Real-Time Data Transmission and Monitoring for Coal Mine Underground Using IoT Smart Helmet

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***Abstract*— Real-time smart helmets have been created to find dangerous occasions and gases in the mines. Smart helmet is not only the advancement of head protectors, but we have considered the main dangers in the mine. The first fixation level of different gases, for example, carbon, methane, and NO2, and their related issues. The creation of this helmet is focused on the mine to supervise and monitor the different hazards present in mines by using IoT Technologies. We aim to develop such a helmet based on a wireless sensor network that provides real-time surveillance and predicted warnings based on an intelligence system. Detect harmful gases in the mining areas and use GPRS to monitor different safety problems in coal production using IoT technology. Its generator emergency alarm sounds using a buzzer when any harmful gases are detected, or a person does not hold a helmet on the head even while a person's Heartbeat is reaching the threshold value. This research addresses the limitations of developing an IoT-based smart helmet that ensures the safety and the situation Awareness of our minors in the Mining industry. The mining industry faces significant safety challenges due to hazardous environments and potential dangers like falling objects, gas leaks, and insufficient air circulation. Traditional methods of monitoring miner safety rely on manual intervention or limited sensor capabilities, leading to potential delays in detecting critical situations. This research aims to address these limitations by developing an IoT-based smart helmet that enhances safety and situational awareness for miners in the mining industry.**

***Keywords*—Helmets, IoT, Mining and Real-Time Data**

I. INTRODUCTION

MINING is the process of extracting different Minerals and valuable materials from the Earth. During this process, different explosions are increasing day by day and become a huge crisis in the coal mines and other industries. The safety of human beings is a negligible area in the field of mining and underground industry. There are different petroleum and natural gases or even radiation that can be extracted, which is dangerous for the life of the miner.

Pakistan is a country that is renowned for its extensive and valuable mineral resources and having a big mining business. According to the stats of World Energy 2020, Pakistan has some of the largest coal and mineral reserves around 3064 million tons. However, this coal mining in Pakistan is not secure. There are only 3000 registered coal mines in Baluchistan which engages 40000 miners. These miners are aged around 14 to 40 and work for 14 hours a day. There are many health issues and safety issues for miners inside the mine. According to the current estimation around 500 miners lost their lives in the mines due to the explosion of the gases that were cloth and did not follow the precautions for the mining.

A mining helmet is created after realizing the problems of minors inside the mine and modified to improve the minor safety also adding some intelligence and detection power of gases to rescue the life of the minors Before any life hazard. Helmets are the essential thing that must be worn by the miners during the mining. These helmets are specialty designs with multiple sensors to detect different gases and some special health sensors that take the Heartbeat and Pulse rate of the miner during the mining process. These helmets are weightless and comfortable to use by the miners. To achieve this goal GPRS Technology uses, cloud IoT technology to send the data to the monitoring unit. The helmets are effective, providing early warning to secure minor life by detecting different gases like carbon monoxide, carbon dioxide, and Methane in the mining area.

Different IoT sensors and actuators are used to fulfill the helmet requirements. Gas sensors detect several gases, including carbon monoxide, methane, and propane, in underground coal mines. When the environmental parameter surpasses the designated normal level, an emergency alarm is triggered. The mobile devices are arranged in various areas and are connected via wireless mesh networking. Each worker's location and environmental data will be sent to a central control room via each helmet.

II. LITERATURE REVIEW

The following section will provide a review of relevant literature on smart helmets in mining, and existing research on integrating these technologies.

III. EXISTING SYSTEM

Currently, there are many helmets on the market; these are just used to protect the heads of miners. Some helmets can also detect different gases, but these helmets also do not predict the hazards that are going to be faced by miners. The literature related to mine technology is available but very limited.

Table 1: Overview of previous work

Topic name	Author	Solution	Limitation
IoT-Based Smart Helmetfor Unsafe Event Detection for Mining Industry (2017) [1]	Unsafe event detection	Employs gas sensors for CO, IR sensors for helmet removal, pressure sensors for impact detection, and humidity sensors to alert miners and control rooms of hazardous events.	Limited sensor range for gas detection.
IOT-based Smart Helmet for Hazard Detection in Mining Industry (2023) [2]	Hazard detection in mine by using IoT	The system combines different sensors to detect gases (such as methane and CO2), and monitor, temperature, humidity, noise levels, and impact. It uses wireless communication enable real-timemonitoring.	Requires significant processing power for complex sensor data, potentially impacting battery life.
A Learning Predictive Models for Underground Coal Mine Environment Using Sensor Data (2021) [3]	Safety monitoring	Combines helmet- mounted sensors for gas detection (CO, CO2), temperature, and humidity with cloud-based data processing a environmental conditions.	Relies on a stable internet connection for cloud communication, potentially problematic in underground mines with limited connectivity.
Design and Implementation of an IoT-enabled Smart Helmet for Underground Mine Safety (2022) [4]	Underground mine safety checkers	Utilizes gas sensors(CO, alerts.	Lacks functionalities like impact detection or helmet removal monitoring, potentially missing crucial safety aspects.
S. S. Harsha, S. C. Reddy and S. P. Mary Internet of Things	Home Automation System	Internet of Things	Enhanced home automation system using Internet of Things

IV. PROPOSED SYSTEM

To explain the proposed system there are 6 units. IR (infrared sensor) sensor, which is used to detect whetherthe minor, is wearing a safety helmet or not. Air quality sensors which are used to detect air pollution inside the coal mines additionally can detect emissions gases including carbon monoxide methane and carbon dioxide. Heartbeat sensor to calculate the value of the heart pulse in real-time. GPS schedule to share the live location of the miners inside the mine. The Data Processing Unit is an Arduino Microcontroller that collects all the data from all sensors and concludes whether needs any intimation to the wireless unit or the user wearing it .buzzer alarm system receives the data from these sensors and computes whether that threshold value is achieved and generates the alarm and send message to all nodes via mesh network. GPRS module with cloud Technology through this the information regarding the gas levels and Heartbeat pulse are uploaded into a server and the server stores the data the stored data is displayed on the server login channels to compare the values with the data set and this can see the previous record of gases level. The data set of predefined Heartbeat values. A lighting unit is used to give an alarm sound to the miner using a buzzer when any harmful gases are detected when the Heartbeat of a miner approaches to threshold value or when a person not wearing a helmet. In LCD the data is displayed.

A. Helmet Detection Unit

Infrared Sensor (IR Sensor): This sensor is used to detect whether the miner is wearing a safety helmet. The sensor can detect the presence or absence of the helmet based on the reflection of infrared light.

B. Air Quality Monitoring Unit

Air Quality Sensor: This sensor is designed to detect air pollution inside the coal mines. It can monitor various emissions, including carbon monoxide (CO), methane (CH_4), and carbon dioxide (CO_2). The sensor provides real-time data on the concentration of these gases to ensure the safety of miners. Mq4 sensor used to detect these gases. Normal value for CO is 30 ppm, and 32 for CO_2.

C. Health Monitoring Unit

Heartbeat Sensor: This sensor measures the heart pulse of the miner in real time. The data from the heartbeat sensor is crucial for monitoring the health condition of the miner and detecting any abnormalities that might indicate health risks.

Compute and compare these values with the trained dataset. We are applying CNN random forest technique to analyze the data.

D. Location Tracking Unit

GPS Module: This module shares the live location of the miners inside the mine. GPS data helps in tracking the movement of the miners and locating them in case of emergencies.

E. Data Processing and Communication Unit

Arduino Microcontroller: The Arduino microcontroller acts as the Data Processing Unit, collecting data from all the sensors (IR sensor, air quality sensor, heartbeat sensor, and GPS module). The microcontroller processes this data to determine if any thresholds are exceeded and if any

immediate actions are required.

Buzzer Alarm System: This system receives processed data from the Arduino microcontroller. It computes whether the threshold values for gas levels, heartbeat rate, or helmet detection are reached. If any of the threshold values are breached, the buzzer alarm is triggered to alertthe miner.

Mesh Network Communication: When an alarm is triggered, a message is sent to all nodes via the mesh network to ensure wide coverage and timely notificationto relevant personnel.

F. Cloud Integration and Display Unit

GPRS Module with Cloud IoT Technology: This module uploads information regarding gas levels and heartbeat pulse to a server. The server stores the data and displays it on a web interface, accessible through server login channels. This allows for real-time monitoring and historical data analysis. The system compares real-time values with predefined datasets to detect any anomalies.

Lighting Unit and Buzzer: If harmful gases are detected orif the heartbeat rate approaches a dangerous threshold, or if the miner is not wearing a helmet, the lighting unit gives a visual alarm, and the buzzer sounds an audible alarm.

LCD Display: An LCD screen is used to display real-time data from the sensors. This includes gas levels, heartbeat rate, and helmet status, providing immediate feedback to the mine.

V. WORKFLOW CHART

The following figures display the working process and data processing of the helmet.

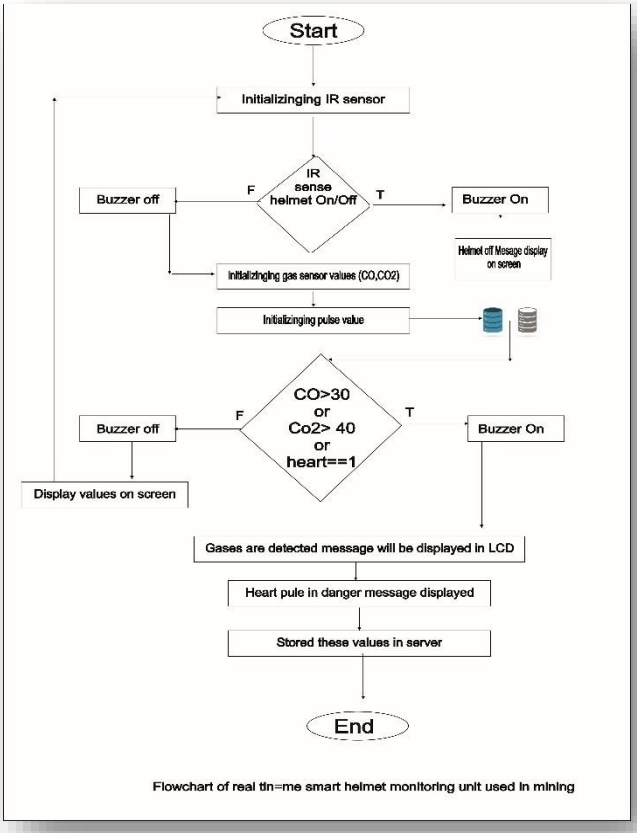

Fig. 1: Flow chart of helmet

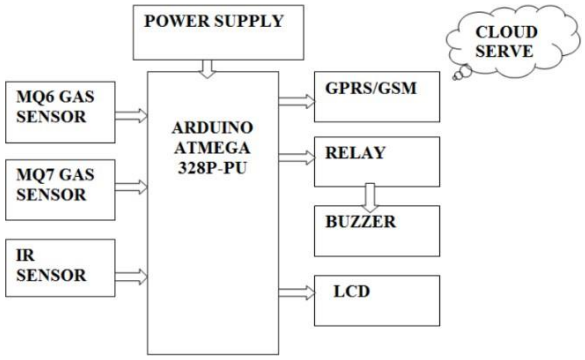

Fig. 2: Block diagram of helmet

VI. CONCLUSION

The intelligent helmet is designed to detect different gases like carbon oxide and carbon dioxide is oxide gases that can elaborate in the mind. Not only this but this helmet 10 also detects the heart rate and pulse of the minor. If the pulse rate reaches the threshold value the system can generate an alert for surveillance. This is time also alert the minor when the helmet is removed while Mining in the Mining industry in the system, we use GPRSto transmit data from the minor industry to the server IoT technology is widely used technology from transmit the data by using different protocols. The pulse rate of the minor is further linked with the trained data set and predicts the value of whether the minor is in danger or out of danger. If the minor is in danger the Alert is generated for the surveillance.

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