Smart Helmet for Mining Safety

[1]M.Jaya Sankar, [2]N. Premchandu, [3]N. Hemanth, [4]N. Karthik, [5]M. Pavan Kumar, [6]Dr. B. Kiran Kumar

[1,2,3,4,5]U. G Student, Dept ELECTRONICS AND COMMUNICATION ENGINEERING, St.Ann's College of Engineering and Technology (Autonomous), Chirala, Bapatla Dist, Andhra Pradesh – 523187, India
[6]Associate Professor, Dept ELECTRONICS AND COMMUNICATION ENGINEERING, St.Ann's College of Engineering and Technology (Autonomous), Chirala, Bapatla Dist, Andhra Pradesh – 523187, India

ABSTRACT

Mining has different dangers because of the dangerous environment characterized by high temperatures, methane gas, carbon dioxide, and other hazardous gases. The regular cases of accidents in mines make it imperative to use modern safety technologies that can shield miners against such hazards. The safety of miners in underground mines needs adequate monitoring and communications. The Smart Helmet is intended to minimize such safety issues by integrating temperature, light, and hazardous gassensor. It has a built-in GSM module that sends SMS notifications to pre-configured numbers in case of emergencies, ensuring timely responses. The Wi-Fi-based monitoring system, which uses a raspberry pi pico w module, retrieves real-time sensor data. provides alert notifications for hazards via an application user interface as well as a buzzer system. The research work described here is an improved safety solution for mine labor because it provides real-time observation of mining conditions, quick solutions during an emergency, alerts. The Smart Helmet improves situation awareness, minimizes the possibility of accidents, providing a pragmatic and trustworthy way of enhancing safety standards in the mining sector. A fan is inserted on helmet for the ventilation purpose.

KEYWORDS:

Smart Helmet; Mining Safety; IOT-Based Monitoring; GSM Module; Raspberry Pi Pico W; Gas Sensor (MQ-2) or Oxygen Sensor; Temperature Sensor (DHT11);Pulse Sensor; Wireless Communication; Emergency Alert System; Hazard Detection; Environment Sensors.

INTRDOCTION

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. 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. As mines expand, the risks associated with completing tasks also increase. 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. 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 eco-nomic prosperity.

RELATED WORK

In underground mining there is a concern about the safety of the workers due to its highly changing environment. Thousands of miners die from mining accidents every year. To save the workers life and to improve safety in mining environment it is important to take some safety measures and to improve communication between workers and control stations to avoid life threatening situations. With the help of the smart helmet, we can provide security and rescue measures in case of any emergency conditions. This project holds broad applicability across diverse mining contexts, encompassing coal, metal, and mineral mining operations globally. Its adaptability extends to both underground and open-pit mining environments, addressing specific safety challenges in each setting. The system's scalability makes it suitable for various scales of mining operations, from small-scale to large industrial endeavors. With a focus on global implementation, the project caters to regional variations in mining practices, safety regulations, and environmental conditions. Overall, the "Mine Safe" system offers a comprehensive safety solution applicable to the varied landscape of mining activities worldwide.

LITERATURE SURVEY

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 Wi-Fi module for Internet of Things connectivity, and a GSM modem for delivering emergency SMS messages. This system is particularly used for detecting safety at workplaces but not for the workers. This paper introduces an Intelligent Helmet system equipped with various sensors and utilizing thinks speak protocol for real-time monitoring of hazardous conditions. The proposed system integrates multiple sensors, including temperature, methane gas, and heart rate, with a thinks speak mesh network ensuring reliable data transmission for timely alerting and emergency response. This System 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 miner, underground conditions. The collected data is intended to be transmitted accessing an ever-changing internet protocol using an encrypted Wi-Fi channel. Hazardous environments at the workplace are a significant contributor to injuries due to accidents as well as chronic diseases. There are many occupational health and safety (OHS) systems, but they are costly or not flexible. This paper presents a low-cost OHS. It consists of various sensors that can be used to monitor whether a safety helmet is being worn, the worker is mobile and safety boots are being worn. The system interfaces with a wireless sensor network and is suitable for operation in environments such as under- ground mines and sawmills. This paper presents implementation of safety helmet for mine workers. This helmet is equipped with methane and carbon monoxide gas sensor. This sensor senses the gas and data is transmitted to the control room wirelessly, through a wireless module called X-Bee connected with the helmet. When the methane or carbon-monoxide gas concentration is beyond the critical level, controller in the control room triggers an alarm and keeps the plant and the workers safe by preventing an upcoming accident.

EXISTING METHOD

In the existing mining system, the conventional helmet functions as a protective measure against potential hazards, ensuring the safety of miners. However, this system has inherent limitations. While the primary purpose of the helmet is to shield the head from injuries, challenges arise in maintaining environmental awareness. The weight and discomfort of the helmet often prompt miners to remove it, subjecting them to unsafe conditions. Additionally, the existing system lacks fall detection capabilities, presenting a potential risk as workers may faint and fall unexpectedly, particularly when exposed to dangerous gases in the mining area. Miners also face the danger of colliding with substantial objects like mining equipment or hard rocks, exposing them to severe life-threatening risks. In such scenarios, a fall detection sensor plays a crucial role, addressing a significant gap in the capabilities of existing helmets. The current alert system relies on a buzzer, which activates in the event of any abnormal condition. However, it lacks specificity regarding the particular condition, making it challenging to discern the reason for the alert. Having a system that specifies the exact cause during alerts would enhance our understanding and enable us to respond more cautiously to the identified cause. Traditional helmets focus primarily on protecting the head but lack sensors for real-time monitoring of environmental conditions. Miners may be unaware of changes in temperature, humidity, or the presence of hazardous gases, exposing them to potential risks. Conventional helmets lack advanced fall detection capabilities, making it challenging to promptly identify and respond to miners who may experience unexpected falls. This limitation poses a significant risk, especially in dynamic and challenging mining environments. The alert systems in traditional helmets typically rely on generic buzzers that activate during abnormal conditions.

PROPOSED METHOD

The innovation at hand represents a groundbreaking development in workplace safety – an advanced protective helmet equipped with a sophisticated array of sensors designed for exhaustive detection and analysis. This pioneering system integrates two primary categories of sensors: environmental sensors for monitoring workplace conditions and sensors dedicated to tracking the well-being of workers. Within the suite of environmental sensors, a gas sensor is employed to detect hazardous gases, while temperature and humidity sensors identify abnormal fluctuations in the work environment. Beyond localized alerts, the system ensures wider communication by sending alert messages to registered mobile numbers, accompanied details facilitated by GSM modules. This integration enhances emergency response capabilities, allowing for timely and accurate intervention in critical situations. To facilitate comprehensive data management, the system incorporates a WiFi module that stores information on Thing Speak. This not only ensures real-time data access but also enables data retention for future references and predictive analyses. In essence, the advanced helmet system emerges as a cutting-edge solution that goes beyond traditional safety measures. It elevates workplace safety through its capabilities for real- time monitoring, precise alerts, and the generation of data-driven insights, marking a significant leap forward in ensuring the well-being of workers in diverse industrial settings. 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. temperatureand humidity sensors to detect abnormal fluctuations in temperature and humidity.

ARCHITECTURE

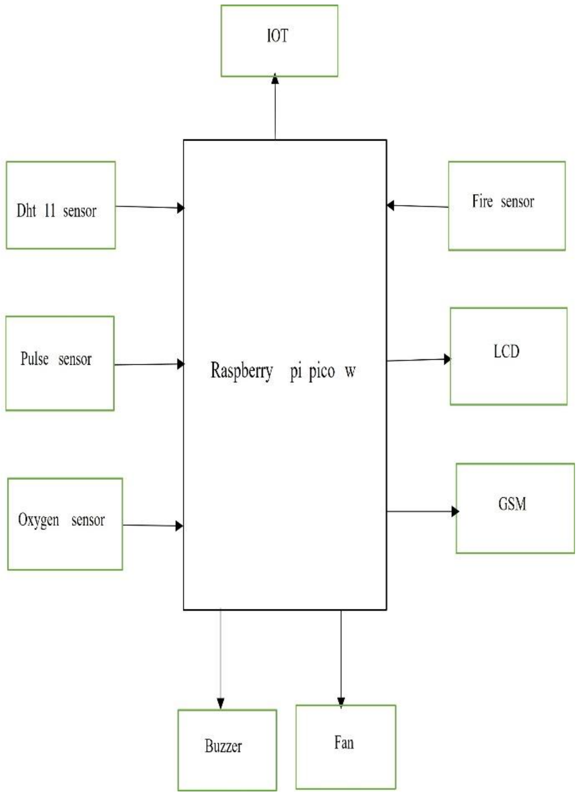

Figure 1: proposed method architecture

METHODOLOGY DESCRIPTION

To implement this project Iterative model is used. It involves continuous cycle of Planning, Analysis, Implementation and Evaluation, Testing, Deployment, Review, etc., Each cycle produces a segment of development that forms the basis for the nextcycle of iterative development. The iterative model is a software development life cycle (SDLC) approach in which initial development work is carried out based on well-stated basic requirements, and successive enhancements are added to this base piece of software through iterations until the final system is built.

HARDWARE AND SOFTWARE REQUIREMENTS

Raspberry Pi Pico W

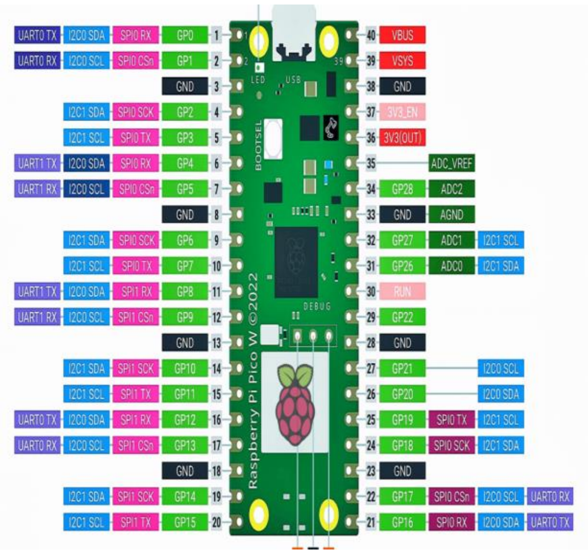

Figure 2.1: Raspberry Pi Pico W

The Raspberry Pi Pico W is a compact and low-cost microcontroller board developed by the Raspberry Pi Foundation. It is based on the RP2040 microcontroller, which features a dual-core ARM Cortex-M0+ processor running at up to 133 MHz. Unlike a full Raspberry Pi computer, the Pico W is designed for embedded and real-time applications, making it ideal for control systems and IoT projects.

DHT11 Sensor

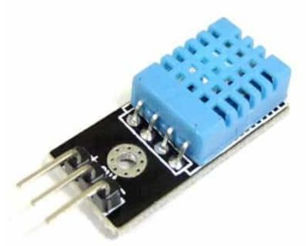

Figure 2.2: DHT11 Sensor

DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.

Pulse Sensor

Figure 2.3: Pulse Sensor

The basic heartbeat sensor consists of a light emitting diode and a detector like a light detecting resistor or a photodiode. The heart beat pulses causes a variation in the flow of blood to different regions of the body. When a tissue is illuminated with the light source, i.e. light emitted by the led, it either reflects (a finger tissue) or transmits the light (earlobe).

Oxygen Sensor

Figure 2.4: Oxygen Sensor

For IoT oxygen monitoring projects, popular and effective sensors include the DFRobot Gravity I2C for ambient monitoring (0–25% Vol) and MAX30100/MAX30102 modules for SpO2 (blood oxygen) health projects.

Buzzer

Figure 2.5: Buzzer

A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

Fan

Figure 2.6: Fan

A **DC fan** is used with the **Raspberry Pi Pico W** as an output device to provide cooling and ventilation in embedded and IoT applications. The Pico W operates at **3.3 V GPIO levels** and cannot directly drive a fan because a DC fan requires **higher voltage (5 V or 12 V) and more current**. Hence, an external **driver circuit such as a relay or transistor** is used between the Pico W and the fan.

Fire Sensor

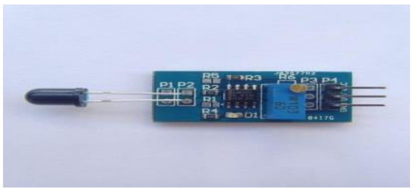

Figure 2.7: Fire Sensor

Flame sensor is the most sensitive to ordinary light that is why its reaction is generally used as flame alarm purposes. This module can detect flame or wavelength in 760 nm to 1100 nm range of light source. Small plate output interface can and singlechip can be directly connected to the microcomputer IO port.

LCD

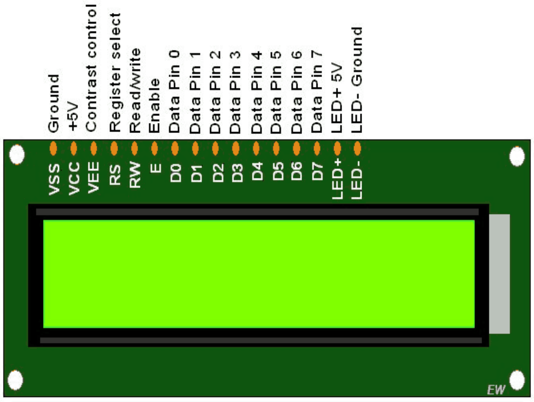

Figure 2.8: LCD

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16×2 LCD display is very basic module and is very commonly used in various devices and circuits.

GSM

Figure 2.9: GSM

GSM is a mobile communication modem; it is stands for global system for mobile communication (GSM). The idea of GSM was developed at Bell Laboratories in 1970. It is widely used mobile communication system in the world. GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands.

Arduino IDE

The Arduino IDE is the software tool used to write, compile, and upload Arduino sketches to an Arduino board. It is a free and open-source software tool that can be downloaded from the Arduino website for Windows, Mac OS X, and Linux operating systems. The Arduino IDE provides a user-friendly interface for creating, editing, and managing Arduino sketches. It includes a text editor with features such as syntax highlighting, auto-indentation, and code completion to make programming easier and faster.

Programming Language

C programming language is a widely used programming language that is often used in embedded systems, including Arduino development. Arduino is an open- source platform that provides hardware and software tools for building and programming microcontroller-based projects. To use C programming language with Arduino, you would typically use the Arduino Integrated Development Environment (IDE), which is a software tool that provides a user-friendly interface for writing, compiling, and uploading C code to Arduino boards.

ThingSpeak

ThingSpeak is an Internet of Things (IoT) platform developed by MathWorks, designed to facilitate the collection, analysis, and visualization of real-time data from various IoT devices. Users can send data to ThingSpeak using protocols such as HTTP or MQTT, and the platform organizes this information into channels. Each channel represents a specific type of data, and users can create multiple channels to categorize and store diverse sets of information.

RESULTS AND DISCUSSION

Figure 3.1: Humidity Sensor Output

DHT11 uses only one wire for communication. The voltage levels with certain time value defines the logic one or logic zero on this pin.The communication process is divided in three steps, first is to send request to DHT11 sensor then sensor will send response pulse and then it starts sending data of total 40 bits to the microcontroller.

Figure 3.2: Temperature Sensor Output

Next two segments contain temperature value in decimal integer form. This value gives us temperature in Celsius form.Last segment is the checksum which holds checksum of first four segments. Here checksum byte is direct addition of humidity and temperature value. And we can verify it, whether it is same as checksum value or not. If it is not equal, then there is some error in the received data. Once data received, DHT11 pin goes in low power consumption mode till next start pulse. After sending 40-bit data, DHT11 sensor sends 54us low level and then goes high. After this DHT11 goes in sleep mode.

Figure 3.3: Heart Rate Sensor Output

Some of the light is absorbed by the blood and the transmitted or the reflected light is received by the light detector. The amount of light absorbed depends on the blood volume in that tissue. The detector output is in form of electrical signal and is proportional to the heart beat rate.

Figure 3.4: Fire Sensor Output

On-board signal output indication, output effective signal is high level, and the same time the indicator light up, output signal can directly connect with microcontroller IO. On-board signal output indication, output effective signal is high level, and the same time the indicator light up, output signal can directly connect with microcontroller IO.

CONCLSUION

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.

FUTURE ENHANCEMENT

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 Wi-Fi 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.

REFERENCES

[1] T. Sowmya, G. Srinivasa Rao, Ch. Sruthi, Tanuja, I. Bhavya, and M. Sindhu Priya, "Smart helmet for mining workers," *Journal of Engineering Sciences*, vol. 14, pp. 0377–9254, 2023.

[2] S. Jeya Seelan, J. Krittika, C. E. G. Cerene Eunice, B. Arunachalam, "IoT based intelligent helmet for miners," *International Journal of Electrical Engineering and Technology*, vol. 12, pp. 123–128, Mar. 2021.

[3] J. Gao, X. Gao, W. Zhu, J. Zhu, and B. Wei, "Coal mine detect and rescue robot design and research," in *Proc. IEEE*, 2008.

[4] J. C. Wang, Y. T. Lin, H. T. Jheng, J. S. Wu, and R. J. Li, "Object tracking for autonomous biped robot," in *Proc. IEEE*, 2010.

[5] S. Manikandan, G. A. Francis Mithya, C. Kamal, S. Dhilip Kumar, R. Hariprasath, and P. Sankar, "A smart helmet for air quality and hazardous event detection for the mining industry," *International Journal of Innovative Technology and Exploring Engineering*, vol. 8, Oct. 2019.

[6] S. P. Borkar and V. B. Baru, "IoT based smart helmet for underground mines," *International Journal of Research in Engineering, Science and Management*, vol. 1, Sep. 2018.

[7] A. P. Squelch, "Virtual reality for mine safety training in South Africa," *Journal of the South African Institute of Mining and Metallurgy*, pp. 209–216, Jul. 2001.

[8] X. B. Jiang, "ZigBee technology and its applications," *Low-Voltage Apparatus*, 2005.

[9] Z. J. Tian, "Digital mobile voice communication encode and voice communication design," *China Coal*, 2007.

[10] H. M. Zhu and L. Zhang, "Design of warp tension embedded intelligent control system based on μC/OS and ARM," *Mechanical & Electrical Engineering Magazine*, 2006.

[11] X. Zhang, X. J. Qiao, and E. Liu, "Design of high precision instrument for measuring temperature, humidity and dew point," *Instrument Technique and Sensor*, 2006.

[12] L. Ma and H. Guo, "Smart sensor for underground coal mine based on ZigBee protocol," *Instrument Technique and Sensor*, 2007.

[13] "Implementation of smart safety helmet for coal mine workers," in *Proc. IEEE Int. Conf. Power Electronics, Intelligent Control and Energy Systems (ICPEICES)*, Jorhat, India.

[14] J. G. Vargas Hernández and M. D. L. R. Plascencia, "Application of the industry-based theory: The case of Mexican company Cemex," *Management & Administration*, vol. 1, no. 2, pp. 31–44, 2017.

[15] S. Gupta and R. Vashisth, "Implementation and analysis of smart helmet," in *Proc. IEEE Int. Conf. Signal Processing, Computing and Control (ISPCC)*, Solan, India, Sep. 2017.

[16] W. Y. Chang and P. C. Chang, "Application of radial basis function neural network to estimate the state of health for LFP battery," *International Journal of Electrical and Electronics Engineering*, vol. 7, no. 1, pp. 1–6, 2018.

[17] R. Kulkarni and S. Sangam, "Smart system for hazardous event detection and evaluation in mining industries," *International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering*, vol. 5, no. 3, 2017.

[18] S. Sharma and G. Kumar, "A dual wideband stair shape microstrip patch antenna for C & X band," *International Journal of Electronics and Communication Engineering*, vol. 5, no. 4, pp. 1–8, 2016.

[19] S. Li, L. D. Xu, and S. Zhao, "The Internet of Things: A survey," *Information Systems Frontiers*, vol. 17, no. 2, pp. 243–259, Apr. 2015.

[20] M. A. Razzaque, M. Milojevic-Jevric, A. Palade, and S. Clarke, "Middleware for Internet of Things: A survey," *IEEE Internet of Things Journal*, vol. 3, no. 1, pp. 70–95, Feb. 2016.

[21] N. A. Pantazis, S. A. Nikolidakis, and D. D. Vergados, "Energy-efficient routing protocols in wireless sensor networks: A survey," *IEEE Communications Surveys & Tutorials*, vol. 15, no. 2, pp. 551–591, 2013.

[22] H. Karl and A. Willig, *Protocols and Architectures for Wireless Sensor Networks*. Wiley, 2005.

[23] D. Kumar, T. C. Aseri, and R. B. Patel, "EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks," *Computer Communications*, vol. 32, no. 4, pp. 662–667, 2009.

[24] J. Gutierrez, J. F. Villa-Medina, A. Nieto-Garibay, and M. A. Porta-Gandara, "Automated irrigation system using a wireless sensor network and GPRS module," *IEEE Transactions on Instrumentation and Measurement*, vol. 63, no. 1, pp. 166–176, Jan. 2014.

[25] A. Kumar and G. P. Hancke, "Energy-efficient environment monitoring system based on IEEE 802.15.4 standard," *IEEE Sensors Journal*, vol. 14, no. 8, pp. 2557–2566, Aug. 2014.