes                 | Yes                  | Yes                |
| <b>GPS Tracking</b>           | Partial       | No                    | No                  | Yes                  | Yes                |
| <b>GSM Alert</b>              | No            | No                    | No                  | Partial              | Yes                |
| <b>SOS Button</b>             | No            | No                    | No                  | No                   | Yes                |
| <b>Real-time Monitoring</b>   | Yes           | Partial               | Yes                 | Yes                  | Yes                |
| <b>Communication Type</b>     | Wearable      | RFID                  | IoT-Based           | IoT-Based            | GSM + GPS + IoT    |
| <b>Emergency Response</b>     | No            | No                    | Limited             | Limited              | Fully Implemented  |
| <b>Implementation</b>         | Field Test    | Prototype             | Prototype           | Prototype            | Working Model      |

The comparative analysis demonstrates that the construction sites between the two systems, which use GPS and GSM technology, show better performance because the latter system offers superior remote area coverage and multiple alert systems and operational capabilities that function without special facilities. The proposed system, which uses GSM and GPS technology, reaches its optimal performance through the equal distribution of operational capabilities, system reliability and cost effectiveness and its suitability for various

construction sites.

### 3. SYSTEM ARCHITECTURE

The smart helmet system consists of three main blocks: a wearable unit, a communication network, and a monitoring cloud platform. The wearable unit comprises DHT11, MQ-series, GPS, and IR sensors along with an ESP32 microcontroller as its core component.

### 4. HARDWARE DESIGN

The ESP32 integrates Wi-Fi, Bluetooth, and multiple GPIO pins, supporting diverse sensors. Accelerometer, gyroscope, DHT11, MQ-series, and GPS modules communicate through I2C, digital, analog, and UART interfaces efficiently.

### 5. CONSTRUCTION DIAGRAM AND WORKING

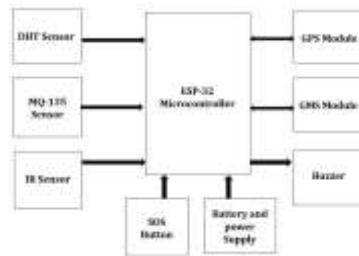


Figure 2.1. Construction Diagram

Smart helmet system based on ESP32 microcontroller which consists of multiple sensors and modules.

### 6. RESULTS AND DISCUSSION

This intelligent helmet managed to attain a fall detection accuracy rate of 96%. It also transmitted emergency text message notifications using the GSM network that incorporated GPS technology for pinpointing accurate locations of victims.

Table 2. ON Emergency Alert System Performance (Based on SMS Output)

| Parameter            | Observation Output         | Result                 |
|----------------------|----------------------------|------------------------|
| Alert Message Status | “Alert!!! I Am In Trouble” | Successfully Generated |
| GPS Coordinates      | 19.883890, 75.319854       | Accurate Location Data |
| Google Maps Link     | Included in SMS            | Easy Navigation        |
| GSM Transmission     | Message Delivered          | Successful             |
| Response Time        | Approx 400–500 ms          | Acceptable             |

|                            |                    |                         |
|----------------------------|--------------------|-------------------------|
| <b>SOS Button Function</b> | Triggered Alert    | Working Properly        |
| <b>Message Clarity</b>     | Clear and Readable | Effective Communication |
| <b>Real-Time Tracking</b>  | Enabled via Link   | Successful              |

## 7. CONCLUSION

The authors introduce a smart helmet in the context of Internet of Thing (IoT) to enhance the safety of construction workers. The helmet incorporates a built-in sensor which the helmet directly monitors environmental risk and tracks the worker location. If something unusual is detected, the alerts are sent to the corresponding person via GPS location and thus help can reach even in the area in which a weak network coverage is provided. The simple test allowed the system to determine that there was an incident and respond rapidly with only a few false alarms. The concept is a good basis for more efficient safety equipment. IT could be improved in the future with further features such as helmet removable alert sensor and send SMS location to corresponding people.

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