IoT and AI based Smart Helmet for Miners

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Abstract*— Smart helmets have been increasingly adopted in mining operations as a means of providing miners with a safer working environment. The smart helmet for miners is a device that incorporates various technologies that enable miners to receive real-time information about their working conditions, their location, and the state of the mine. Our aim is to explore the various technologies that are currently being used in smart helmets and their effectiveness in enhancing the safety of miners in the mining industry. This project focuses on a mine monitoring system based on the low-cost Wi-Fi protocol. Our project intends to create wireless sensor network, implement real-time surveillance with early- warning intelligence on dangerous gases, temperature, humidity, blood pressure, oxygen content in blood and heartbeat in mining areas and employ Wi-Fi communication to eliminate potential safety issues in coal extraction. In addition to that we are going to track the location of workers through GPS. In our project we're incorporating artificial intelligence (AI) in smart helmets for miners that have the potential to greatly improve safety and efficiency in the mining industry. With sensors embedded in the helmet, AI can analyze data to detect hazards such as toxic gases, high temperatures, and falling rocks, alerting the miner through visual or auditory signals. Additionally, AI can monitor the miner's health, detecting signs of fatigue or dehydration, and facilitate real-time communication and collaboration with other miners. Asset tracking and management and predictive maintenance can also be improved with the help of AI, tracking the location of miners and mining equipment in real-time and predicting equipment failure before it occurs. However, it is crucial to ensure that any AI systems used in mining are designed and tested with safety and ethical considerations in mind to prevent potential harm to the miners or the environment.

Keywords— IoT, AI, GPS, GSM, EEG, Wi-Fi.

I. INTRODUCTION

The mining industry is known for its dangerous and challenging work environment, where workers are exposed to numerous hazards, including falling rocks, toxic gases, and high temperatures. In such a scenario, the use of smart helmets can help improve the safety and efficiency of miners.

Our project involves smart helmet for miners using Raspberry Pi with the help of Artificial Intelligence (AI) in addition to IoT. Raspberry Pi is a single-board computer that can be used for various applications, including IoT and AI. The smart helmet proposed in this project aims to incorporate IoT and AI technologies to provide real-time monitoring and alerting of potential hazards, personalized health monitoring, and real-time communication and collaboration. The smart helmet will be equipped with various sensors such as gas detectors, temperature sensors and humidity sensors. These sensors will collect data and transmit it to the Raspberry Pi for analysis. AI algorithms will be used to analyze the data collected by the sensors and detect potential hazards. For example, gas detectors will detect toxic gases, and AI algorithms will analyze the data to determine the level of danger and trigger an alarm or alert the miner through the helmet's display.

Additionally, the smart helmet will also be equipped with sensors to monitor the miner's health, such as heart rate and breathing rate monitors. This information will be analyzed by AI algorithms to detect signs of fatigue or dehydration, which could indicate that the miner needs to take a break or drink water. Real-time communication and collaboration between miners are crucial for the safety and efficiency of mining operations. The smart helmet proposed in this project will be equipped with a microphone and speaker system that allows miners to communicate with each other in real-time. The system will use AI algorithms to filter out background noise and enhance voice recognition, making it easier for miners to hear and understand each other even in noisy or crowded environments. Lastly, the smart helmet will also be equipped with GPS sensors and an accelerometer to track the location of the miner and provide asset tracking and management. This will allow supervisors to monitor productivity and adjust the mining process as needed.

II. LITERATURE SURVEY

B. Priyanka, S.K. Satyanarayana, M. Anjali Sri Teja, CH. Srikanth, and G. Sanjana et al., [1] proposed a new smart and safety system that can provide the environment information such as Panic switch button that is applied to provide supportive methods for the miners in case of emergency situations. The disadvantage of this project was the implementation of hardware that is placed inside the coal mines, when a natural calamity or a roof fall occurred, the system will get damaged. So, the reliability and long life of conventional communication system is poor. Another problem is that the working condition of coal mine is very noisy and if the distance of miner and system is long, miner does not get proper message. The smart helmet's power

consumption was very high, leading to low battery backup of the helmet.

V. Sai Prasanna Kumar, M. Shiva Rama Krishna, and K. Shambavi et al., [2] proposed a System that detects harmful gases, high temperatures, humidity, vibration, obstacles and collisions. It also uses LoRa communication technology and GSM to send and receive information, Arduino to process the information. sensors such as MQ02, DHT11, IR sensor, vibration sensor to get the parameters. The major disadvantage is that it doesn't focus much on miner's health condition and also doesn't detect the working location of the miner.

Rupali Arjun Shejule and V. R. Pawar et al., [3] The paper suggests that by using this helmet, the miner can easily get alert about the harmful gasses leaking out during mining. This system can also alert the miner when helmet is removed while mining in the mining caves. However, the major drawback is that it uses GPRS for the communication since the mining takes place under the earth crust GPRS will not be available and it needs additional investment to facilitate GPRS in mining area.

Shruti P. Borkar and V. B. Baru et al., [4] proposed a smart helmet which is able to detect different types of hazardous gasses as well as detect events such as, humidity condition of mines, then temperature and existence of combustible gases. It was able to detect whether the helmet is worn by the miner or not, and light intensity inside present inside the mines. The major drawback of this project was that the system was not able to detect collision inside the mines, and not able to check the miner's blood pressure. It also didn't have emergency buttons provided in the helmet which is required during bad situations.

P. Hazarika et al., [5] The helmet is fit with MQ3 and MQ4 gas sensor. The gasses are sensed by using these sensors. The Zig-Bee which is connected with the helmet is used to transmit the information to the control room, the microcontroller in the control room initiates an alarm signal when methane and carbon monoxide gas is in critical level. It is very useful technique in mining industries because of its ability, cheap in cost and stable. The cons of this research are that this system does not detect fall of the person and doesn't detect whether the miner wears the helmet or not and no emergency buttons are provided.

Yongping Wu and Guo Feng et al., [6] introduced a system that uses Bluetooth technology is to establish a common low power, low-cost wireless communication protocol and also can be controlled using software opening system. At the same time, the system uses CAN bus technology maturely, has realized the combination of wired and wireless data transmission system. The major drawback of this system was that the Bluetooth is short distance wireless technology and use of cabling in depths of mines is a difficult task. So, the reliability and long life of conventional communication system is poor. Due to the harsh environment inside the mine, the installation and maintenance of the wired communication is very difficult.

G Pradeepkumar, S Sanjay Rahul, N Sudharsanaa, S Suvetha, Dineshkumar Ponnusamy et al., [7] proposed a system to detect harmful gases using an air quality sensor, and then transmit the data to a base station using a LoRaWAN module. While this system may be useful for detecting harmful gases, it has the disadvantage of not focusing much on the miner's health condition and not detecting the working location of the miner. To address the miner's health condition, additional sensors could be integrated into the system to monitor vital signs, such as heart rate, respiration, and body temperature. These sensors could be worn by the miner or integrated into their clothing to provide continuous monitoring.

Rishi Sharma, Dr. Manish Kumar, Akshay Sisodiya, Aakash Kumar, ER. Shweta, Aditya Seth et al., [8] designed a smart helmet system for mining industry application. Where the provided system will keep on monitoring the hazardous events such as temperature, humidity, gas, removal helmet of the miner and obstacle damage to the helmet. the power of the designed helmet system circuit was evaluated with respect to a previous work. The programming and troubleshooting were evaluated on mainly two sections, helmet section and control room section.

III. METHODOLOGY

The proposed system aims to improve the safety of miners working in underground mines by monitoring their health parameters and detecting hazardous events. The system consists of two parts: the transmitter end and the receiver end.

The transmitter end is responsible for collecting data from various sensors attached to the miner's helmet, such as gas sensors, temperature and humidity sensors, IR sensors, blood pressure sensors, SpO2 sensors, GPS, and Wi-Fi modules. The transmitter end is shown in Fig. 1 & 2. The appropriate sensors are chosen based on their ability to operate in the harsh environment of mines and accurately measure the relevant parameters. The data collected by these sensors is sent to the receiver end in real-time using a Raspberry Pi and Python-based software.

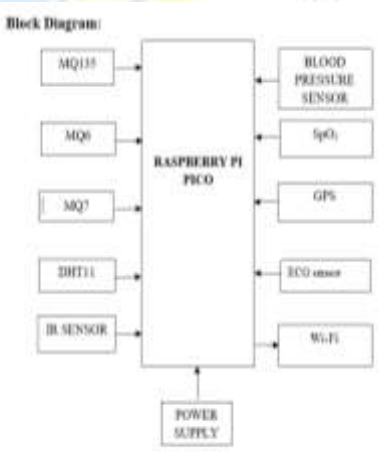

Fig. 1 Block Diagram of Transmitting end

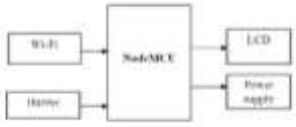

Fig. 2 Block Diagram of Node Mcu

The receiver end is responsible for receiving and processing the data from the transmitter end. It consists of a NodeMCU, a buzzer, an LCD, and a power supply. The NodeMCU is connected to the Raspberry Pi and programmed to receive data from the sensors on the miner's helmet. The buzzer is

connected to the NodeMCU and programmed to emit an audible alarm in case of any hazardous event detected by the sensors. The LCD is connected to the NodeMCU to display the status of the miner's helmet. The power supply provides sufficient power for the system to operate efficiently. Using ECG sensor and the machine learning model fatigue of the miner can be calculated.

In addition, the receiver end is integrated with an IoT and AI-based system that analyses the data received from the sensors and takes appropriate actions based on the results of the analysis. The system is tested and calibrated to ensure that it is functioning correctly. The testing involves simulating different hazardous events and verifying that the alarm is triggered appropriately. The calibration is done to ensure that the thresholds for the different types of hazards are set correctly.

Overall, the proposed system has the potential to significantly improve the safety of miners working in underground mines by monitoring their health parameters and detecting hazardous events in real-time. By doing so, the system can help prevent accidents and save lives. However, it is important to note that the system should be regularly maintained and updated to ensure its continued effectiveness.

IV. RESULT AND DISCUSSION

The proposed system is thus developed and it helps in alerting the receiver side in case of critical conditions. GPS helps to track the miner's location during abnormalities in the sensor information. The helmet unit which collects the temperature, pressure, force and hazardous gas data has been designed to alert the control room in case of abnormal condition. The reading of each sensor data can be visualized in thingspeak software. Graph the collected data can be seen in below figures

Fig 3 Temperature at mining site

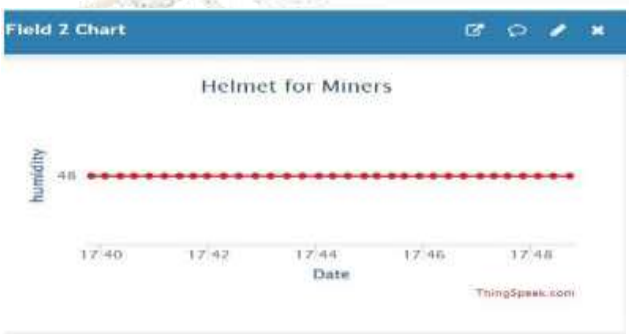

Fig 4 Humidity at mining site

Fig 5 MQ6 Gas sensor measurement

Fig 8 MQ135 Gas sensor measurement

V. CONCLUSION

In conclusion, the IoT and AI-based smart helmet for miners using Raspberry Pi is a promising innovation in the field of mining safety. By combining advanced sensor technology with artificial intelligence algorithms, this smart helmet can effectively monitor the miner's vital signs, detect hazardous gases, and provide real-time alerts to prevent accidents. The integration of Raspberry Pi provides an efficient and cost-effective solution for data processing and analysis, making it a feasible option for small-scale mining operations.

Furthermore, the smart helmet's ability to collect and analyze data can also enable mine operators to make informed decisions about worker safety and mine operations. The application of IoT and AI technology in mining safety has the potential to revolutionize the industry, and the smart helmet is just one example of how these technologies can be used to create safer and more efficient working conditions for miners. Overall, the smart helmet using IoT and AI technology holds great promise for improving mining safety and efficiency, and it is a significant step towards a safer future for miners.

This project can be further extended by adding GSM module to help the miners to share their location when they get stuck while mining. We can also integrate the helmet with a smart mask to help the miners breathe easily to survive the ravaging dust caused due to mining. We can also implement fall detection into our project which helps us to contact emergency services when a fall is detected. This uses high precision accelerometers and gyroscopes in order understand the impact of the fall. As we can see here there are many things that can be added to improve the project but ultimately the main goal is to look after miner's safety. The scope of the project can be expanded in any field or sector, which shows that the project has vast applications and diversity. We can also use the data generated through the smart helmet to monitor and analyze the information and send it for future enhancement and R&D.

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