Mine Safe: IOT Based Smart Helmet for Mining Workers

Praneel Kumar Peruru[1, a)], Yashaswini Jawalkar[2, b)], Pavan Peddinti[3, c)], Tufel Basha Mogal[4, d)], Divya Pommala[5, e)]

Author Affiliations
[1, 2, 3, 4, 5] *Srinivasa Ramanujan Institute of Technology Anantapur, Andhra Pradesh, 515001, India*

Author Email
[a)] Corresponding author: praneel.cse@srit.ac.in
[b)]204g1a05c5@srit.ac.in
[c)]204g1a0571@srit.ac.in
[d)]204g1a05b3@srit.ac.in
[e)]194g1a0528@srit.ac.in

Abstract Mining is recognized as one of the most hazardous occupations globally. The death rate of mining workers at mining sites is increasing day by day. Considering this, we cannot simply avoid mining because it plays a vital role. Instead, an alternative solution is to implement safety measures and continue operations in mines. To ensure the well-being of workers and protect them from potential health hazards, we propose a smart and adaptable helmet for workers. This advanced helmet incorporates a range of specialized sensors to monitor both environmental conditions and workers health. Environmental monitoring is facilitated by Gas sensor, Temperature and Humidity sensor, ensuring that workers are protected from hazardous conditions. Simultaneously, the helmet employs Accelerometer and Gyroscope sensors, IR sensor, Heart Rate sensor to monitor worker's conditions. Furthermore, an integrated emergency button enables miners to request help swiftly, triggering alerts that pinpoint their exact location. Instead of relying on traditional loud alarms, the helmet communicates crucial information to the miner through a voice interface, offering real- time updates and guidance during emergency situations. The developed helmet system is primarily intended to improve the working environment in mines and ensure worker safety

Keywords: Smart Helmet, Accelerometer and Gyroscopesensor, Voice interface module

INTRODUCTION

In the contemporary landscape of industrial innovation and technological advancement, the integration of smart solutions has become increasingly pivotal across various sectors. One such domain that has witnessed transformative developments is the mining industry, a cornerstone of economic prosperity for nations worldwide. This paper delves into the critical intersection of technology and mining safety, addressing the multifaceted challenges faced by miners and proposing an innovative approach to enhance their well-being and security. Mining is indispensable for the economy of every country, providing numerous opportunities across various industries. The benefits generated by this industry contribute significantly to local communities by processing the materials it offers. However, working in mining poses specific health and safety risks, especially in challenging or unpredictable conditions. The mining industry is complex, involving intricate operations conducted within tunnels, underground passages, and other challenging environments. The intricate nature of mining operations presents a variety of risk variables that may compromise the well-being and security of miners. The Chasnala mining tragedy in the Indian state of Jharkhand, close to Dhanbad, is a heartbreaking example. Almost 372 miners' lives were almost lost in this tragedy, which is regarded as one of the deadliest in the history of the mining industry.

Miners frequently encounter unnoticed environmental factors such as changes in pressure and temperature. The lives of excavators are in grave danger when they crash with big things like hard rocks or mining equipment. The inhalation of dangerous gases poses a substantial risk of injury to miners and is considered a severe threat. Miners are cut off from outside communication under such circumstances.Recognizing the need for proactive safety measures, this paper explores the development of a smart protective helmet system designed to detect and respond to hazardous events in real-time. Beyond event detection, the system encompasses environmental monitoring, GPS tracking, and the provision of

oxygen enhancements to mitigate risks associated with toxic gases. The proposed system not only addresses the immediate safety concerns but also serves as a forward-looking initiative to ensure the well-being of minersin the evolving landscape of the mining industry.

Moreover, considering the rising prominence of the mining sector in certain regions, such as Pakistan with its substantial coal reserves, the paper discusses the challenges faced in making sure that miners are safe. The convergence of technological solutions, such as microcontroller-based monitoring systems and the Internet of Things (IoT), presents as a pivotal strategy to overcome these challenges and fortify the safety infrastructure within the mining industry.

In navigating this discourse, the aim is to contribute to the ongoing dialogue on mining safety by presenting an integrated and forward-thinking approach. By leveraging cutting-edge technologies and innovative solutions, we strive to redefine the safety paradigm for miners, fostering a safer, more secure environment for those working at the heart of economic prosperity.

LITERATURE SURVEY

a. T. Sowmya, G. SrinivasaRao, Ch. Sruthi, I. Tanuja, I. Bhavya, M. Sindhu Priya proposed A system which uses a variety of sensors to monitor workplaces. It incorporates the DHT11 sensor for environmental temperature and humidity monitoring and the MQ2 sensor for recognizing dangerous substances. The Smart helmet is equipped with a WiFi module for Internet of Things connectivity, a GPS location tracker, and a GSM modem for delivering emergency SMS messages. This system is particularly used for detecting safety at workplaces but not for the workers.

b. Jeya Seelan S, Krittika J, Cerene Eunice Getsiah C, Arunachalam B introduces an Intelligent Helmet system equipped with various sensors and utilizing Zigbee protocol for real-time monitoring of hazardous conditions. The proposed system integrates multiple sensors, including temperature, methane gas, and heart rate, with a Zigbee mesh network ensuring reliable data transmission for timely alerting and emergency response.GAO junyao,

c. GAO xueshan, ZHU wei, ZHUjianguo,WEI boyu proposed a wearable IoT-enabled jacket specifically crafted to safeguard individuals employed in coal mines, often subjected to potential hazards. This prototype is engineered to detect multiple factors such as harmful chemicals, the heartbeat of a coal miner, underground conditions, and the miner's GPS location. The collected data is intended to be transmitted accessing an ever-changing internet protocol using an encrypted Wi-Fi channel.

PROPOSED SYSTEM

We have developed an advanced protective helmet embedded with a sophisticated array of sensors designed for comprehensive detection and analysis. The primary sensor categories include environmental sensors and sensors for monitoring the condition of workers. Within the environmental sensor suite, we employed a gas sensor to detect hazardous gases, along with temperature and humidity sensors to detect abnormal fluctuations in temperature and humidity. Additionally, for monitoring the worker’s condition, we've integrated sensors such as a pulse sensor for tracking the worker's heart rate, an infrared sensor to ensure continuous helmet usage, and a MEMS sensor for detecting sudden falls.

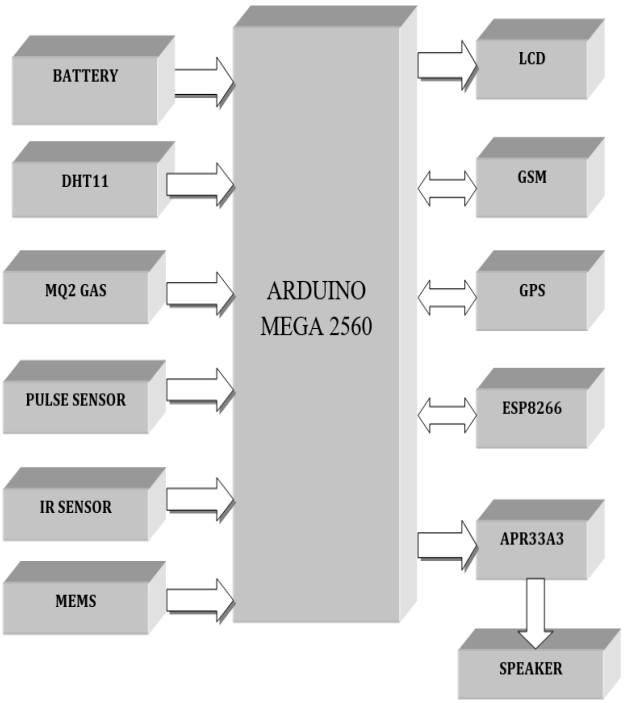

FIGURE 1: Block Diagram

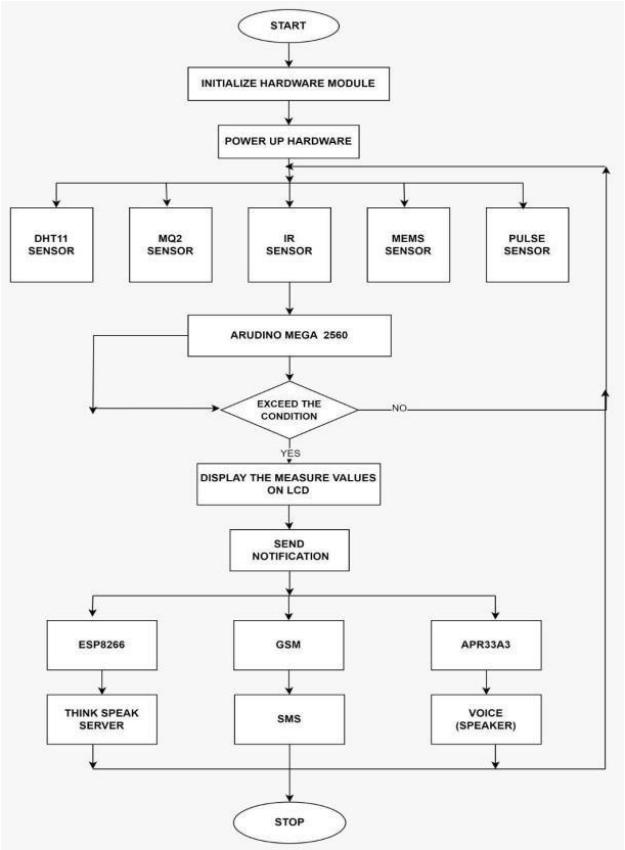

FIGURE 2: Flow Chart

These sensors consistently monitor both environmental conditions and the well-being of workers. When abnormal conditions arise, and the tracked values exceed predefined thresholds, the system triggers a sound alert. Unlike traditional buzzers, we employ an APR33A3 voice module which provides a sound alert that specifies the exact cause. Along with the localized alerts, the system sends alert messages to registered mobile numbers, including GPS location details facilitated by GSM and GPS modules. To ensure data retention for future references and predictive analyses, a WiFi module is utilized to store information on ThingSpeak. This

a comprehensive system signifies a cutting-edge solution that enhances workplace safety through real-time monitoring, accurate alerts, and data-driven insights.

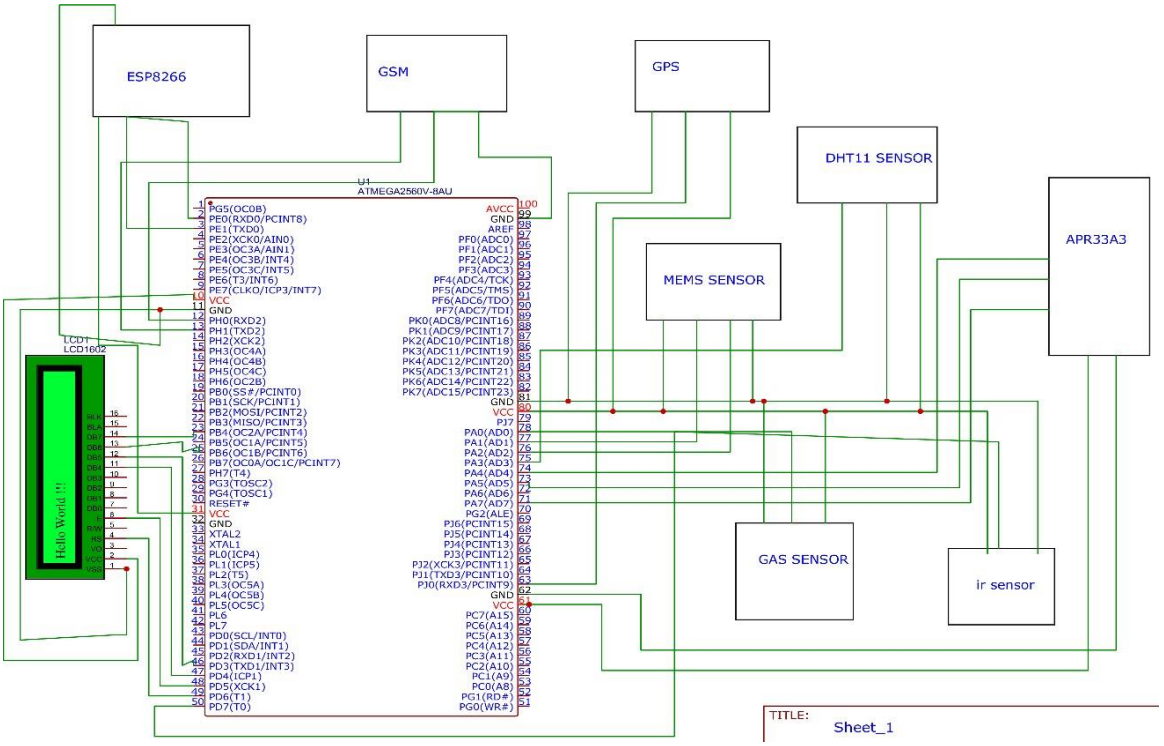

FIGURE 3: Circuit Diagram

HARDWARE AND DESCRIPTION

A. ARDUINO MEGA 2560:

The Arduino Mega 2560, a powerful microcontroller board, is utilized in our project because of its adaptability. It effectively manages a variety of sensors that are essential to mining safety. It allows for a wide range of sensor inputs and has 54 digital and 16 analog I/O connections, which ensures environmental and health monitoring in deep mines. It can store and process data from several sensors with its 256 KB flash memory. Multiple UART ports on the Mega 2560 allow for multi-mode connection, which makes it easier to integrate different communication protocols into our smart helmet system. It is the best option for our project's complex sensor integration and communication requirements due to its adaptability and broad capabilities.

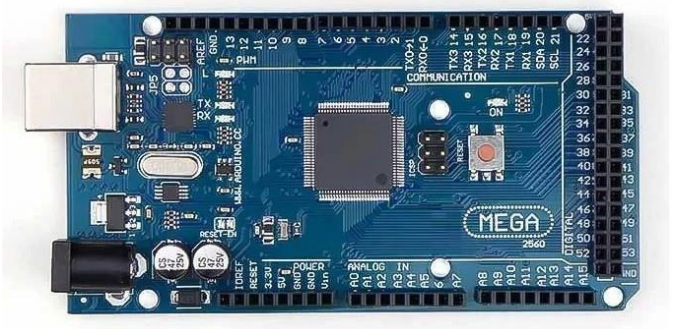

FIGURE 4: Arduino Mega 2560 Board

B. MQ-2 SENSOR

The MQ-2 gas sensor is used because of its reputation for being highly versatile in detecting a wide range of gases, such as hydrogen, butane, propane, methane, alcohol, and smoke. When our smart helmet system is integrated with it, real- time monitoring of underground mining environments is made possible. This improves safety measures by quickly identifying harmful gasses and notifying personnel.

FIGURE 5: MQ-2 Sensor

The MQ-2 sensor's smooth integration with our microcontroller makes it possible to detect gases effectively and reliably, which is essential for protecting the health and safety of mine worker.

C. DHT11 SENSOR

FIGURE 6: DHT11 Sensor

The DHT11 Sensor uses a thermistor and a humidity-sensing element to measure temperature and humidity. The resistance of the humidity-sensing element fluctuates with humidity levels, whereas the resistance of the thermistor changes with temperature. By measuring these resistances and converting them into digital impulses, the sensor gives precise temperature and humidity readings that can be monitored in real time.

D. IR SENSOR

FIGURE 7: IR Sensor

Infrared sensor is a crucial part of the helmet usage verification system in underground mining since it both generates and absorbs infrared light. It enhances safety procedures by confirming workers are wearing helmets through the analysis of reflected signals. The use of the IR sensor improves adherence to safety guidelines and makes a substantial positive impact on the general health and safety of mining workers.

E. HEART RATE SENSOR:

The heart rate sensor, which uses photoplethysmography, is essential to our underground mining project's ongoing health monitoring. With its real-time heart rate data provided by an integrated system, we can better prioritize worker well-being and respond quickly to possible health risks. The use of heart rate sensors makes the workplace safer and greatly improves the general health and safety of mining workers.

FIGURE 8: Heart Rate Sensor

F. MEMS SENSOR:

FIGURE 9: MEMS Sensor

Fall detection systems rely heavily on MEMS sensors, especially accelerometers. These tiny sensors, which are incorporated into our System, detect acceleration variations,making it possible to recognize sudden, unusual movements that could be signs of a fall. Through the use of MEMS sensors, our system improves underground mining safety by quickly identifying and addressing possible fall occurrences,hence promoting the general well-being of mining workers.

G. ESP8266 MODULE

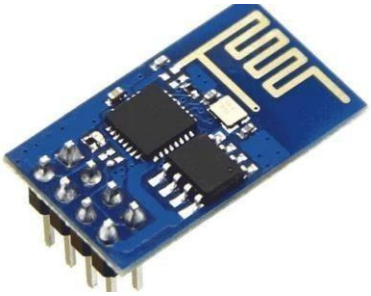

FIGURE 10: ESP8266 Wifi Module

ESP8266 Wifi Module has inbuilt TCP/IP protocol stack, the self-contained System-on-Chip (SOC) ESP8266 WiFi Module makes it simple for any microcontroller to connect to WiFi networks. Due to its versatility, it can either run a program on its own behalf or assign WiFi networking responsibilities to a separate application processor. The ESP8266 module has pre- programmed software with an AT command set that makes it easy to connect to Arduino devices and offers WiFi functionality similar to that of a WiFi shield. In the field of Internet of Things (also known as IoT) development, it is a well- liked and accessible option due to its affordability and broad community support. This module is widely used in many different projects and applications because of its cost, versatility, and vast user base.

H. GSM MODULE

A GSM modem is a device that operates using a SIM card, similar to those found in mobile phones. It is designed to connect to a mobile operator's network, enabling communication via that network. When integrated into a system, such as the smart helmet, the GSM modem serves as a means of communication. The smart helmet controller can use the GSM modem to send and receive messages, including SMS and MMS. This functionality allows the smart helmet system to transmit alerts, notifications, or other information using the mobile network, enhancing its communication capabilities

FIGURE 11: GSM Module

I. GPS MODULE

FIGURE 12: GPS Module

A GPS module is a specialized device that integrates with electronic systems to provide accurate location information based on signals from GPS satellites. It includes a GPS receiver to determine precise geographical coordinates. In the smart helmet system, this module is crucial for real-time tracking, emergency response coordination, and overall site management, enhancing safety in large or complex mining environments.

J. APR33A3 MODULE

The APR33A3 is a voice recording and playback integrated circuit module. It is designed to record and reproduce audio messages or sounds. In the context of the smart helmet system, it is utilized to provide specific alerts in response to detected events. Unlike traditional alert systems with generic buzzers, this module allows the system to articulate precise information about the nature of the alert, it enhances communication and awareness for the miners. It brings a more sophisticated and informative aspect to the alerting system, contributing to improved safety in mining operations

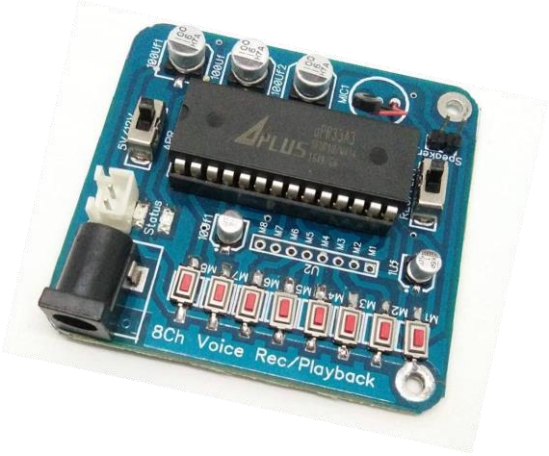

FIGURE 13: Voice Playback Module

PARAMETERS	UNIT	THRESHOLD
Gas Concentration	PPM	2000-5000
Temperature	^{0}C	40
Humidity	%	60
IR	analog	HIGH - LOW
Heart Rate	BPM	100
MEMS	g	1.5 - 2.5

TABLE 1: Threshold values for Various Sensor

CONCLUSION

In conclusion, the integration of IoT-based smart helmets in the mining industry marks a significant advancement in ensuring the safety and well-being of miners. The existing system, relying on traditional helmets, demonstrates certain limitations, particularly in maintaining environmental awareness, fall detection, and specifying the exact cause during alerts. The proposed smart helmet system addresses these gaps by integrating various sensors, including a gas sensor and temperature/humidity sensor for environmental monitoring, ensuring protection against hazardous conditions. Additionally, the helmet utilizes MEMS sensors, an IR sensor, and a heart rate sensor to monitor workers' conditions. Moreover, the system is enhanced by an efficient alerting system, incorporating a voice interface module (APR33A3) and robust communication system by GSM and GPS modules. To facilitate data retention for future references and predictive analyses, a WiFi module is employed to store information on ThingSpeak. This holistic system represents an advanced solution that elevates workplace safety through real-time monitoring, precise alerts, and insights derived from data analysis. Beyond safety enhancement, this comprehensive solution also contributes to improved communication, emergency response, and overall operational efficiency within mining endeavors.

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