ESIOT MINI PROJECT REPORT

Smart Helmet For Coal Miners

Prepared by:

Vaidant Jain- 53

Shravya D’souza- 57

Taha Kapadia- 61

Pranjal Vishwakarma-64

INDEX:

Problem Statement:

Q) Coal mining presents hazards like exposure to gases, heat-related illnesses, and accidents. Current safety gear lacks real-time monitoring and communication, necessitating urgent upgrades to enhance safety and well-being for miners.

INTRODUCTION

In the 21st century, the mining industry has become one of the most dominant sectors of the economy because of the increasing need for metals and other geological materials. Among all the minerals available, coal is used extensively in electricity production due to its high availability .

It can be mined both by surface mining and underground mining. Thus, the safety of underground miners becomes paramount for the concerned authorities.

Coal mines involve dangers like falling objects and the presence of dangerous gases like CH_4, LPG, which could cause serious cardiovascular complications. Removal of helmets while operating in mines is additionally dangerous.

If any bulky object falls on a mineworker's head even after putting on a helmet, the individual may become injured and could die if immediate treatment isn't provided. So, This smart helmet is built in such a way that it will notice all types of dangerous events with the assistance of devices that are mounted on it .
Multiple sensors are mounted on the smart helmet that will help to detect any change in environmental parameters and is also capable of tracking the miners' location incessantly.

A watch will also be provided to the miner which informs the miner about the environmental parameter changes and also notify regarding helmet removal .
In the proposed safety helmet, there are three salient factors. First is detecting the presence of dangerous gases , the second is helmet removal by the miners, and the third one is the panic button pressed in any adverse situation .

Networks within the mines are a serious downside for the communication of miners. Communication within the mines is often carried out in the form of cables which might get disrupted during rockfalls. Additionally, since the cost of fitting and maintaining the cabling is high, the data has to be transferred wirelessly to the observance station through a wireless communication system.

Need and Motivation:

Need Statement:

The need for enhanced safety measures and communication systems within coal mines is paramount. Current safety protocols, including the use of helmets, are inadequate to address the myriad of risks miners face daily. Furthermore, communication breakdowns due to disrupted cable networks exacerbate these dangers, leaving miners vulnerable in emergency situations. There is a critical need for a comprehensive solution that not only improves miner safety but also ensures seamless communication underground.

Motivation

The motivation for this project stems from the urgent need to safeguard the lives and well-being of underground miners. The existing safety challenges, such as falling objects, dangerous gases, and communication disruptions, pose significant risks to miners' safety. Addressing these challenges through innovative technologies, such as smart helmets and wireless communication systems, can significantly mitigate these risks and potentially save lives. The motivation for undertaking this project lies in the fundamental belief that every miner has the right to a safe working environment and effective means of communication in case of emergencies. By tackling these issues head-on, we aim to revolutionize safety standards in the mining industry and ensure the protection of miners worldwide.

Objectives:

1. Enhance Miner Safety:
   - Develop a smart helmet equipped with sensors to detect dangerous gases and environmental changes.
   - Implement features to alert miners of potential hazards, such as falling objects and dangerous gas levels.
   - Incorporate a mechanism to notify miners if their helmets are removed, ensuring adherence to safety protocols.

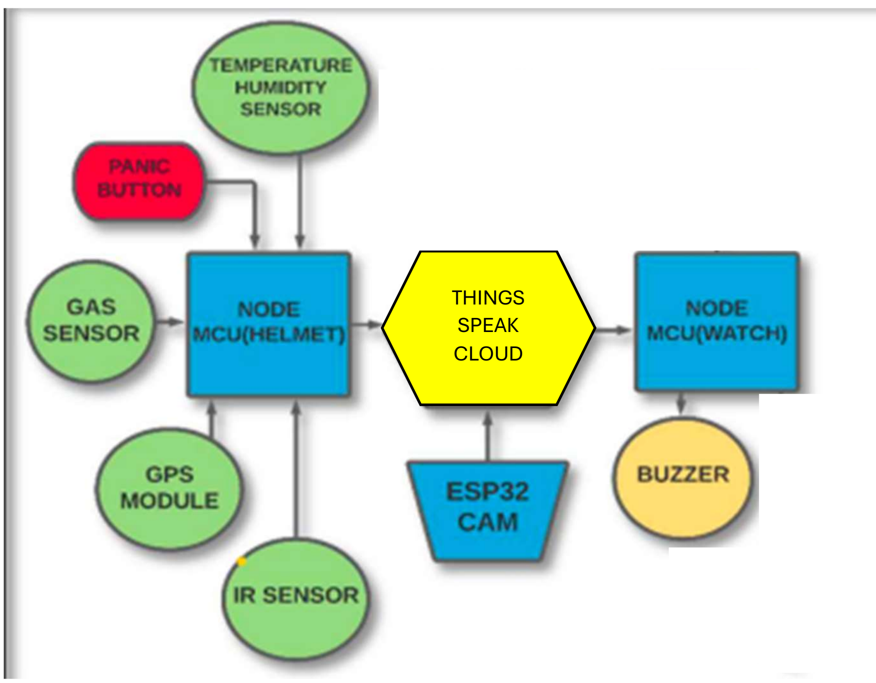
2. Improve Communication Systems:
   - Design a wireless communication system to overcome disruptions caused by cable network failures.
   - Ensure continuous and reliable communication between miners and monitoring stations.
   - Implement measures to facilitate emergency communication, such as a panic button for miners to signal distress situations.

3. Increase Emergency Response Efficiency:
   - Develop protocols for swift and effective emergency response in case of accidents or hazardous situations.
   - Integrate location tracking capabilities into the smart helmet to expedite rescue operations.
   - Establish a seamless communication channel between miners and rescue teams to coordinate rescue efforts efficiently.

4. Reduce Occupational Hazards and Risks:
   - Conduct thorough risk assessments to identify and mitigate potential hazards within coal mines.
   - Implement measures to minimize the occurrence of accidents, injuries, and fatalities among miners.
   - Provide comprehensive training programs to educate miners on safety protocols and the use of new technologies.

5. Enhance Overall Operational Efficiency:
- Streamline data collection and analysis processes to improve decision-making and resource allocation.
- Optimize maintenance schedules and procedures for the smart helmet and communication systems to ensure their reliability.
- Evaluate the cost-effectiveness of implementing the proposed safety and communication solutions to maximize their benefits.

Block diagram/Flow diagram



List Of Components:

1)Helmet:
• The Node-MCU collects the temperature and humidity data from the DHT22 sensor and the gas level data from the MQ7 sensor.
• The GPS module sends the location data to the Things Speak cloud.
• IR sensor notifies if the helmet is removed or not.
• All the data is finally sent to the Things Speak cloud .

2) ESP8266 (Node-MCU):
Node MCU 32-bit is a LX106 RISC microprocessor.
It works at a clock speed of 80MHz and supports RTOS.
It has an operating voltage of 3.35V and can work at a input voltage of 7V to12V.

3)DHT-22: The DHT22 is a digital humidity and temperature sensor. It is commonly used to measure ambient temperature and humidity levels in various environments. The sensor provides accurate and reliable readings, making it suitable for a wide range of applications.

4) MQ-7 Gas sensor: The MQ-7 gas sensor is used to detect gas such as LPG and Butane. MQ-7 gas sensor is made up of Al_2CO_3 ceramic tube with SnO_2 layer. Generally, it is consists of 4 pins to work with. A digital pin is attached to it which can visualize the analog output as a digital value by altering the potentiometer embedded in it.

4)IR Sensor: The IR sensor, also known as infrared sensor, is a device that emits or detects IR radiation to determine specific properties in its surroundings. It consists of an emitter and detector LED in which IR LED (Light Emitting Diode) acts as emitter, and IR photodiode as detector. Photodiode detects IR light of the same wavelength that the IR LED emits.

5)GPS : The Global Positioning System (GPS) is a navigation system that uses satellite for tracking and gives users information about location and time. . The position of a GPS receiver is calculated by accurately timing the signals sent by GPS satellites.

8)Panic button feature : In case of emergency a distress signal can be sent to the mining authorities using the panic button. As the miner presses the panic button a mail is sent to the authorities within 5 seconds which helps the authorities to reach the miner as fast as possible thereby save the miners life.To avoid the possibility of mail ignorance the mail is continuously sent until the authorities give a suitable response.

12)Pulse Sensor (Heart Rate Detection Module):
Integrating a pulse sensor heart rate detection module into the smart helmet for coal miners enhances safety by monitoring miners' heart rates. It detects signs of fatigue, stress, and emergencies, enabling proactive intervention and optimizing safety measures. Additionally, it aids in training and education by analyzing heart rate data to improve overall health and performance in mining operations.

Code:

```
#include <DHT.h>
#include <ESP8266WiFi.h>
#include "ThingSpeak.h"
#include <PulseSensorPlayground.h>
#include <Adafruit_Sensor.h>
#include <SoftwareSerial.h>

#define DHTPIN 4     // Digital pin connected to the DHT sensor
#define DHTTYPE DHT22   // DHT 22  (AM2302)
#define BUTTON 13
#define BUZZ 16

int status=0;
const char* ssid = "vaidant_jain_";
const char* password = "vaidant@12";
unsigned long myChannelNumber = 2505402;
const char * myWriteAPIKey = "2MJV2GOE74JJZCTM";
const int pulsePin = A0;
int prev_button_state= HIGH;
int button_state;
WiFiClient  client;
PulseSensorPlayground pulseSensor;

DHT dht(DHTPIN, DHTTYPE);

void setup() {
  Serial.begin(9600);
  dht.begin();
  // Connecting to a WiFi network
  Serial.println();
  Serial.println();
  Serial.print("Connecting to ");
  Serial.println(ssid);

  WiFi.begin(ssid, password);
```

```
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  pinMode(BUZZ,OUTPUT);
  Serial.println("");
  Serial.println("WiFi connected");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
  ThingSpeak.begin(client);
  pinMode(BUTTON,INPUT_PULLUP);
  pulseSensor.analogInput(pulsePin);

  pulseSensor.setThreshold(550);

  // Start the pulse sensor

  pulseSensor.begin();
}

void loop() {
  delay(200);  // Delay between sensor readings
  float humidity = dht.readHumidity();
  float temperature = dht.readTemperature();

  // Check if any reads failed and exit early (to try again).
  if (isnan(humidity) || isnan(temperature)) {
    Serial.println(F("Failed to read from DHT sensor!"));
    return;
  }


  Serial.print(F("Humidity: "));
  Serial.print(humidity);
  Serial.print(F("%  Temperature: "));
  Serial.print(temperature);
  Serial.println(F("°C"));
  button_state=digitalRead(BUTTON);
  //pulseSensor.update();
  int heartRate = pulseSensor.getBeatsPerMinute();


    Serial.println("Heart rate: " + String(heartRate) + " bpm");
```

```
  if(temperature>50 || humidity>100 || heartRate<40){
    digitalWrite(BUZZ,HIGH);
    delay(2000);
  }
  digitalWrite(BUZZ,LOW);

  if(prev_button_state==LOW && button_state==HIGH){
    Serial.println("State has changed");
  }
  prev_button_state=button_state;
  ThingSpeak.setField(1,temperature);
  ThingSpeak.setField(2,humidity);
  ThingSpeak.setField(3,heartRate);
  ThingSpeak.setField(4,button_state);
  int x = ThingSpeak.writeFields(myChannelNumber,  myWriteAPIKey);
  // if(prev_button_state==HIGH){
  //   delay(2000);
  //   prev_button_state=LOW;
  //   button_state=LOW;
  // }
  //int y = ThingSpeak.writeField(myChannelNumber, 2, humidity, myWriteAPIKey);
  if(x == 200 ){
      Serial.println("Channel update successful.");
    }
    else{
      Serial.println("Problem updating channel. HTTP error code " + String(x));
  }
}
```

Output screenshots / Photographs


Field 4 Chart
Panic Button
Emergency Alert
1
18. Apr
19. Apr
20. Apr
Date
ThingSpeak.com
Panic Button
6 minutes ago
Field 3 Chart
ESIOT Mini Project
Heart Rate
200
100
0
12:00
19. Apr
12:00
20. Apr
12:00
Date
ThingSpeak.com
Heart Rate
0
BPM
7 minutes ago
Field 4 Chart
Panic Button
Emergency Alert
1
18. Apr
19. Apr
20. Apr
Date
ThingSpeak.com
Panic Button
7 minutes ago
ThingSpeak™
Channels
Apps
Devices
Support
Commercial Use
How to Buy
SD
Field 1 Chart
Temperature VS Time
Temperature
32.5
30
27.5
18. Apr
19. Apr
20. Apr
Time
ThingSpeak.com
Field 2 Chart
Humidity VS Time
humidity
60
40
18. Apr
19. Apr
20. Apr
Time
ThingSpeak.com

Applications

1. Gas Detection and Monitoring:
   - Utilize sensors to detect dangerous gases like CH_4 and LPG, providing real-time monitoring of air quality within the mine.
   - Alert miners to the presence of hazardous gases, enabling them to take necessary precautions and evacuate if required.

3. Helmet Removal Detection:
   - Develop a mechanism to detect when miners remove their helmets, triggering immediate alerts to supervisors and fellow miners.
   - Ensure adherence to safety protocols by discouraging helmet removal while working in hazardous environments.

4. Location Tracking and Monitoring:
   - Integrating GPS and Zigbee technology to track miners' locations in real-time, facilitating rapid response in case of emergencies.
   - Enable supervisors to monitor miners' movements and allocate resources efficiently based on their location within the mine.

5. Environmental Parameter Monitoring:
   - Install multiple sensors on the smart helmet to monitor changes in environmental parameters such as temperature, humidity, and air pressure.
   - Provide miners with real-time feedback on environmental conditions to help them make informed decisions and mitigate risks.

6. Communication and Alert Systems:
   - Establish a wireless communication system within the smart helmet to facilitate seamless communication between miners and monitoring stations.
   - Implement an alert system to notify miners of changes in environmental parameters, equipment malfunctions, or emergency situations.

7. Panic Button Functionality:
   - Integrate a panic button into the smart helmet to enable miners to quickly signal distress or call for help in emergency situations.
   - Ensure immediate response from supervisors or rescue teams upon activation of the panic button.

8. Data Transfer and Analysis:
   - Develop mechanisms for wirelessly transferring data from the smart helmet to monitoring stations for real-time analysis.
   - Collect and analyze data on environmental conditions, miner movements, and equipment status to identify trends and improve safety protocols.

Conclusion

A Wi-Fi based smart helmet has been designed for coal miners which is capable of detecting threatening events like the increase in the level of harmful gases inside the mine. This smart helmet is also capable of sending real time temperature and gas levels to the servers thereby keeping the concerned authorities always updated about the mine conditions.

The presence of a panic button in the smart helmet helps the miners to send distress signals easily just with a press of a single button and the GPS module helps the rescue party to find the exact location of the miner quickly thereby saving the lives of miners.

In addition to the helmet, the miners are also provided with a watch which always keeps the miners notified about parameters like temperature, humidity and gas levels. The helmet removal notifier feature helps the authorities to get informed if any miner tries to remove the helmet.

This low-cost, reliable and efficient prototype has been designed and tested with software and hardware debugging. Placement of each module and sensors has also been done carefully thus resulting in the best working of the product.

The proposed model can be upgraded by using a LORA module in addition to the Wi-Fi thereby making the communication process less network dependent.

Further an oximeter can also be included to constantly monitor miners' oxygen level and heart rate. Also, a collision sensor can be installed which can detect any collision or accidents. To detect the increasing water level in mines we can integrate a water level sensor in the miners boots , which will warn the miner of increasing water levels

REFERENCES:

[1] Medunic, Gordana & Mondol, Deepti & Rađenović, Ankica & Nazir, Sadhana. (2018). Review of the latest research on coal, environment, and clean technologies. Rudarsko-geološko-naftni Zbornik. 33.

[2] Xu sheng Z and Yunlong Z. 2010. Accident cause analysis and counter measure of coal and gas outburst nearly two years of our country[J]. Mining Safety and Environmental Protection. 37(1): 84-87

[3] HE Si-yuan,2008, The Research of Energy Efficient MAC Protocols in Gas Monitoring System of Mine. International Symposium on Information Science and Engineering.

[4] S.R.Deokar, J.S.Wakode, "Coal Mine Safety Monitoring and Alerting System", IRJET Volume 04, Mar 2017.

[5] V. Jayasree and M. N. Kumari, "IOT Based Smart Helmet for Construction Workers," 2020 7th International Conference on Smart Structures and Systems (ICSSS), 2020, pp. 1-5, doi: 10.1109/ICSSS49621.2020.9202138.

[6] A.J. Pudke And Sanket Banger, "Coal Mine Monitoring And Alert System With Data Acquisition" IEEE September 2017

[7] Revindran, R., Vijayaraghavan, H., & Huang, M. Y. (2018, September). Smart helmets for safety in mining industry. In 2018 International Conference on Advances in Computing, Communications and Informatics (ICACCI)(pp. 217-221). IEEE.

[8] T. Maity, P. S. Das and M. Mukherjee, "A wireless surveillance and safety system for mine workers based on Zigbee," 2012 1st International Conference on Recent Advances in Information Technology (RAIT), 2012, pp. 148-151, doi: 10.1109/RAIT.2012.6194496.

https://www.cdc.gov/niosh/mining%5C/UserFiles/works/pdfs/ic9149.pdf
https://unece.org/sustainable-energycoal-mine-methane/case-studies
https://www.sanskritiias.com/current-affairs/a-case-study-on-gare-palma-coal-mines
https://www.sciencedirect.com/science/article/pii/B9780080420684500272
https://www.icnl.org/post/analysis/case-study-public-input-in-indian-coal-mines

[10] ZigBee Alliance, "Zigbee wireless standards". www.didgi.com/technology/rf-articles/wireless-zigbee [21] Contiki os. Available: http://www.contiki-os.org/ [11] A. Kaur, A. Jadli, A. Sadhu, S. Goyal, A. Mehra and Rahul, "Cloud Based Surveillance using ESP32 CAM," 2021 International Conference on Intelligent Technology, System and Service for Internet of Everything (ITSS-IoE), 2021, pp. 1-5, doi: 10.1109/ITSS-IoE53029.2021.9615334.