A
Project Report
on

Smart Safety Jacket for Coal-Miners

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Sant Gadge Baba Amravati University, Amravati

Submitted in partial fulfilment of
the requirements for the Degree of
Bachelor of Engineering in
Electronics and Telecommunication Engineering

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Certificate

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Abstract

The mining industry has always been considered one of the most hazardous industries, with coal mining being particularly dangerous due to the risks of explosions, cave-ins, and exposure to toxic gases. As a result, ensuring the safety of miners has always been a top priority for mining companies.

In recent years, there have been significant advances in wearable technology, leading to the development of smart safety jackets that can enhance the safety of coal miners. The smart safety jacket is a wearable device that is equipped with various sensors and advanced communication technologies that can detect and communicate potential safety risks to miners and safety personnel.

The jacket is designed to monitor the miner's vital signs and detect any abnormalities, such as high body temperature or abnormal heart rate, which could indicate the onset of heat exhaustion or other health issues. It can also detect dangerous gases such as methane and carbon monoxide, which can build up in underground mines and pose a significant safety risk to miners. Additionally, the jacket is fitted with obstacle detection sensors that can detect obstacles or potential hazards in the miner's path, such as rocks or machinery, and alert the miner to avoid them.

The jacket also features a GPS system that can track the miner's location and provide real-time updates to safety personnel, enabling them to quickly locate the miner in the event of an emergency. The data collected by the jacket is transmitted wirelessly to a central server, where it can be analyzed to provide insights into the safety of the mining environment. For example, data from the gas sensors can be used to identify areas where gas concentrations are particularly high, allowing mining companies to take proactive steps to mitigate the risk of gas-related accidents.

In conclusion, the smart safety jacket for coal miners represents a significant advance in mining safety technology. By providing real-time data on potential safety risks, it can help miners and safety personnel to make more informed decisions and take proactive steps to mitigate risks. Ultimately, this technology has the potential to reduce accidents and injuries in the mining industry, leading to a safer and more productive workplace for miners.

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Abbreviations

Wi-Fi	- Wireless Fidelity
GPS	- Global Positioning System Fix Data
ESP32	- Espressif Systems 32
PCB	- Printed Circuit Board
MCU	- Microcontroller Unit
PWM	- Pulse Wave Modulation
I2C	- Inter Integrated Circuit
SPI	- Serial Peripheral Interface
USB	- Universal Serial Bus
UART	- Universal Asynchronous Receiver Transmitter
IR sensor	- Infrared sensor
LED	- Light Emitting Diode
NTC	- Negative Temperature Coefficient
RF	- Radio Frequency
IoT	- Internet of Things
IIoT	- Industrial Internet of Things
LIFI	- Light Fidelity
HIC	- Head Injury Criteria
ADC	- Analog to Digital Converter
DAC	- Digital to Analog Converter
PPM	- Parts Per Million
FTFF	- Fast Time to First Fix

NMEA	- National Marine Electronics Association
RMC	- Recommended Minimum Specific GNSS Data
SMS	- Short Messaging Service
API	- Application Programming Interface
IDE	- Integrated Development Environment
ICSP	- In-Circuit Serial Programming
VCC	- Voltage at the Common Collector
GND	- Ground
TX	- Transmitter Antenna
RX	- Receiver Antenna
PC	- Personal Computer

Chapter 1

Introduction

Chapter 1
Introduction

1.1 Thesis introduction

Coal mining is considered one of the most dangerous professions in the world due to the numerous hazards associated with the industry. The underground working environment in coal mines presents numerous physical and health risks to miners, including exposure to toxic fumes, fire, and explosions, as well as the risk of other accidents. The health and safety of miners, who play a critical role in driving the industry, should be given the highest priority

The Internet of Things is nothing but the devices or things communicating with each other by using the internet. With the recent development in IoT people are getting familiar with IoT. As it stores the data in the cloud coming from sensors it can be accessed by the supervisor or responsible authority from anywhere, where they are connected to the internet.

Coal mine is itself a very vulnerable place to work on thus mining becomes a hazardous profession. As many of the miners lost their lives due to unawareness of their health conditions. Workers or miners are the front leader in running industry and thus their health risk needs to be considered and should be given highest priority. There are 565 coal mines, 40 oil mines and 2000 metal mines employing more than one million miners. In the last five years (2015-2019) around 150 fatalities are reported with a fatality rate of around 10-12%. With the emergence of the Industrial Internet of Things (IIoT) a smart safety jacket is developed which will monitor the miner's health and also provide precautionary measures for miner's safety using the concept of IoT.

The main reasons for accidents taking place in coal mines are due to various reasons. Accidents can occur due to side fall, roof fall, explosive, hazardous gasses and many other several causes. In this paper, we have worked on the issues which miners are facing and developed a safety jacket, gathered information from the sensors which we have utilized and the results is achieved utilizing the Thing-Speak platform.

The other thing we are doing for the safety of miners is to maintain a safe and clean environment for miners to work on and free of hazardous gasses. We have used different health sensors such as pulse sensor, temperature and Humidity sensor, which

are integrated in the safety jacket. Further ESP32 which is a Wi-Fi module is used to transmit the data wirelessly to servers like Thing-Speak, this data is fetched to our website using API. Here we can visualize the sensor data in the proper manner and are able to make any decision in case of an abnormal situation.

The other way in which we provide safety to miners is through providing them a safe environment to work in, like hazardous free glasses. As the mining takes place deep below 1000 meters it contains different toxic gases like methane gas (CH4), Carbon Monoxide (CO) Carbon dioxide (CO2), Ammonia (NH3) which are deadly if not maintained at a certain level. To detect these toxic gases, we have the MQ family gas sensor which consists of different gas sensors like MQ-4 sensor for methane, MQ-7 for Ammonia. If we maintain these gases at different levels then we can provide a safe working environment.

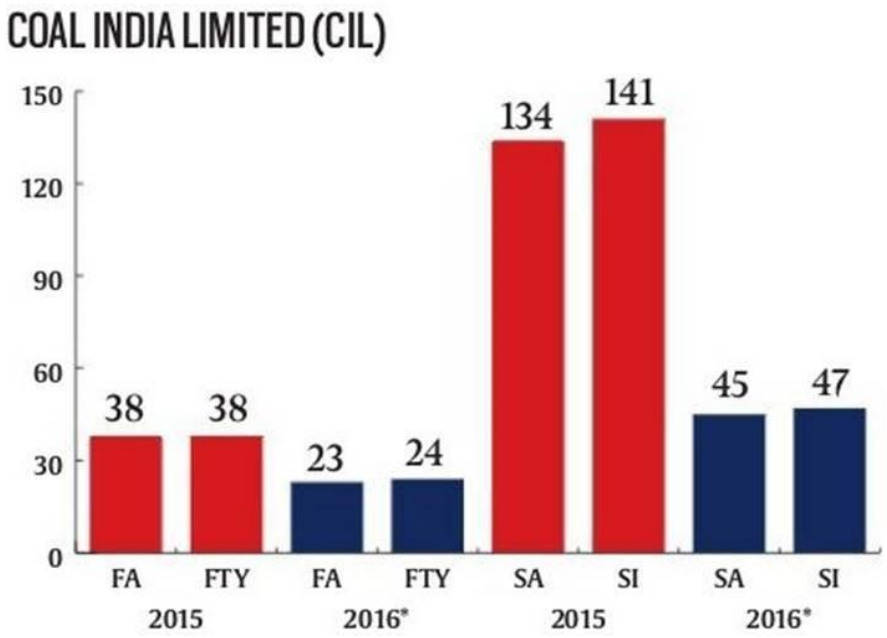

Figure 1.1 Safety status of Coal mine

1.2 Safety Jacket description

There are many health effects on miners when they are working in mine like pulse rate, headache, unconsciousness, dizziness and several others. In this work the safety jacket will monitor the pulse rate which will give us the information about how the miner's heart is functioning and from that we can conclude that the miner is normal or in an abnormal state. The next parameter which the safety jacket will monitor is temperature which will give the information about the miner's body temperature.

The admin can also monitor the health condition of coal miner through a website where he/she can access the data sensed by sensors. The safety jacket also contains an emergency panel for coal miners in case the miner gets unconscious and feels dizzy. After pressing the button on the jacket, the alarm started and people nearby can rescue the coal miners along with this admin also get notified about the same.

Integrating smart safety jackets with different health sensors such as pulse sensor, temperature sensor, humidity sensor and then connect it with ESP32 which is a Wi-Fi module and connect it with the internet. Sensors constantly send the sensor data to the cloud and if any abnormal situation occurs it will send a message to the responsible person in the control room as well as it will alert the miners. As mining takes place deep underground it can be more vulnerable to toxic gases, low oxygen level, and hazardous gases can be detected with the MQ gas sensor family. The developed system is mainly implemented to improve the working condition inside the coal mines and also to ensure workers safety.

Chapter 2

Literature Review

Chapter 2

Literature Review

2.1 Literature Review

A smart helmet for air quality and hazardous event detection for the mining industry

C. J. Behr, A. Kumar, G. P. Hancke

2016 IEEE International Conference on Industrial Technology (ICIT)

A smart helmet has been developed that is able to detect of hazardous events in the mines industry. In the development of helmet, we have considered the three main types of hazards such as air quality, helmet removal, and collision (miners are struck by an object). The first is the concentration level of the hazardous gases such as CO, SO2, NO2, and particulate matter. The second hazardous event was classified as a miner removing the mining helmet off their head. An IR sensor was developed unsuccessfully but an off-the shelf IR sensor was then used to successfully determine when the helmet is on the miner's head. The third hazardous event is defined as an event where miners are struck by an object against the head with a force exceeding a value of 1000 on the HIC (Head Injury Criteria).

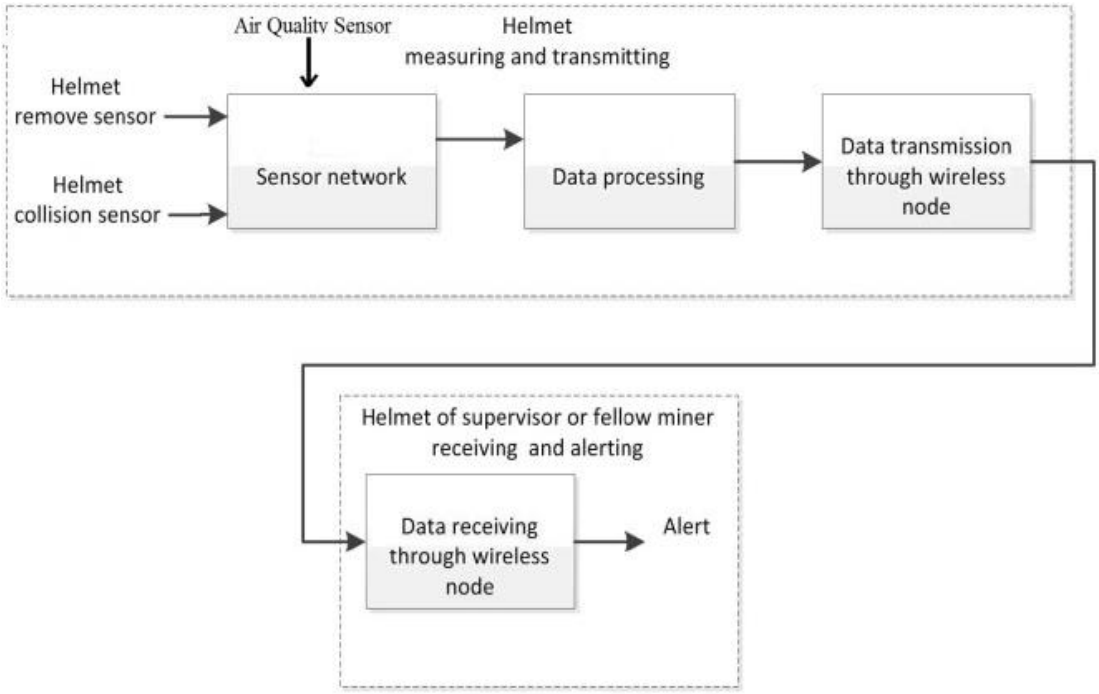

Figure 2.1 Function Block diagram of Smart Helmet

An accelerometer was used to measure the acceleration of the head and the HIC was calculated in software. The layout of the visualization software was completed; how-

ever, the implementation was unsuccessful. Tests were successfully done to calibrate the accelerometer. PCB's that were designed and made included a breakout board and a prototype board. A whole software implementation was done based on Contiki operating system in order to do the control of the measuring of sensors and of calculations done with the measured values. This paper presents the undertaken design detailing solutions to issues raised in previous research.

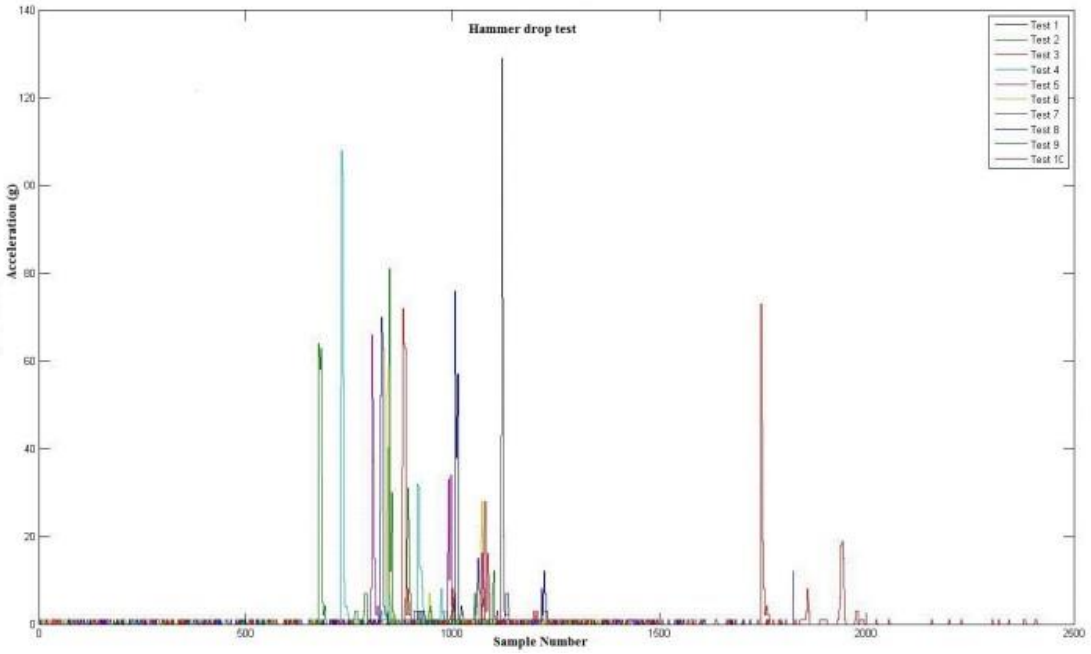

Figure 2.2 Accelerometer measurement with hammer dropped

The mining industry is known to be a high-risk industry due to the potential hazards associated with mining activities. One of the major hazards in the mining industry is the risk of head injuries caused by falling objects or collisions. In order to mitigate this risk, various safety measures have been put in place, including the use of safety helmets. However, these measures are not fool proof, and accidents can still occur.

In recent years, the development of smart helmets has emerged as a promising solution to enhance the safety of miners in the mining industry. This paper presents the design of a smart helmet that is able to detect hazardous events in the mining industry, including air quality, helmet removal, and collision.

2.1.1 Design:

The smart helmet design is based on the use of sensors to detect hazardous events. The sensors used include gas sensors to detect the concentration level of hazardous gases such as CO, SO2, NO2, and particulate matter, an IR sensor to detect when the

helmet is on the miner's head, and an accelerometer to measure the acceleration of the head in case of collision.

The gas sensors were used to monitor the air quality inside the mine. The sensors were calibrated and tested to ensure accurate readings. The IR sensor was initially de-veloped but was unsuccessful, so an off-the-shelf IR sensor was used to success-fully determine when the helmet is on the miner's head. The accelerometer was used to measure the acceleration of the head in case of collision, and the Head Injury Cri-teria (HIC) was calculated in software to determine if the collision was hazardous.

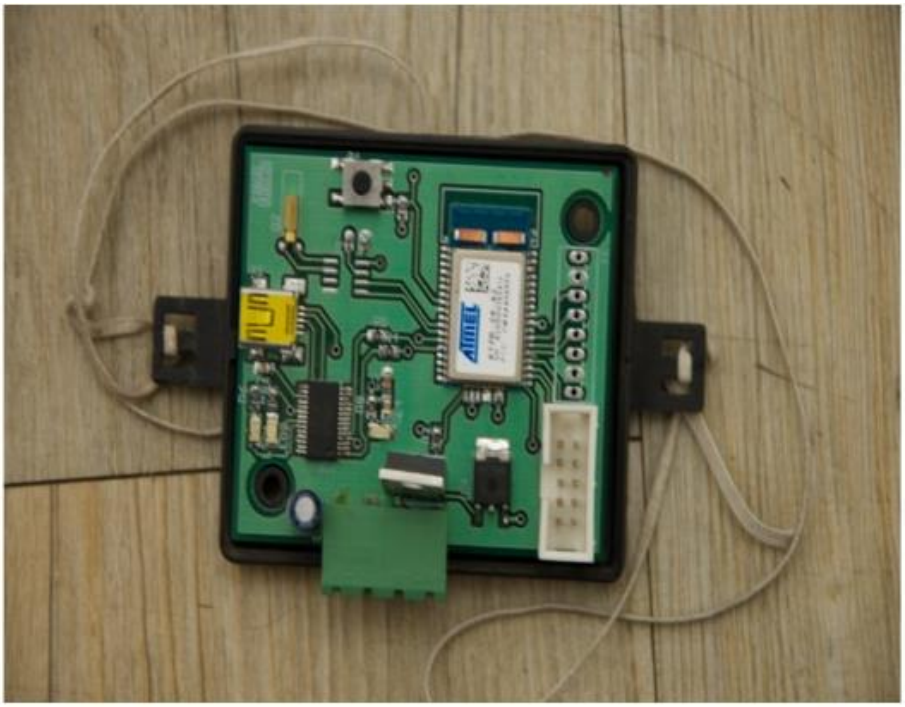

Figure 2.3 Smart Helmet Module

The layout of the visualization software was completed, but the implementation was unsuccessful. However, a whole software implementation was done based on the Contiki operating system to control the measuring of sensors and calculations done with the measured values. PCBs were designed and made, including a breakout board and a prototype board.

2.1.2 Discussion:

The smart helmet design presented in this paper addresses three main types of hazards in the mining industry, including air quality, helmet removal, and collision. The gas sensors used in the helmet were able to accurately detect the concentration level of hazardous gases in the mine. The IR sensor and accelerometer were used to detect helmet removal and collisions, respectively.

The design of the smart helmet presented in this paper has the potential to significantly enhance the safety of miners in the mining industry. However, there are some limitations to this design. For instance, the implementation of the visualization software was unsuccessful, which may limit the usefulness of the helmet. Addition-ally, the cost of the smart helmet may be a limiting factor for small-scale mining operations.

- Hemet connected with sensor using Arduino uno LIFI technology used to connect sensor data to the admin portal
- Data Transmission is not much efficient as transmission rate is very low (loss of data may occur) it led to late alert
- Non-detachable equipment which are not user friendly, as the sensor on the helmet are not cover, they can be easily damaged by the hazardous condition in mines

In conclusion, the design of a smart helmet for the mining industry was presented in this paper. The helmet is able to detect hazardous events, including air quality, helmet removal, and collision, using gas sensors, an IR sensor, and an accelerometer. The design of the smart helmet has the potential to significantly enhance the safety of miners in the mining industry. However, there are some limitations to the design, including the unsuccessful implementation of the visualization software and the cost of the helmet. Further research is needed to improve the design and address these limitations.

2.1.3 Scope in our project

Wireless technology has revolutionized the way we communicate and connect to the internet. The two most commonly used wireless technologies are WIFI and LIFI. Both these technologies have their own advantages and disadvantages. However, in industrial environments such as mining sites, WIFI technology is generally preferred over LIFI technology due to its longer range, greater compatibility, and lower cost.

WIFI technology uses radio waves to transmit data between devices. It has a longer range than LIFI technology, which uses light waves to transmit data. This makes WIFI more suitable for large industrial environments such as mining sites.

In mining environments, the communication network plays a critical role in ensuring the safety and productivity of the workforce. WIFI technology offers better cover-age, which is essential in mining sites where communication can be difficult. With a strong

WIFI network, miners can communicate with each other and with the control room, even in the most remote and difficult areas of the mine.

In addition, WIFI technology is already well-established and widely used. Most modern devices, such as smartphones, tablets, and laptops, are WIFI-enabled. This means that it is easier and more cost-effective to implement WIFI technology in ex-isting systems. WIFI networks can also be easily expanded and upgraded as the need arises.

On the other hand, LIFI technology is a relatively new technology that is not yet as widely available as WIFI. LIFI technology uses light waves to transmit data, which means that it is not affected by electromagnetic interference. However, it has a shorter range and is more easily blocked by physical obstacles. In addition, LIFI-enabled devices are still relatively uncommon, which makes it more difficult to implement LIFI technology in existing systems.

Furthermore, WIFI technology is generally less expensive than LIFI technology. The cost of implementing a WIFI network is relatively low, especially when compared to the cost of installing and maintaining a LIFI network. In an environment with a value of 1000, such as a mining site, cost-effectiveness is an important consideration for companies and organizations with limited budgets.

Feature	**WiFi Technology**	**LiFi Technology**
Data transmission	Radio waves	Visible light
Frequency	2.4 GHz and 5 GHz	400 THz to 800 THz
Range	Several hundred feet indoors	Limited to area illuminated by LED light
Interference	Susceptible to electromagnetic	No electromagnetic interference
Security	Vulnerable to hacking	More secure due to physical limitations
Speed	Typically, slower than LiFi	Can achieve very high speeds (up to 100 Gbps)
Availability	Widely available and commonly used	Still emerging and not as widely available
Installation	No specialized equipment required	Requires specialized equipment for lighting and receivers
Energy Efficiency	Moderate to high power consumption	Very low power consumption (LED lights)

Table 2.1 Difference Between Li-Fi vs Wi-Fi

2.2 Literature Review

Zig-Bee Based Intelligent Helmet For Coal Miners

Arun Katara, Anand Dandale, Abhilesh Chore, Anurag Bhandarwar

2015

Fifth International Conference on Communication Systems and Network Technologies

In recent days coal mining has been very dangerous activity for the workers. Who work in mine. Because of numbers of adverse effects environment. During mining operation dangerous gases. Like methane may be released into the air also underground mining hazards. Include suffocation, gas poisoning, roof collapse and gas explosion by keeping all those activities which done in underground coal mine we designed a system i.e., Zig bee based intelligent helmet for coal miners. For monitoring hazard gases, temperature condition and humidity. Level in air the improve safety features in our system dramatically increases life expectancy by alerting them about hazards. In this system, the helmet has three sensors temperature sensors, hu-midity sensor and gas sensor to monitor the condition in coal mining. If there is any hazardous condition occurs the buzzer get alarm which is positioned on helmet then gives the information to control station through the zig bee trans receiver. So that miners have the chance to rescue his life from the hazards occurs in coal mines.

The mining industry, particularly coal mining, has been recognized as one of the most dangerous occupations in the world. Mining operations involve various hazardous activities such as the release of dangerous gases like methane, carbon monoxide, Sulphur dioxide, and nitrogen oxide into the air, as well as underground mining hazards such as suffocation, gas poisoning, roof collapse, and gas explosion. These hazards pose significant risks to the health and safety of miners, and therefore, it is crucial to ensure that proper safety measures are in place to protect them.

In recent years, several researchers have developed intelligent safety systems for miners to enhance their safety while working in coal mines. One such system is the Zigbee-based intelligent helmet for coal miners, which was developed by researchers. This system uses three sensors, namely temperature sensors, humidity sensors, and gas sensors, to monitor the environmental conditions in the coal mine.

The system's helmet is equipped with these sensors that can detect the temperature, humidity, and gas levels in the surrounding environment. If any of the conditions exceed the safe levels, the helmet's buzzer will sound an alarm, alerting the miner to the

potential hazard. The Zigbee transceiver in the helmet then sends the information to the control station, where the necessary action can be taken to prevent any harm to

The first sensor in the helmet is the gas sensor, which monitors the concentration of hazardous gases like methane, CO, SO2, and NO2 in the air. The second sensor is the temperature sensor, which measures the temperature of the mine. The third sensor is the humidity sensor, which measures the moisture content in the air.

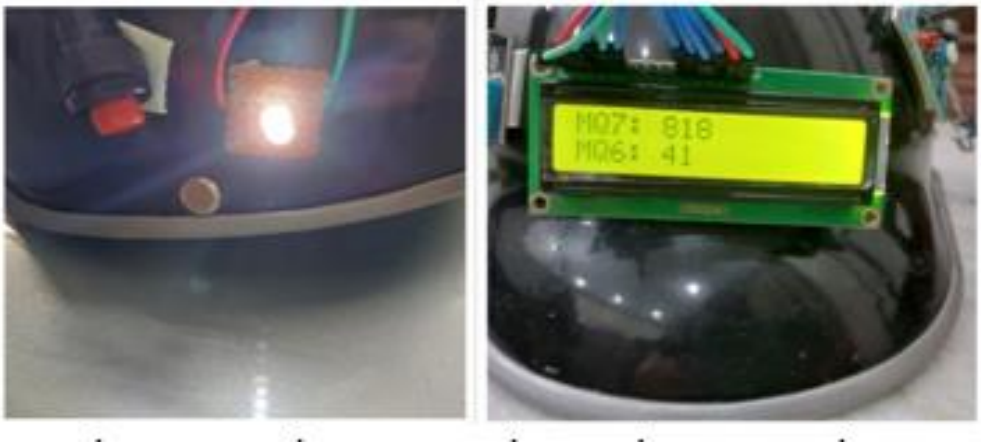

Figure 2.4 Alert generation and sensor values

When any of these sensors detect a hazardous condition, a buzzer alarm is activated on the helmet. The alarm is positioned on the helmet to be audible to the miner. Additionally, the system has a Zig bee transceiver that sends information about the hazardous condition to the control station. This allows the control station to take action and rescue the miners if necessary.

The Zig bee-based intelligent helmet for coal miners is an excellent example of how technology can improve safety in hazardous work environments. This system has been tested in coal mines and has proven to be effective in alerting miners to hazardous conditions. It has helped to reduce accidents and improve safety in coal mines.

One of the major advantages of this system is its ability to provide real-time information about the mine's environment. The system continuously monitors the air quality, temperature, and humidity levels, providing miners with up-to-date information about the conditions in the mine. This allows miners to take appropriate safe-ty measures and avoid hazardous conditions.

Another advantage of this system is its portability. The helmet is lightweight and easy to wear, making it convenient for miners to use. The system is also easy to in-stall and maintain, making it an affordable safety solution for small and medium-sized mines.

However, one of the limitations of using Zigbee technology is its limited bandwidth, which may not be suitable for transmitting large amounts of data. In contrast, Wi-Fi technology offers a much higher bandwidth and can transmit data over a longer distance. Therefore, in recent times, some researchers have proposed the use of Wi-Fi technology in safety systems for miners.

- The better version which we are going to produce in our project after researching through the research paper are as follow: -
- We are using a smart jacket which bis more coinvent for the user with detachable sensor system
- In place of Zig-bee technology we are using esp-826632-bit MCU model which is much faster and has greater range over Zig-bee technology
- As helmet with so many sensors can be very uncomfortable to wear in such high temperature inside the mines so we use a detachable belt which can be easily fit into the waist

In conclusion, the Zigbee-based intelligent helmet is an effective safety system for miners that can enhance their safety while working in coal mines. It is a cost-effective, reliable, and easy-to-maintain system that can detect hazardous conditions and alert miners to potential dangers. However, the use of Wi-Fi technology may offer some advantages over Zigbee, particularly in terms of range and bandwidth. Therefore, it is important to weigh the pros and cons of each technology before deciding on which one to use in a safety system for miners.

2.2.1 Scope in our project

NodeMCU ESP8266 and ZigBee are both wireless communication protocols that can be used for IoT applications. However, there are some differences between the two, and the choice of which to use depends on your specific use case.

Here are some reasons why you might choose to use NodeMCU ESP8266 over ZigBee:

1. Cost: NodeMCU ESP8266 is typically less expensive than ZigBee modules.
2. Wi-Fi compatibility: NodeMCU ESP8266 supports Wi-Fi communication, which can be useful if you need to connect to a Wi-Fi network or use the internet for your IoT application. ZigBee, on the other hand, uses a proprietary protocol that does not support Wi-Fi.

3. Versatility: NodeMCU ESP8266 is a more versatile platform, capable of running custom firmware, which can enable you to do more with your device.
4. Ease of programming: NodeMCU ESP8266 is easier to program than ZigBee, as it uses the familiar Arduino IDE and has a large community of developers who have created libraries and examples that can be used to get started quickly.
5. Familiarity: If you already have experience with Arduino programming, NodeMCU ESP8266 will be an easy platform to pick up.
6. Open source: NodeMCU ESP8266 is an open-source platform, which means that you can modify and customize the code to fit your specific needs.
7. Large community: NodeMCU ESP8266 has a large and active community of developers, which means that you can find plenty of support and resources online.
8. Rich feature set: NodeMCU ESP8266 has a rich feature set, including support for digital and analog inputs and outputs, PWM, I2C, SPI, and more.
9. Easy to integrate with other systems: Since NodeMCU ESP8266 supports Wi-Fi, it can be easily integrated with other systems, such as cloud services, web servers, and mobile apps.
10. Rapid prototyping: With its ease of use and versatility, NodeMCU ESP8266 is a great platform for rapid prototyping and experimenting with new IoT applications.

Feature	Zigbee Technology	Esp-8266 32-bit MCU
Frequency	2.4 GHz	2.4 GHz
Data Transfer Rate	Up to 250 Kbps	Up to 80 MHz (depending on the specific module used)
Range	Up to 70 meters indoors, up to 400 meters line of sight outdoors	Up to 400 meters with line of sight
Power Consumption	Low power consumption	Low power consumption
Security	High level of security with encryption features	Security can be implemented using various protocols
Network Topology	Mesh network topology	Can be used in various network topologies
Data Throughput	Lower throughput compared to esp-8266 MCU	Higher throughput with support for multiple protocols
Development Cost	Lower development cost	Higher development cost than Zigbee

Table 2.2 Difference between Zigbee Technology vs Esp-8266 32-bit MCU

2.3 Literature Review

Smart Helmet Using RF and WSN Technology for Underground Mine Safety

Year: 2014

2014 International Conference on Intelligent Computing Applications

Shabina S.

The underground mines all over the world are adversely affected by various hazards including gaseous explosions, landslides, fire hazards, etc. This leads to the significance of safety for the mine workers. A better communication technology has to be employed for an intelligent sensing and warning system. For this, RF technology is chosen for the communication inside the mines. The wireless sensor network is provided for the sensing of adverse working environment conditions. Combining both these technologies, a new smart helmet module is developed. The wireless sensor network consisting of various sensors senses mine environment parameters like temperature, pressure, humidity, gases like methane, carbon monoxide, etc. The measured parameters are processed and are used for an early intelligence warning system with the help of programmed alarm sounds, if there is any serious deviation from the normal parameter value range. The RF technology is also used as locating system, which helps in locating the mine-workers. This RF based wireless sensor network is reliable with easy installation and fast sensing and locating system. The design provides three modules, namely helmet module, localizer module, and control room module. The helmet module comprises of various sensors, microcontroller, antennas, encoders, decoders, etc. The helmet module acts as an intelligent, low power node in the wireless sensor network. The control room module contains antennas, PC, decoder, etc. The sensors are used to measure the variations in the temperature, humidity, pressure, fire and take decisions for required actions based on the measured data to ensure the safety of the underground mine workers. The RF technology also ensures the localization of the mine workers for their safety in a dangerous working platform. Thus the proposed system ensures safety and a reliable wireless communication inside the underground mines.

The development of a smart helmet module integrating wireless sensor networks and RF technology for underground mines is indeed a significant step towards enhancing safety and communication in hazardous environments. The system you described offers a comprehensive solution by utilizing various sensors to monitor environmental parameters, including temperature, pressure, humidity, and gases like methane and

carbon monoxide. These measurements are processed, and if there are deviations from the normal parameter ranges, programmed alarm sounds are triggered, providing early warnings to mine workers.

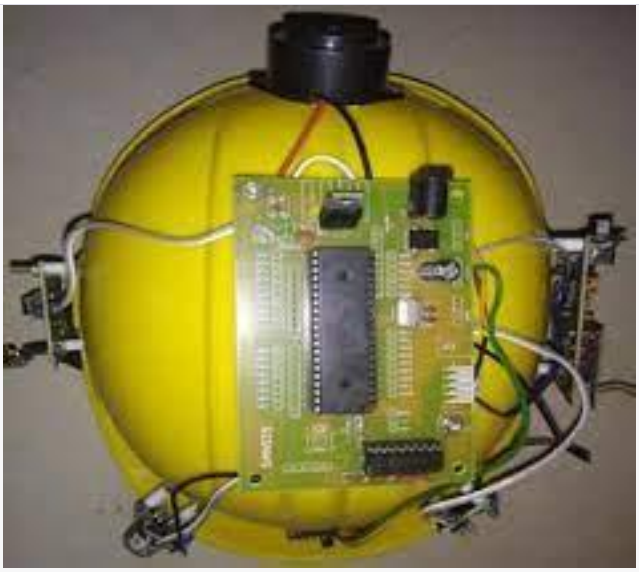

Figure 2.5 Helmet with sensors

The RF technology employed in the system serves a dual purpose. Firstly, it enables communication inside the mines by acting as a wireless communication network, facilitating the transmission of data from the sensors to the control room module. This wireless communication system is reliable, and its easy installation and fast sensing capabilities make it suitable for the challenging underground mine environ-ment.

Secondly, the RF technology also serves as a locating system for mine workers. By integrating RF-based localization, the system can track the positions of the workers in real-time, enabling better coordination and ensuring their safety in potentially dangerous situations. This feature is crucial for emergency response and evacuation procedures.

The overall system architecture includes three modules: the helmet module, localiz-er module, and control room module. The helmet module, equipped with sensors, microcontrollers, antennas, encoders, and decoders, acts as an intelligent node with-in the wireless sensor network. It continuously collects and transmits data to the con-trol room module. The localizer module assists in locating the mine workers using RF technology.

The control room module consists of antennas, a PC, and a decoder. It receives data from the helmet modules and processes the information to identify any deviations

from normal conditions. If critical situations arise, appropriate actions can be taken promptly to ensure the safety of the underground mine workers.

By combining wireless sensor networks, RF technology, and intelligent processing, the proposed system offers an effective solution to mitigate hazards and enhance safety in underground mines. It provides real-time monitoring, early warning sys-tems, and localization capabilities, enabling a rapid response to adverse conditions and ensuring the well-being of the workers.

It is crucial to ensure the safety of mine workers in underground mines, as they are exposed to various hazards such as gaseous explosions, landslides, and fire hazards. A better communication technology is required for an intelligent sensing and warning system. RF technology is a suitable choice for communication inside the mines, as it can provide reliable and fast communication in the underground environment.

The wireless sensor network with various sensors can sense mine environment parameters such as temperature, pressure, humidity, and gases like methane, carbon monoxide, etc. The measured parameters are processed and used for an early intelligence warning system with the help of programmed alarm sounds. This warning system can alert mine workers in case of any serious deviation from the normal parameter value range.

The RF technology is also used as a locating system to help in locating the mineworkers, which is an essential feature for their safety in a dangerous working platform. This RF-based wireless sensor network is reliable with easy installation and fast sensing and locating systems.

The proposed system consists of three modules, namely helmet module, localizer module, and control room module. The helmet module comprises various sensors, microcontroller, antennas, encoders, decoders, etc. The control room module contains antennas, PC, decoder, etc. The sensors measure the variations in temperature, humidity, pressure, and fire, and take decisions for required actions based on the measured data to ensure the safety of the underground mine workers.

In conclusion, the proposed system is an intelligent, low power node in the wireless sensor network, ensuring safety and reliable wireless communication inside the underground mines. This system is an excellent example of the implementation of modern technology in the mining industry, contributing to the improvement of working conditions and the safety of mine workers.

2.3.1 Scope in our project

Integration of a WIFI module: You plan to incorporate a WIFI module that uses RF (Radio Frequency) into a jacket. This module will serve as a replacement for the traditional helmet. The inclusion of the WIFI module aims to provide wireless connectivity and potentially enable additional features or functionalities.

Weight reduction and distribution: The current helmet design includes numerous sensors and a microcontroller, which contributes to increased weight. In your project, you propose a solution to distribute the weight by relocating the sensors and microcontroller from the helmet to a belt worn around the waist. This adjustment aims to reduce the weight on the head and improve overall comfort for the wearer.

Improved usability: By attaching the WIFI module to the jacket instead of the helmet, you anticipate that the device will be easier to use and work with. This change may eliminate the need for wearing a helmet altogether while still providing the desired functionalities.

- Utilizing a WIFI module: The project involves incorporating a WIFI module that operates on RF (Radio Frequency) technology.
- Jacket integration: The WIFI module will be attached to a jacket, replacing the traditional helmet.
- Improved usability: The jacket-mounted WIFI module is expected to offer increased convenience and ease of use compared to a helmet.
- Weight reduction goal: The project aims to address the issue of increased helmet weight caused by multiple sensors and a microcontroller.
- Weight distribution solution: The proposed solution involves redistributing the weight by adjusting the placement of sensors and the microcontroller.
- Belt placement: The sensors and microcontroller will be positioned in a belt worn around the waist.
- Comfort enhancement: By shifting the weight from the helmet to the waist belt, the project aims to improve overall comfort for the wearer.
- Enhanced mobility: The adjusted weight distribution enables greater freedom of movement, reducing strain on the head.
- Wireless connectivity: The integrated WIFI module allows for wireless communication and connectivity features.

- Retaining functionality: Despite the absence of a traditional helmet, the project intends to maintain or enhance the functionalities provided by the sensors and microcontroller.
- The better version which we are going to produce in our project after researching through the research paper are as follows: -
- We use the WIFI module which uses RF and we attach it into the jacket in place of helmet which is much easier to use and work with
- As they use so many sensors and microcontroller in a helmet it Increase the weight of the helmet.
- We here have come with a solution of distributing the weight by adjusting the sensors and microcontroller in the form of belt around the waist

Why we should our WIFI module over RF (Radio Frequency) technology?

Choosing a WIFI module over RF technology can offer several advantages in certain applications. Here are some reasons why you might consider using a WIFI module:

1. Higher data transfer rates: WIFI modules generally support higher data transfer rates compared to traditional RF technology. This means faster communication and transmission of data.
2. Wider range: WIFI modules typically provide a broader coverage range compared to RF technology, allowing for greater flexibility in communication over longer distances.
3. Standardized protocol: WIFI operates on standard protocols (such as IEEE802.11) that are widely adopted and supported by various devices and platforms. This ensures compatibility and interoperability with a wide range of devices and systems.
4. Better integration with existing networks: WIFI modules can easily connect to existing wireless networks, enabling seamless integration with other devices and infrastructure already utilizing WIFI technology.
5. Enhanced security features: WIFI modules often offer advanced security features, such as encryption protocols (e.g., WPA2) and authentication mechanisms, providing a higher level of data protection compared to traditional RF technology.
6. Ubiquitous availability: WIFI networks are prevalent in many environments, including homes, offices, public spaces, and commercial establishments. Uti-

lizing a WIFI module allows users to leverage existing infrastructure and access points without the need for additional RF hardware.

7. Compatibility with internet connectivity: WIFI modules can directly connect to the internet, allowing for seamless integration with web-based services and cloud platforms. This enables real-time data transfer, remote monitoring, and control capabilities.

It's important to note that the suitability of WIFI or RF technology depends on the specific requirements and constraints of your project. RF technology may still be preferable in certain scenarios where long-range communication, power efficiency, or specialized frequency bands are critical.

Aspect	**Wi-Fi Module**	**RF Technology**
Communication	Uses Wi-Fi standard for wireless data	Uses various RF frequencies for wireless communication
Range	Typically has a limited range (up to a few hundred feet)	Range can vary depending on the frequency used, but generally longer range potential
Data Transfe	High-speed data transfer	Data transfer rates can vary, typically lower than Wi-Fi
Power Consumption	Consumes higher power due to high-speed data transfer	Consumes lower power due to lower data transfer rates
Interference	Susceptible to interference from other Wi-Fi networks and devices	Can be less susceptible to interference, depending on frequency and environment
Network Topology	Typically used in infrastructure mode (connects to a Wi-Fi router)	Can be used in various network topologies, including point-to-point and mesh
Security	Provides advanced security protocols (WPA2, WPA3) for data encryption	Security measures may vary and need to be implemented separately

Table 2.3 Difference between Wi-Fi Module vs RF Technology

The proposed system of employing RF technology in combination with a wireless sensor network and smart helmet module aims to enhance safety and communication inside underground mines. The system consists of three main modules: the helmet module, localizer module, and control room module.

The helmet module is equipped with various sensors, a microcontroller, antennas, encoders, and decoders. These sensors are responsible for measuring parameters such as temperature, pressure, humidity, and gases like methane and carbon monoxide. The measured data is processed within the module to identify any serious deviations from normal parameter ranges. If such deviations are detected, programmed alarm sounds are triggered, alerting the mine workers of potential hazards.

The localizer module utilizes RF technology for the localization of mine workers within the underground mine. This helps track the whereabouts of workers in real-time, allowing for timely response in case of emergencies or accidents. The RF-based locating system provides reliable and fast sensing and locating capabilities, improving overall safety.

The control room module comprises antennas, a PC, and a decoder. This module serves as a central hub for receiving and processing data from the wireless sensor network and the localizer module. By monitoring the data received from the sensors, the control room can assess the mine's environment conditions and take necessary actions to ensure the safety of the workers.

The wireless sensor network, facilitated by RF technology, enables seamless communication between the helmet modules, localizer module, and control room module. The network provides a reliable means of transmitting sensor data and localization information, allowing for efficient monitoring and response in case of hazardous situations.

Overall, the proposed system offers a comprehensive solution for addressing safety concerns in underground mines. By integrating RF technology, wireless sensor networks, and intelligent helmet modules, mine workers can benefit from improved communication, early warning systems, and real-time localization, ensuring their safty in challenging working environments.

Chapter 3
Design & Implementation

Chapter 3

Design & implementation

3.1 Implementation of smart safety jacket

A smart safety jacket is equipped with different internal sensors for which sense the health parameters of miners working in mine. After collecting the data sensor is connected to ESP32 which is a Wi-Fi module and it sends sensor data to the server from where the responsible authority can make decisions based on signals received from the sensor.

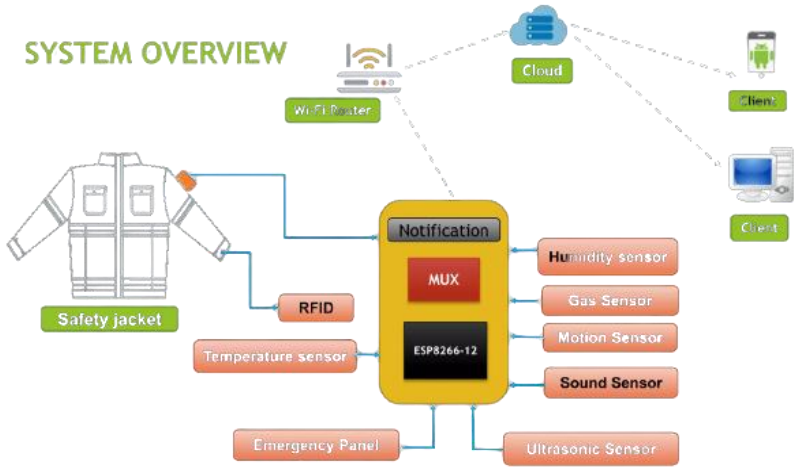

Figure 3.1 Smart Safety Jacket

The jacket is designed to monitor the miner's vital signs and detect any abnormalities, such as high body temperature or abnormal heart rate, which could indicate the onset of heat exhaustion or other health issues. It can also detect dangerous gases such as methane and carbon monoxide, which can build up in underground mines and pose a significant safety risk to miners. Additionally, the jacket is fitted with obstacle detection sensors that can detect obstacles or potential hazards in the miner's path, such as rocks or machinery, and alert the miner to avoid them.

3.2 Pulse Rate Sensor:

This sensor is the small and compatible sensor which fits on the fingertips or at the nerves of the miners. It encloses with the LED and an ambient light sensor the LED emits light which will directly fall on the nerves and if the blood is detected then the light received by the light sensor will be more because the light is reflected by blood and this change in received light is used to determine the heart rate. A pulse sensor is a device that is used to measure the heartbeat or pulse rate of an individual. Here is some more information about the pulse sensor

Figure 3.2 Pulse Rate Sensor

3.2.1 Applications: Pulse sensors are commonly used in various applications such as fitness trackers, medical devices, and other similar applications where heart rate monitoring is required.

3.2.2 Features: Some of the key features of pulse sensors include their high accuracy, real-time monitoring capability, and their ability to measure heart rate in a non-invasive manner. They are also typically small, lightweight, and easy to use, making them ideal for wearable applications.

3.2.3 Precautions: When using a pulse sensor, it is important to take certain precautions to ensure the safety and accuracy of the readings. These include properly positioning the sensor on the skin, avoiding movement or activity that may interfere with the reading, and calibrating the sensor to the individual user.

Overall, pulse sensors are a useful and reliable tool for monitoring heart rate and can be used in a variety of applications. Their non-invasive nature and real-time monitoring capability make them an ideal choice for many different types of projects

3.3 Temperature and Humidity sensor:

The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers the sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. The DHT11 sensor is a digital temperature and humidity sensor that is widely used in various electronic applications. Here is some more information about the DHT11 sensor

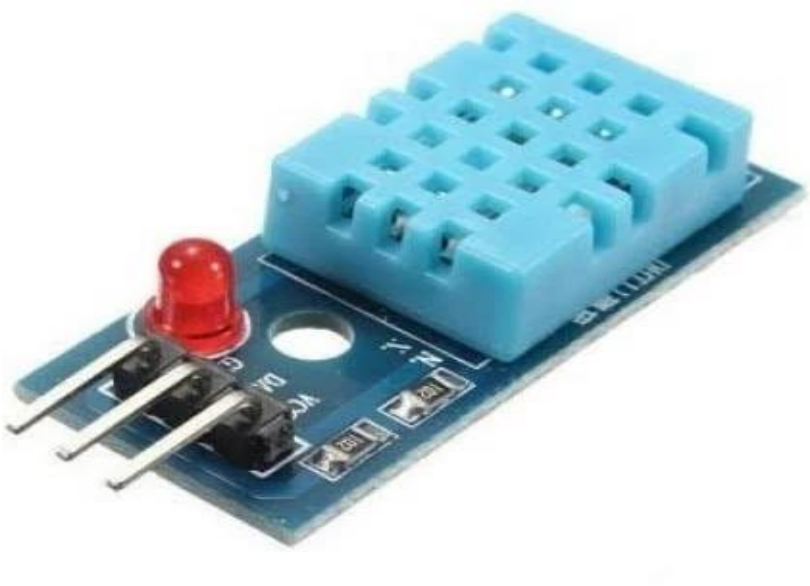

Figure 3.3 DTH11 Sensor

3.3.1 Applications: The DHT11 sensor is commonly used in various applications such as weather stations, home automation systems, and other similar applications where temperature and humidity measurements are required.

3.3.2 Features: Some of the key features of the DHT11 sensor include its high accuracy, low power consumption, and its ability to measure temperature in the range of 0 to 50°C with an accuracy of ±2°C and humidity in the range of 20% to 90% with an accuracy of ±5%.

3.3.3 Precautions: When using the DHT11 sensor, it is important to take certain precautions to ensure the accuracy and reliability of the sensor. These include properly calibrating the sensor, using it in a well-ventilated area, and avoiding exposure to extreme temperatures or humidity levels that may affect its performance.

Overall, the DHT11 sensor is a versatile and reliable sensor that is widely used in various electronic applications to measure temperature and humidity. Its high accuracy and low power consumption make it an ideal choice for many different types of projects.

3.4 Gas Sensor MQ4

The MQ-4 gas sensor is a gas sensor that is used to detect the presence of methane, which is a flammable gas that is commonly found in natural gas, coal mines, and other industrial settings. The sensor works by detecting changes in resistance as the gas interacts with the sensing material inside the sensor.

Figure 3.4 MQ4 Gas Sensor

3.4.1 Applications: The MQ-4 gas sensor is commonly used in various applications such as gas leakage detectors, gas alarms, gas concentration detectors, and other similar applications. It is widely used in industrial settings such as coal mines, gas pipelines, and gas storage facilities to detect the presence of methane and other flammable gases.

3.4.2 Features: Some of the key features of the MQ-4 gas sensor include its high sensitivity, low power consumption, and its ability to detect methane concentrations ranging from 200 to 10,000 ppm. It is also a relatively low-cost sensor and is widely available in the market.

3.4.3 Precautions: When using the MQ-4 gas sensor, it is important to take certain precautions to ensure the safety of the user and the environment. These include properly calibrating the sensor, using it in a well-ventilated area, and ensuring that it is not exposed to high levels of humidity or other environmental factors that may affect its performance.

Overall, the MQ-4 gas sensor is a versatile and reliable sensor that is widely used in various industrial applications to detect the presence of methane and other flammable gases.

3.5 Gas Sensor MQ7

The MQ-7 gas sensor is a gas sensor that is commonly used to detect the presence of carbon monoxide (CO), which is a toxic gas that is produced by the incomplete combustion of fossil fuels. Here is some more information about the MQ-7 gas sensor:

Figure 3.5 MQ7 Gas Sensor

3.5.1 Applications:

The MQ-7 gas sensor is commonly used in various applications such as carbon monoxide detectors, gas alarms, and other similar applications. It is widely used in residential and commercial buildings, as well as in industrial settings, to detect the presence of carbon monoxide.

3.5.2 Features:

Some of the key features of the MQ-7 gas sensor include its high sensitivity, low power consumption, and its ability to detect carbon monoxide concentrations ranging from 20 to 200 ppm. It is also a relatively low-cost sensor and is widely available in the market.

3.5.3 Precautions:

When using the MQ-7 gas sensor, it is important to take certain precautions to ensure the safety of the user and the environment. These include properly calibrating the sensor, using it in a well-ventilated area, and ensuring that it is not exposed to high levels of humidity or other environmental factors that may affect its performance.

Overall, the MQ-7 gas sensor is a versatile and reliable sensor that is widely used in various applications to detect the presence of carbon monoxide, which is a toxic gas that can be harmful to human health.

3.6 Wi-Fi Module ESP32:

We have implemented the smart safety jacket and have set up the health sensor with NodeMCU and have shown the sensor data on the IoT cloud using the ThingSpeak platform. Pulse sensor is connected to NodeMCU for sending sensor data to IoT cloud

ESP32 is a popular Wi-Fi and Bluetooth module developed by Espressif Systems. It is widely used in various applications such as home automation, Internet of Things (IoT), robotics, and other applications where wireless connectivity and processing power are required. Here are some more details about the ESP32 Wi-Fi module

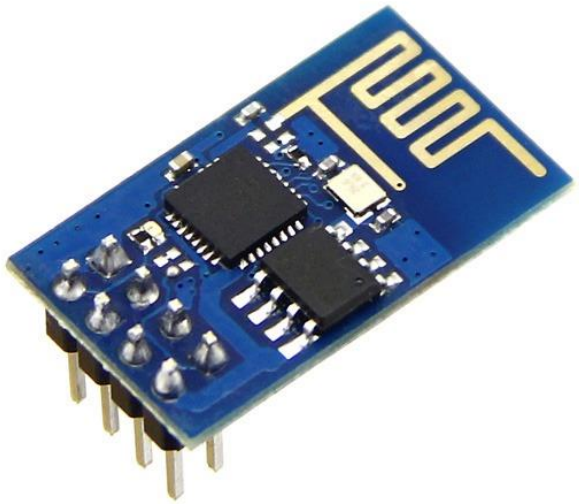

Figure 3.6 Wi-Fi module ESP32

3.6.1 Features: Some of the key features of the ESP32 Wi-Fi module include its high processing power, low power consumption, built-in Wi-Fi and Bluetooth connectivity, and support for various interfaces such as SPI, I2C, UART, and PWM. It also includes a variety of built-in peripherals such as timers, ADCs, and DACs, which makes it an ideal choice for a wide range of applications.

3.6.2 Applications: The ESP32 Wi-Fi module is commonly used in various applications such as home automation, IoT, robotics, and other similar applications where wireless connectivity and processing power are required. Its versatility and high performance make it an ideal choice for many different types of projects.

Overall, the ESP32 Wi-Fi module is a versatile and powerful Wi-Fi and Bluetooth module that is widely used in various electronic applications. Its high processing power, low power consumption, built-in Wi-Fi and Bluetooth connectivity, and support for various interfaces make it an ideal choice for many different types of projects.

3.7 Arduino Uno Microcontroller

Arduino Uno is a popular microcontroller board based on the ATmega328P microcontroller. It is widely used in various electronic projects and applications. Here

are some more details about the Arduino Uno The Arduino UNO includes 6 analog pin inputs, 14 digital pins, a USB connector, a power jack, and an ICSP (In-Circuit Serial Programming) header. It is programmed based on IDE, which stands for Integrated Development Environment. It can run on both online and offline platforms.

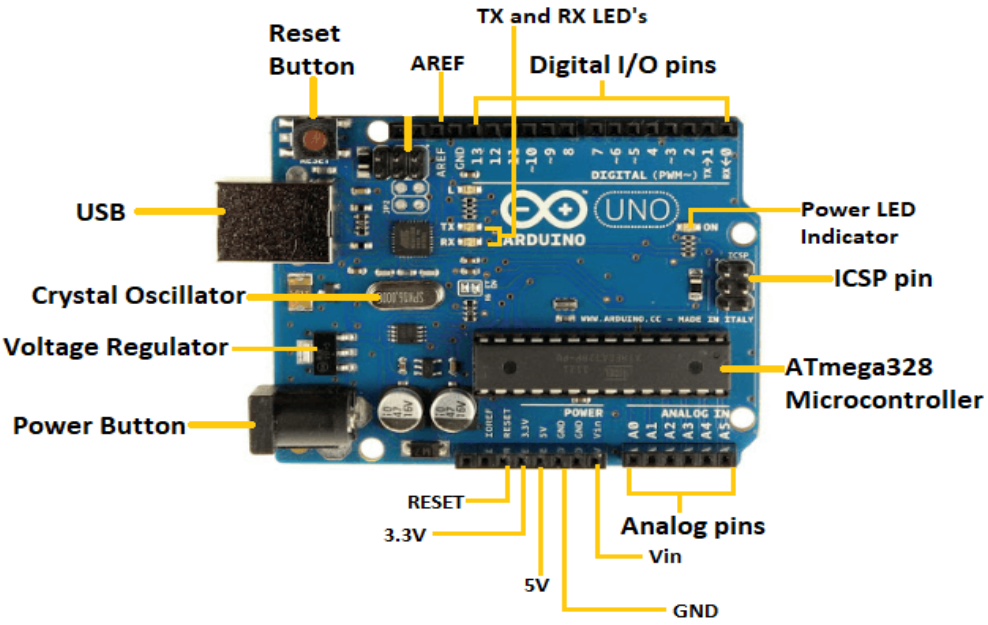

Figure 3.7 Arduino Uno Microcontroller

3.7.1 Features: Some of the key features of the Arduino Uno board include its low cost, easy-to-use software, and wide availability of shields and accessories. It also includes a variety of built-in peripherals such as digital and analog inputs and outputs, UART, SPI, and I2C, which makes it an ideal choice for a wide range of applications.

3.7.2 Applications: The Arduino Uno board is commonly used in various applications such as robotics, home automation, Internet of Things (IoT), and other similar applications where microcontroller-based processing and control are required. Its versatility and ease of use make it an ideal choice for hobbyists and professionals alike.

Overall, the Arduino Uno is a versatile and popular microcontroller board that is widely used in various electronic applications. Its low cost, ease of use, and wide availability of shields and accessories make it an ideal choice for a wide range of projects.

3.8 Emergency panel:

In case of any emergency, if a miner presses the emergency button on a smart safety jacket, the logic changes from 0 to 1 and sends the notification to the control room that a particular miner is in danger. y. If gases and temperature level rises from their

normal concentration, the worker falls down or his heartbeat slows down then normal. The buzzer turns on and warns the worker and control room about emergency situations.

Figure 3.8 Emergency Switch

3.9 *Miner Monitoring Process:*

The monitoring process can be carried out in two ways, by developing a web application for monitoring miners from personal computers and laptops etc. similarly an android app has been developed for monitoring miners from smart phones. Work allocation can be done according to requirement and tracking of each and every miner can be done using developing web apps. the person who is monitoring miner in mining area has responsibilities to take right action in right time for protecting miners from hazardous.

A web application can be developed to enable monitoring from personal computers and laptops. This application would provide a user-friendly interface for monitoring and managing the mine workers' data. The web application can display real-time data collected from the sensors in the mine, such as temperature, humidity, gas levels, and other relevant parameters. It can also provide alerts and notifications in case of any abnormal readings or hazardous conditions. Work allocation and tracking of individual miners can be facilitated through the web application, allowing supervisors to assign tasks and monitor the progress of each worker

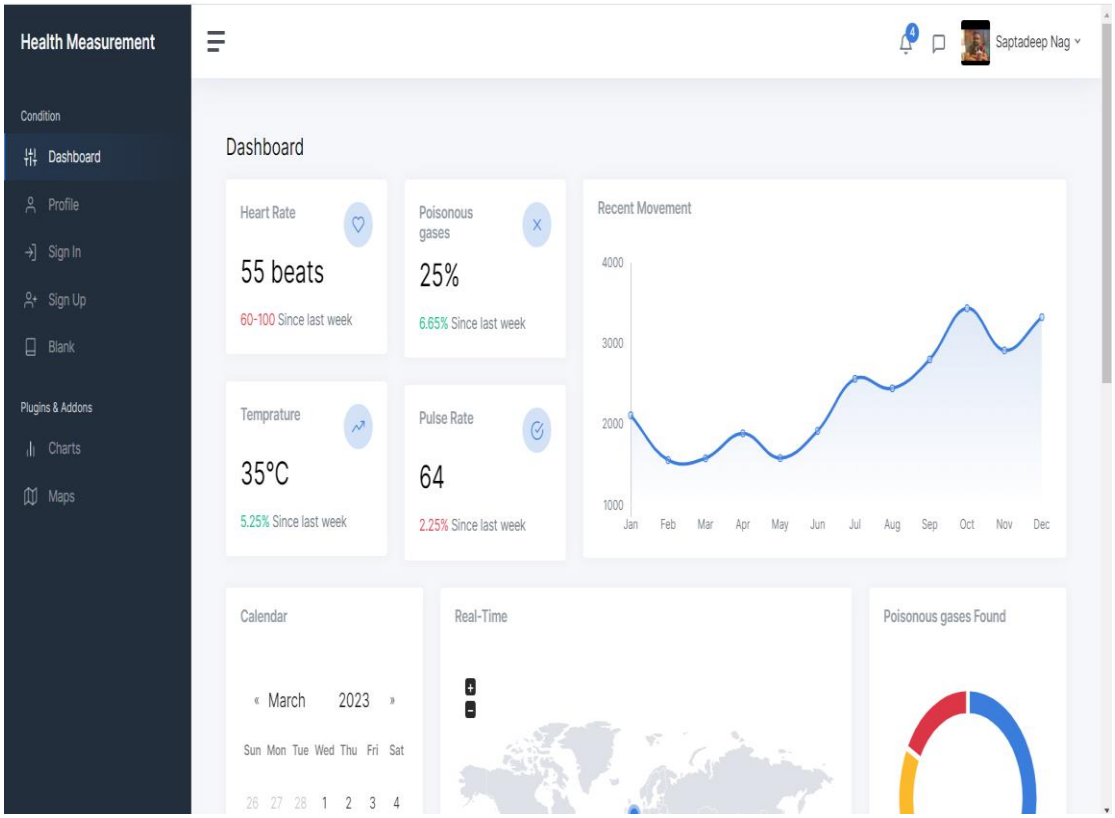

Figure 3.9 Dashboard

3.10 NEO-6M GPS Module

The NEO-6M GPS module is a popular GPS (Global Positioning System) module commonly used for location tracking and navigation purposes. Here's some information about the NEO-6M GPS module:

GPS Technology: The NEO-6M GPS module utilizes GPS technology, which is a satellite-based navigation system. It receives signals from multiple satellites orbiting the Earth to calculate precise positioning information.

3.10.1 Features: The NEO-6M GPS module offers several features and functionalities, including:

Positioning Accuracy: The module provides high positioning accuracy, typically within a few meters.

Fast Time to First Fix (TTFF): It has a fast TTFF, allowing for quick acquisition of satellite signals and obtaining a position fix.

Low Power Consumption: The module is designed to operate with low power consumption, making it suitable for portable and battery-powered devices.

Serial Communication: It communicates with external devices using serial communication protocols like UART (Universal Asynchronous Receiver-Transmitter).

Support for NMEA Protocol: The module supports the NMEA (National Marine Electronics Association) protocol for data communication and provides standardized data formats for easy integration with other systems.

Integrated Antenna: Some versions of the NEO-6M module come with an integrated ceramic patch antenna, simplifying the hardware setup.

Pin Configuration: The NEO-6M module typically has a standard 4-pin interface, including VCC, GND, TX (Transmit), and RX (Receive) pins. It requires a stable power supply and connection to a microcontroller or other devices capable of receiving and processing serial data.

Communication Protocol: The NEO-6M GPS module communicates with the host device or microcontroller using the NMEA protocol. It sends GPS data in standard NMEA sentences, such as GGA (Global Positioning System Fix Data) and RMC (Recommended Minimum Specific GNSS Data). These sentences provide information about latitude, longitude, altitude, speed, and other relevant GPS data.

Integration and Usage: To use the NEO-6M GPS module, you typically need to connect the appropriate power supply (usually 3.3V or 5V), ground, and serial communication pins to your microcontroller or device. You can then send commands and receive GPS data through serial communication. There are libraries and code examples available for popular microcontrollers, making it relatively easy to integrate the module into your projects.

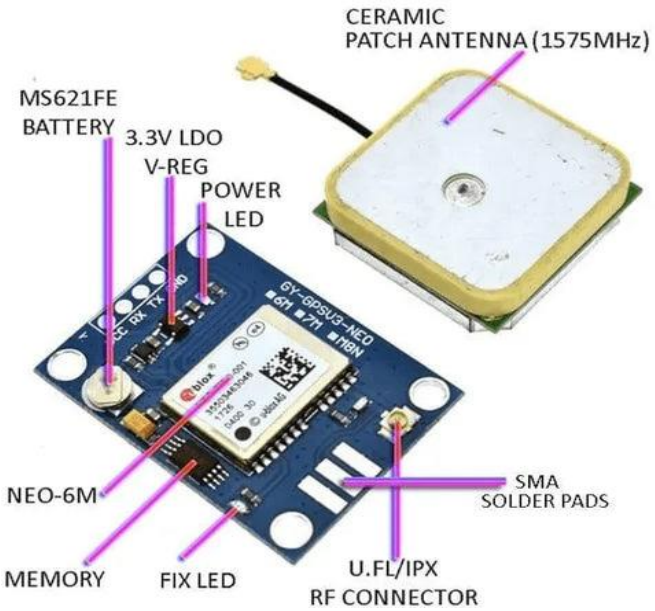

Figure 3.10 NEO-6M GPS module

The integration of a smart safety jacket with internal sensors, an ESP32 Wi-Fi module, and a server provides a comprehensive solution for monitoring the health parameters of miners in a mine environment. Here is how the system operates:

Smart Safety Jacket: The safety jacket is equipped with various internal sensors designed to measure specific health parameters of the miners. These sensors could include heart rate sensors, temperature sensors, respiratory rate sensors, and possibly other relevant sensors depending on the requirements. The sensors continuously collect data regarding the miners' health conditions while they are working in the mine.

ESP32 Wi-Fi Module: The collected data from the sensors is transmitted to an ESP32 module. The ESP32 module acts as a communication hub within the smart safety jacket. It processes the sensor data and establishes a Wi-Fi connection.

Server Communication: The ESP32 module establishes a connection with a designated server using Wi-Fi. The server acts as a centralized platform for receiving and storing the sensor data from multiple smart safety jackets. It is responsible for processing and analyzing the received data to provide insights and facilitate decision-making.

Decision-Making and Monitoring: The server receives the sensor data transmitted from each smart safety jacket. The responsible authority, such as mine supervisors or healthcare professionals, can access the server and monitor the data in real-time. They can analyze the health parameters of individual miners, identify any anomalies or critical conditions, and make informed decisions based on the signals received from the sensors.

Alerting and Notifications: In case of any abnormal health parameter readings or critical situations, the server can trigger alerts or notifications to the responsible authority. These alerts can be sent via email, SMS, or through a dedicated application interface. The authority can then take appropriate actions, such as sending help to the affected miner or initiating necessary medical interventions.

By integrating a smart safety jacket with internal sensors, Wi-Fi connectivity through the ESP32 module, and a server for data processing and decision-making, the system enables continuous monitoring of miners' health parameters in real-time. It facilitates early detection of health issues, timely interventions, and improved overall safety within the mine environment.

Chapter 4

Results

Chapter 4

Results

4.1 Software Simulation Results

This chapter shows all simulated results performed on the Self-made web page created by our developing team.

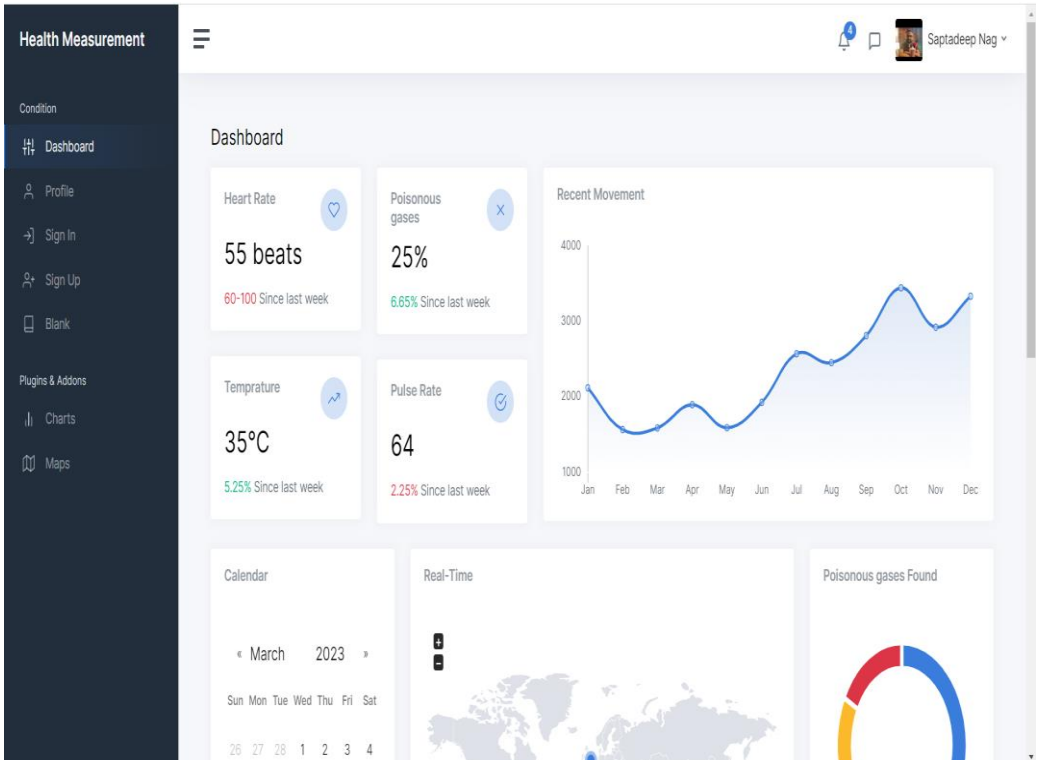

Figure 4.1 Dashboard Simulation of our web page created for the admin

The monitoring process can be carried out in two ways, by developing a web application for monitoring miners from personal computers and laptops etc. similarly an android app has been developed for monitoring miners from smart phones. Work allocation can be done according to requirement and tracking of each and every miner can be done using developing web apps. the person who is monitoring miner in mining area has responsibilities to take right action in right time for protecting miners from hazardous.

A web application can be developed to enable monitoring from personal computers and laptops. This application would provide a user-friendly interface for monitoring and managing the mine workers' data. The web application can display real-time data collected from the sensors in the mine, such as temperature, humidity, gas levels, and other relevant parameters. It can also provide alerts and notifications in case of any abnormal readings or hazardous conditions.

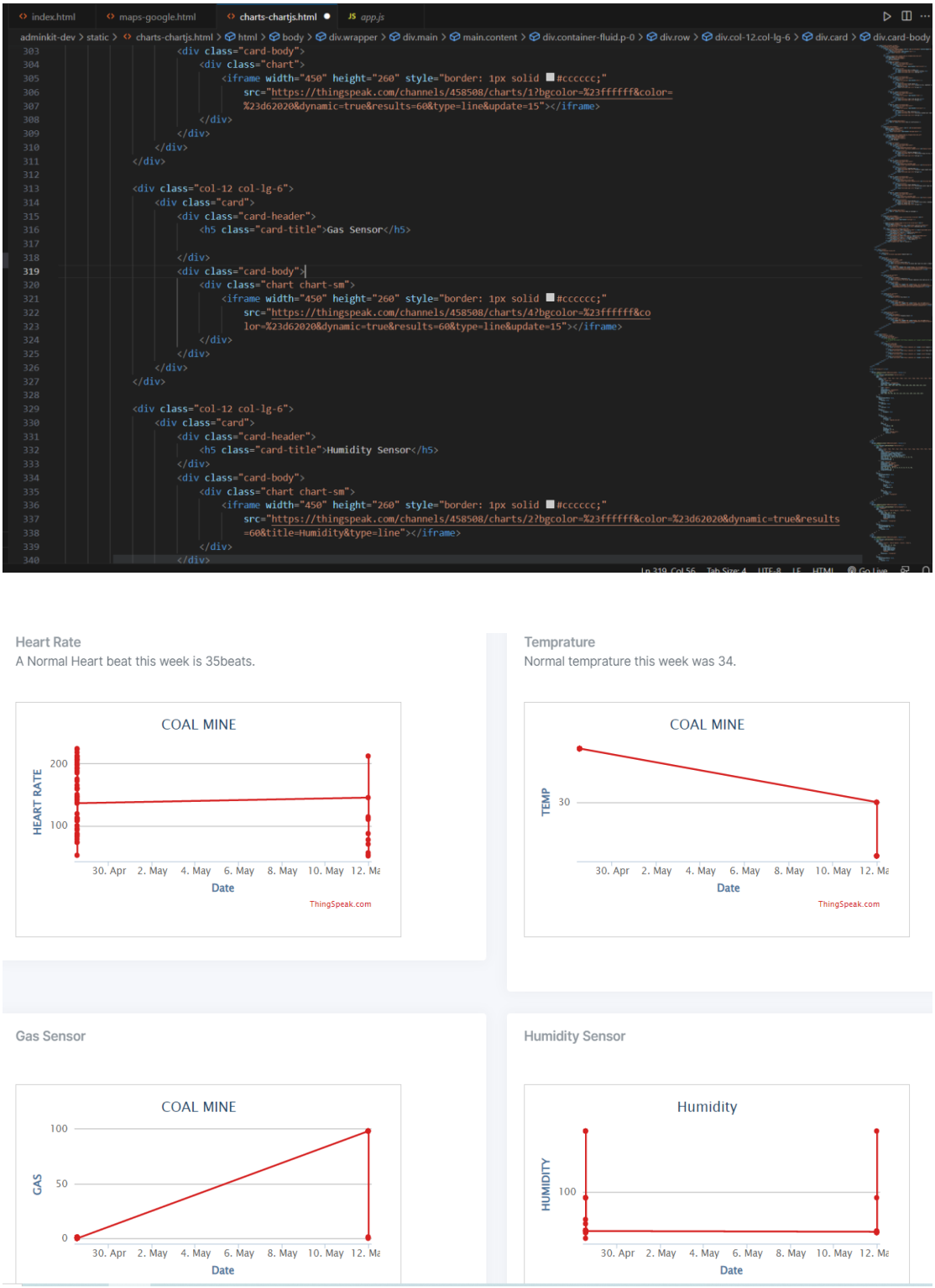

Figure 4.2 The graphical representation of our data and code snippet of fetching data using API

X-Axis: Time: The X-axis represents the time period during which the gas sensor readings were recorded. It is usually divided into intervals such as seconds, minutes, hours, or days. Y-Axis: Gas Concentration: The Y-axis represents the concentration or level of the detected gas. It could be measured in parts per million (ppm), percent (%), or any other relevant unit.

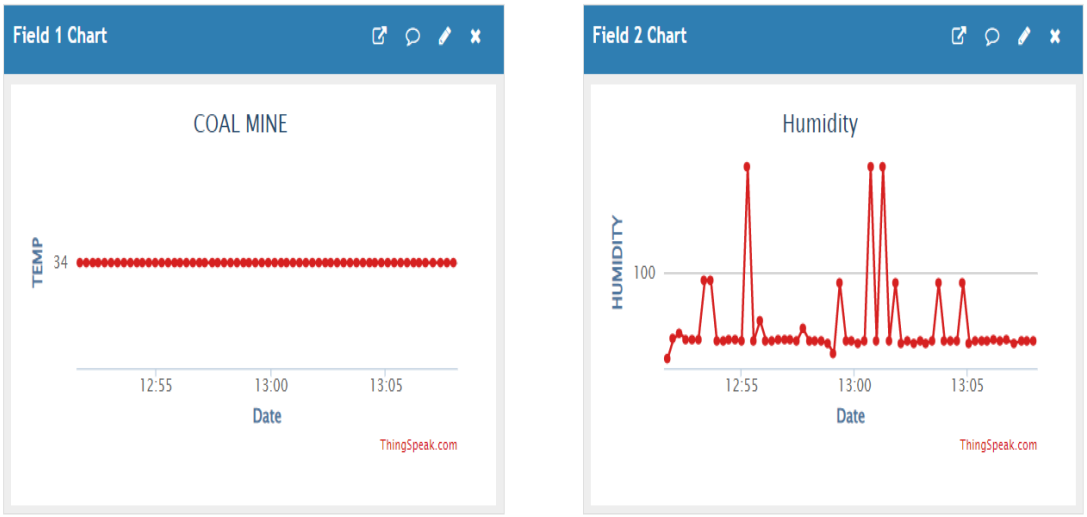

Figure 4.3 The graphical representation Temperature and Humidity DTH11

4.1.1 Temperature and Humidity sensor:

The sensor comes with a dedicated NTC to measure temperature and an 8-bit micro-controller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers the sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. The DHT11 sensor is a digital temperature and humidity sensor that is widely used in various electronic applications. Here is some more information about the DHT11 sensor

The DTH11 sensor is a popular and affordable digital temperature and humidity sensor commonly used in various applications. It provides accurate measurements of temperature and relative humidity and is often used in environmental monitoring, home automation, and weather stations. The graphical representation of DTH11 sensor data typically shows two main plots: one for temperature and another for humidity

The temperature plot displays the changes in temperature over time. It usually has time along the x-axis and temperature values along the y-axis. The plot may show a line graph or scatter plot, with each point representing a temperature measurement at a specific time. By observing the temperature plot, patterns such as temperature fluctuations, trends, or sudden changes can be identified. The humidity plot illustrates the variations in relative humidity. Similar to the temperature plot, it has time on the x-axis and humidity values on the y-axis. The plot may also be represented as a line graph or scatter plot, with each point indicating the humidity reading at a specific time. This plot helps visualize humidity levels and any patterns or trends associated.

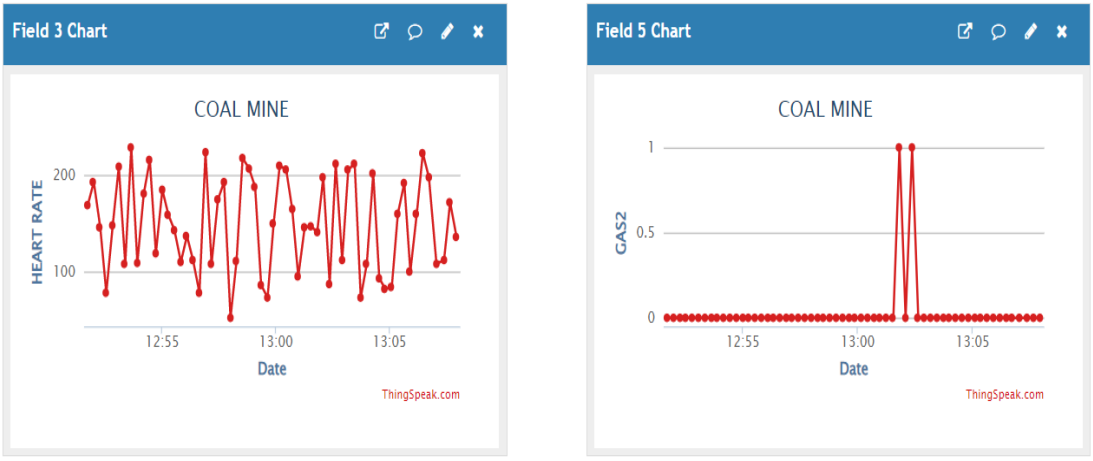

Figure 4.4 The Graphical representation Heart rate and Gas sensed

4.1.2 Pulse Rate Sensor:

This sensor is the small and compatible sensor which fits on the fingertips or at the nerves of the miners. It encloses with the LED and an ambient light sensor the LED emits light which will directly fall on the nerves and if the blood is detected then the light received by the light sensor will be more because the light is reflected by blood and this change in received light is used to determine the heart rate. A pulse sensor is a device that is used to measure the heartbeat or pulse rate of an individual. Here is some more information about the pulse sensor

X-Axis: Time: The X-axis represents the time period during which the heart rate readings were recorded. It is usually divided into intervals such as seconds, minutes, hours, or days.

Y-Axis: Heart Rate: The Y-axis represents the heart rate, typically measured in beats per minute (BPM). It shows the range of heart rate values recorded during the given time period.

Data Points: The graph displays data points that represent the heart rate at different time intervals. Each data point indicates the heart rate value at a specific point in time.

Trend Line or Curve: A trend line or curve may be included to show the general trend of the heart rate over time. This line helps identify any increasing, decreasing, or stable patterns in the heart rate data.

X-Axis: Time: The X-axis represents the time period during which the gas sensor readings were recorded. It is usually divided into intervals such as seconds, minutes, hours, or days. Y-Axis: Gas Concentration: The Y-axis represents the concentration or level of the detected gas. It could be measured in parts per million (ppm), percent.

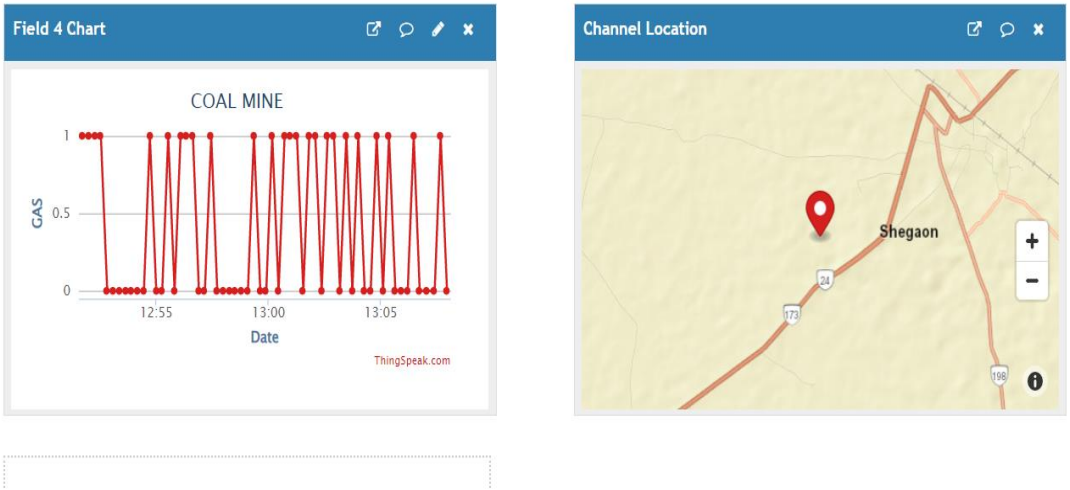

Figure 4.5 The Graphical representation Gas sensed and Live location

4.1.3 NEO-6M GPS Module

The NEO-6M GPS module is a popular GPS (Global Positioning System) module commonly used for location tracking and navigation purposes. Here's some information about the NEO-6M GPS module:

GPS Technology: The NEO-6M GPS module utilizes GPS technology, which is a satellite-based navigation system. It receives signals from multiple satellites orbiting the Earth to calculate precise positioning information.

X-Axis: Time or Distance: The X-axis represents either the time intervals or the distance covered, depending on the nature of the data being presented. If the GPS sensor data is time-based, the X-axis will represent the time duration of the recorded data. If the data is distance-based, the X-axis will represent the distance covered during the recorded data.

Y-Axis: Position or Speed: The Y-axis represents the GPS data being measured, which could be either the latitude and longitude positions or the speed recorded by the GPS sensor. The unit of measurement will be specific to the GPS parameter being plotted.

Data Points: The graph will display data points that represent the GPS measurements at different time intervals or distances. Each data point indicates the recorded position or speed at a specific point in time or distance.

Route or Path: The graph might include a visual representation of the route or path traveled. This can be shown as a line connecting the data points, indicating the actual path taken.

4.2 Hardware Implementation & Simulation Results

This chapter shows all simulated results performed on our Hardware Kit created by our team.

Figure 4.6 Prototype of Jacket and Sensor mounted on it

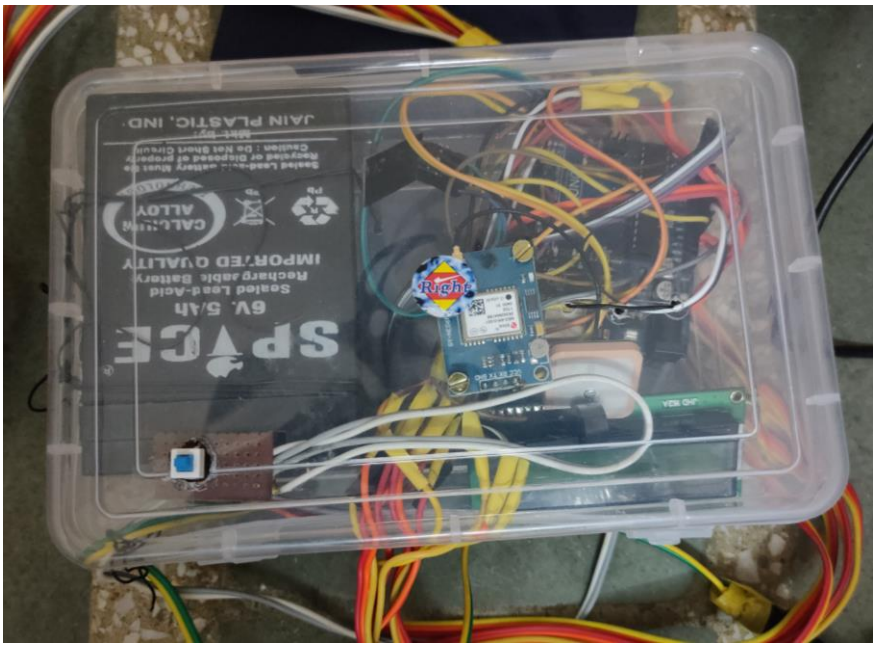

Figure 4.7 Prototype of Power box and Sensor and Microcontroller mounted on it

Figure 4.8 Prototype of Jacket and Sensor mounted on it with Applied voltage

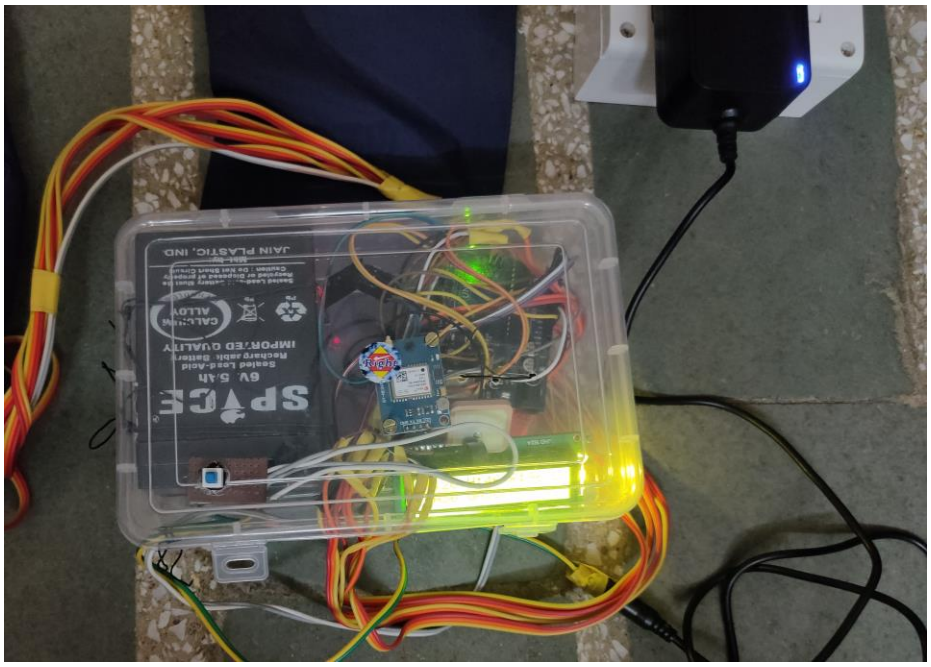

Figure 4.9 Prototype of Power box and Sensor and Microcontroller mounted on it with Applied voltage

Figure 4.10 LCD screen showing Live Reading of sensed parameters by sensor

Working and implementation hardware

The working prototype of a smart safety jacket for coal miners is a wearable device that aims to improve safety in the mining industry. The jacket includes various sensors such as gas sensors, temperature sensors, humidity sensors, and motion sensors that are mounted on it. These sensors are powered by an applied voltage that is carefully regulated to ensure optimal sensor performance.

The prototype of a smart safety jacket for coal miners incorporates various sensors to enhance safety and monitor vital parameters. One such sensor mounted on the jacket is typically a gas sensor, which detects harmful gases like methane and carbon monoxide in the mine environment. This sensor plays a crucial role in alerting miners to potentially dangerous gas levels.

The gas sensor, for example, detects harmful gases in the mine environment and alerts miners when gas levels exceed safe limits. The temperature and humidity sensors monitor the environmental conditions inside the mine, ensuring miners are working in safe and comfortable surroundings. The motion sensor detects any abnormal movements or falls, triggering alerts to other miners or supervisors.

The smart safety jacket is designed to be durable and resistant to harsh mining conditions, and it includes features like reflective strips and a bright LED light for improved

visibility. The sensors are connected to a microcontroller, which collects and processes the data and sends it to a central monitoring system via wireless communication.

The gas sensor operates using an applied voltage. When gas molecules come into contact with the sensor's surface, they react, causing a change in conductivity or resistance. The applied voltage facilitates this detection process. By measuring the resistance or conductivity changes, the gas sensor can determine the presence and concentration of gases.

Apart from the gas sensor, the smart safety jacket may also include other sensors such as temperature sensors, humidity sensors, and possibly even motion sensors. These sensors help monitor the overall environmental conditions inside the mine, ensuring that miners are working in safe and comfortable surroundings.

The applied voltage in the jacket's sensor system serves as the power source for the sensors. It supplies the necessary electrical energy to enable the sensors to function properly and collect data. The voltage is carefully regulated to ensure the sensors operate within their specified range and provide accurate readings.

The central monitoring system uses advanced algorithms to analyze the sensor data and identify any potential safety hazards. The system provides real-time alerts to miners and supervisors, enabling them to take immediate action to prevent accidents.

In summary, the working prototype of a smart safety jacket for coal miners is a wearable device that incorporates various sensors mounted on it, powered by an applied voltage. The sensors detect and monitor vital parameters to improve safety in the mining industry, and the data is collected and analyzed by a central monitoring system, which provides real-time alerts to miners and supervisors to prevent accidents.

Conclusion

Conclusion

The use of smart safety jackets for coal miners is an emerging technology that has the potential to revolutionize the mining industry. The jacket is equipped with various sensors and communication technologies that provide miners with real-time data on their health and safety. This technology has the potential to significantly enhance the safety and well-being of miners while improving the efficiency of the mining process.

One of the key benefits of smart safety jackets is their ability to monitor the health of miners. The jacket can be equipped with sensors that measure a miner's heart rate, body temperature, and blood oxygen levels. This information can be used to alert miners and their supervisors to potential health problems, allowing for early intervention and preventative measures. This technology can also help reduce the number of accidents and injuries caused by fatigue or health issues.

Another benefit of smart safety jackets is their communication capabilities. The jacket can be equipped with two-way radios, GPS tracking, and gas detection sensors. This enables miners to stay connected with their colleagues and supervisors while working underground. It also allows miners to quickly alert their supervisors in case of an emergency, such as a cave-in or gas leak. This rapid communication can help save lives and prevent serious accidents.

Personalized safety features are another potential benefit of smart safety jackets. The jackets can be designed to fit the needs of individual miners. For example, a miner who is claustrophobic may need a jacket that provides extra breathing space, while a miner with a hearing impairment may need a jacket that alerts them to danger using visual signals. This customization can significantly enhance the comfort and safety of miners, allowing them to focus on their work and stay safe.

Smart safety jackets also have the potential to be integrated with other safety technologies. For example, they can be integrated with gas detection sensors to provide real-time data on gas levels in the mine. This information can be used to alert miners and their supervisors to potential gas leaks, reducing the risk of explosions and other serious accidents. Additionally, smart safety jackets can be integrated with data analytics technology, enabling miners and their supervisors to analyze data on miner movements, location, and activities. This can help identify potential safety risks and optimize the mining process.

In conclusion, the use of smart safety jackets for coal miners is an exciting technology with significant potential for improving the safety and well-being of miners. These jackets can monitor miner health, provide rapid communication capabilities, offer personalized safety features, and be integrated with other safety technologies. The technology has the potential to significantly reduce the number of accidents and fatalities in the mining industry while improving the efficiency of the mining process. Further research and development are required to fully realize the potential of smart safety jackets, but their use represents a significant step towards making mining a safer and more efficient industry.

Future Scope

The integration of a smart safety jacket with internal sensors, an ESP32 Wi-Fi module, and a server provides a comprehensive solution for monitoring the health parameters of miners in a mine environment. Here is how the system operates:

Smart Safety Jacket: The safety jacket is equipped with various internal sensors designed to measure specific health parameters of the miners. These sensors could include heart rate sensors, temperature sensors, respiratory rate sensors, and possibly other relevant sensors depending on the requirements. The sensors continuously collect data regarding the miners' health conditions while they are working in the mine.

ESP32 Wi-Fi Module: The collected data from the sensors is transmitted to an ESP32 module. The ESP32 module acts as a communication hub within the smart safety jacket. It processes the sensor data and establishes a Wi-Fi connection.

Server Communication: The ESP32 module establishes a connection with a designated server using Wi-Fi. The server acts as a centralized platform for receiving and storing the sensor data from multiple smart safety jackets. It is responsible for processing and analysing the received data to provide insights and facilitate decision-making.

Decision-Making and Monitoring: The server receives the sensor data transmitted from each smart safety jacket. The responsible authority, such as mine supervisors or healthcare professionals, can access the server and monitor the data in real-time. They can analyse the health parameters of individual miners, identify any anomalies or critical conditions, and make informed decisions based on the signals received from the sensors.

Alerting and Notifications: In case of any abnormal health parameter readings or critical situations, the server can trigger alerts or notifications to the responsible authority. These alerts can be sent via email, SMS, or through a dedicated application interface. The authority can then take appropriate actions, such as sending help to the affected miner or initiating necessary medical interventions.

By integrating a smart safety jacket with internal sensors, Wi-Fi connectivity through the ESP32 module, and a server for data processing and decision-making, the system enables continuous monitoring of miners' health parameters in real-time.

Integration of advanced sensor technologies: Future smart safety jackets may incorporate advanced sensor technologies, such as gas sensors with increased accuracy and sensitivity, as well as additional sensors for detecting other hazardous substances or environmental factors. This could provide more comprehensive monitoring and early detection of potential dangers.

Real-time data analytics: Developing sophisticated algorithms and data analytics capabilities will enable real-time analysis of sensor data collected from the jackets. This could include predictive analytics to identify patterns or trends that may indicate potential safety risks. Such insights can help miners and supervisors make informed decisions and take preventive measures in a timely manner.

Communication and connectivity improvements: Enhancements in wireless communication technologies will enable seamless and reliable connectivity between the smart safety jackets and the central monitoring system. This could facilitate faster transmission of data, alerts, and communication between miners, supervisors, and rescue teams.

Integration with automation and robotics: As the mining industry embraces automation and robotics, smart safety jackets could be integrated with these technologies. For example, jackets could communicate with autonomous mining equipment or robotic systems to enhance coordination and safety protocols.

Health monitoring and biometrics: Future smart safety jackets may include health monitoring features, such as heart rate monitors, respiratory rate sensors, and fatigue detection systems. These capabilities could help assess the physical well-being of miners and provide early warnings of potential health issues or fatigue-related risks.

Enhanced durability and comfort: Ongoing research and development can focus on improving the durability, ergonomics, and comfort of smart safety jackets. Using lightweight and flexible materials, enhancing breathability, and considering ergonomic design elements will ensure that miners can comfortably wear the jackets for extended periods without hindering their work.

In conclusion, the future scope of smart safety jackets for coal miners involves advancements in sensor technologies, real-time data analytics, communication, integration with automation and robotics, health monitoring, and overall improvements in durability and comfort.

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