

# Smart Helmet for Air Quality and Hazardous Gas Detection

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**Abstract:** A smart helmet has been developed that is able to detect of hazardous events in the mines industry. In the development of helmet, we have considered the three main types of hazard such as air quality, helmet removal, and collision (miners are struck by an object). The first is the concentration level of the hazardous gases such as CO, SO<sub>2</sub>, NO<sub>2</sub>, and particulate matter. The second hazardous event was classified as a miner removing the mining helmet off their head. An IR sensor was developed unsuccessfully but an off-the shelf IR sensor was then used to successfully determine when the helmet is on the miner's head. The third hazardous event is defined as an event where miners are struck by an object against the head with a force exceeding a value of 1000 on the HIC (Head Injury Criteria). An accelerometer was used to measure the acceleration of the head and the HIC was calculated in software. The layout of the visualisation software was completed, however the implementation was unsuccessful. Tests were successfully done to calibrate the accelerometer. PCB's that were designed and made included a breakout board and a prototype board. A whole software implementation was done based on Contiki operating system in order to do the control of the measuring of sensors and of calculations done with the measured values. This paper presents the undertaken design detailing solutions to issues raised in previous research.

**Keywords:** Arduino, IR sensor, gas sensor.

## I. INTRODUCTION

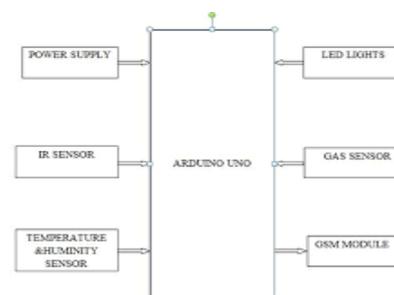
In the mining industry, workers face numerous occupational hazards, including exposure to poor air quality, toxic gases, and potentially life-threatening conditions such as cave-ins or sudden equipment malfunctions. These hazards not only pose a direct risk to workers' health and safety but also have far-reaching implications on productivity and operational costs. The importance of real-time monitoring and rapid response to hazardous events has, therefore, become a focal point in advancing mine safety. Additionally, by integrating smart

technology with cloud-based data analysis, the helmet enables safety supervisors to monitor conditions remotely, offering real-time insights and data logging that can improve safety protocols. This smart helmet solution has the potential not only to mitigate risks but also to improve emergency response times and foster a culture of proactive safety in the mining industry

## II. METHODOLOGY

- Unit (MCU): ESP32 was selected for its integrated Wi-Fi/Bluetooth capabilities and low power consumption.
- Gas Sensors: MQ-2 and MQ-7 were used for flammable gases and CO detection. BME680 and CCS811 were employed for monitoring VOCs and CO<sub>2</sub> levels.
- Environmental Sensors: The BME280 sensor was used for temperature and humidity. PMS5003 was integrated to monitor PM2.5 and PM10 levels.
- Power Supply: A 3.7V Li-ion battery with a boost converter was used to ensure stable voltage. Battery management included overcharge/discharge protection.
- Communication Modules: Bluetooth and Wi-Fi were used for local and cloud-based communication, respectively.
- User Interface: An OLED display and buzzer were incorporated for real-time feedback.

## III. MODELING AND ANALYSIS



#### IV. RESULTS



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#### IV. CONCLUSION

In conclusion, smart helmets equipped with air quality and hazard detection technologies represent a significant advancement in the mining industry, offering transformative potential for worker safety, operational efficiency, and environmental compliance. These helmets enhance real-time monitoring of toxic gases, structural hazards, and worker health, allowing for prompt responses to critical risks and improving overall safety in a challenging work environment. As technology evolves, future iterations of smart helmets will integrate advanced AI for predictive hazard detection, augmented reality for navigation and task guidance, and broader IoT connectivity for seamless coordination with other smart systems.

#### V. REFERENCES

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