CHAPTER 1

INTRODUCTION

An IoT-based mining helmet is a revolutionary technology designed to improve the safety and efficiency of workers in mining environments. The helmet is equipped with sensors and communication devices that collect data about the worker's health, location, and environment. This information is then transmitted to a central database, where it can be analyzed in real-time to identify potential hazards, monitor worker performance, and optimize mining operations. The IoT-based mining helmet is designed to enhance the safety of workers in the mining industry by providing real-time monitoring of critical health parameters such as heart rate, body temperature, and breathing rate. The helmet is also equipped with sensors that can detect dangerous gases and other environmental hazards that could pose a threat to worker safety.

In addition to improving worker safety, the IoT-based mining helmet can also help to improve the efficiency of mining operations. By providing real-time data on worker performance and location, the helmet can help managers optimize work schedules, track productivity, and reduce downtime. The IoT-based mining helmet represents a significant advancement in mining technology, offering a powerful tool for improving worker safety, optimizing mining operations, and ultimately increasing profitability for mining companies.

An Internet of Things (IoT) based smart helmet for accident detection and notification, a prototype was proposed for detection of accidents on road. We provide an improved version of this by implementing more sensors and not making it exclusively for road accidents but also for industrial workers. In “IoT Based Smart Helmet for Underground Mines”, authors proposed a system in which smart helmet consists of various sensors.

BACKGROUND

IoT stands for "Internet of Things" and refers to a network of physical objects, devices, vehicles, and other items that are embedded with sensors, software, and connectivity, enabling them to collect and exchange data. The data collected from these devices can be analyzed to provide insights, automate processes, and enable new applications and services. The IoT is typically composed of devices that are connected to the internet and communicate with each other and other systems through wireless or wired networks. Examples of IoT devices include smart home appliances, wearables, industrial sensors, and vehicles.

Industrial sectors encompass a wide range of activities, from manufacturing and construction to mining and energy production. Despite advancements in technology and safety regulations, industrial workplaces remain inherently hazardous due to factors such as heavy machinery, high temperatures, toxic gases, and confined spaces. These conditions pose risks to workers' physical well-being and can lead to accidents, injuries, and even fatalities. Ensuring the safety of industrial workers is not only a legal and ethical imperative but also crucial for maintaining operational efficiency and reducing financial liabilities associated with accidents and downtime.

The emergence of the Internet of Things (IoT) technology has brought about transformative changes in various industries. IoT involves connecting devices, sensors, and systems to the internet to enable data collection, analysis, and remote control. In the context of industrial safety and productivity, IoT offers the potential to revolutionize workplace management and risk mitigation. By embedding sensors and communication capabilities into everyday equipment, IoT allows for real-time monitoring, predictive maintenance, and data-driven decision-making.

OBJECTIVE

The primary objective of this project is to design, develop, and implement an IoT-based safety helmet specifically tailored for mining workers. The helmet will integrate advanced sensors, communication modules, and data processing capabilities to enhance safety and situational awareness in the challenging mining environment. An essential objective is to integrate a range of sensors within the safety helmet to monitor critical environmental parameters relevant to mining, including temperature, humidity, gas concentrations, and air quality. This real-time monitoring will enable early detection of hazardous conditions such as high levels of toxic gases or inadequate ventilation.The project aims to create an intelligent alert system that can promptly identify and communicate potential hazards to mining workers. By analyzing data from sensors, the helmet will generate alerts for dangerous conditions such as gas leaks, unsafe temperatures, or poor air quality, enabling workers to take immediate precautions.

Scope

The scope of this project revolves around the creation of an IoT-based safety helmet designed exclusively for mining workers. The project's core objective is to conceive, develop, and implement a cutting-edge safety helmet that seamlessly integrates advanced sensors, communication modules, and data processing capabilities, thereby substantially augmenting safety measures, situational awareness, and overall operational efficiency in the mining environment.

The project encompasses a series of essential elements, including the design and development of a fully functional IoT-enabled safety helmet prototype. This prototype will integrate environmental sensors to monitor crucial conditions such as temperature, humidity, and gas concentrations within the mine. In addition, the safety helmet will incorporate physiological sensors for real-time tracking of miners' health indicators like heart rate and body temperature. GPS technology will be harnessed to enable accurate and continuous location tracking of mining personnel, fostering rapid response capabilities.

The project's ambit extends to the implementation of an astute hazard alert system, leveraging sensor data analysis to promptly identify and communicate potential threats to miners. Furthermore, a cloud-based platform will be established to facilitate secure data storage, comprehensive analysis, and remote access to critical information. A user-friendly mobile application will be developed, offering miners and supervisors the means to access real-time data and alerts, thereby empowering them to make informed decisions.

the project will yield a fully functional prototype of the IoT-enabled safety helmet, a cloud-based data platform, and a user-friendly mobile application. The associated comprehensive documentation will include design specifications, implementation methodologies, and user guidelines. The successful completion of this project rests upon the collaboration with mining site management for field testing and validation, adherence to project timelines, and the availability of necessary technical expertise. Although future enhancements, such as predictive analysis with machine learning or compatibility extensions to other hazardous industries, are not within the project's immediate scope, the groundwork laid here is poised to substantially enhance the safety and efficiency of mining operations.

Applicability

The applicability of this project is far-reaching and holds immense potential to revolutionize safety and operational paradigms in the mining industry. The IoT-based safety helmet developed within this project has a direct and immediate impact on enhancing the well-being of mining workers and the efficiency of mining operations. By integrating real-time environmental monitoring, physiological tracking, and hazard alerts, the safety helmet addresses the critical challenges of the mining environment, where exposure to hazardous gases, unstable temperatures, and strenuous physical conditions is commonplace.

The applicability of the IoT-enabled safety helmet extends to both surface and underground mining operations, where the risk of accidents, health hazards, and operational disruptions is ever-present. This innovation offers a comprehensive solution to mitigate these risks by providing continuous monitoring and early warning systems. It empowers miners with real-time information about their surroundings, allowing them to make informed decisions to ensure their safety.

The applicability of the project goes beyond immediate safety concerns. The data collected from the safety helmets can be utilized for thorough analysis of workplace conditions, incident investigation, and process optimization. By identifying patterns and trends, mining companies can proactively implement changes to improve safety protocols, enhance worker training programs, and streamline operational workflows.

In essence, the applicability of this project is not confined solely to mining workers' safety; it encompasses the broader domain of reshaping mining operations through data-driven insights and technological innovation. The IoT-based safety helmet has the potential to set a new industry standard, heralding a safer, more efficient, and technologically advanced era for the mining sector.

Project Management

The image below shows triple constraints for software projects. It is an essential part of software organization to deliver quality product, keeping the cost within client's budget constrain and deliver the project as per scheduled. There are several factors, both internal and external, which may impact this triple constrain triangle. Any of the three factors can severely impact the other two.

Therefore, software project management is essential to incorporate user requirements along with budget and time constraints.

Fig 1.1 Software Project Management

Importance of IoT in Mining Industry

The mining industry is rapidly adopting IoT technologies to improve efficiency, safety, and sustainability. Here are some of the ways IoT is important in the mining industry:

1. Asset tracking and monitoring: IoT devices can be used to track and monitor the location, status, and condition of mining equipment and vehicles in real-time. This can help mining companies optimize equipment utilization, reduce downtime, and improve maintenance schedules.
2. Safety and security: IoT devices such as wearables and sensors can be used to monitor workers' health and safety in real-time. This can help detect and prevent accidents and improve emergency response time.
3. Environmental monitoring: IoT devices can be used to monitor air and water quality, noise levels, and other environmental factors. This can help mining companies comply with regulations and reduce their impact on the environment.
4. Process optimization: IoT devices can be used to collect and analyze data from mining operations, allowing companies to identify areas for improvement and optimize processes for greater efficiency.
5. Autonomous vehicles and drones: IoT-enabled autonomous vehicles and drones can be used to explore and map mining sites, reducing the need for human operatorsin hazardous or remote areas.

Purpose of IoT-based Mining Helmet

An IoT-based mining helmet is a wearable device that incorporates various sensors, connectivity, and software to enhance safety and productivity in the mining industry. The purpose of an IoT-based mining helmet is to provide miners with real-time monitoring of their surroundings and vital signs, and to improve communication and response times in case of emergencies. Here are some of the key features and benefits of an IoT-based mining helmet:

1. Environmental monitoring: IoT sensors embedded in the helmet can monitor the air quality, temperature, humidity, and other environmental factors in real-time. This can help miners detect and avoid hazardous conditions and improve their overall well-being.
2. Vital signs monitoring: IoT sensors can also monitor the heart rate, breathing rate, and other vital signs of miners in real-time. This can help detect signs of fatigue or stress and improve the safety of miners.
3. Location tracking: IoT connectivity can be used to track the location of miners in real-time, allowing for better management of resources and emergency response.
4. Communication: IoT connectivity can also enable voice and text communication between miners and supervisors, improving collaboration and response times in case of emergencies.
5. Hazard detection and warning: IoT sensors can detect and warn miners of hazardous conditions such as gas leaks, cave-ins, and fires, improving their safety and reducing the risk of accidents.

CHAPTER 2

IOT BASED MINING HELMET FEATURES

An IoT-based mining helmet can have a wide range of features to enhance safety and efficiency in mining operations. Some possible features are:

1. Real-time tracking: The helmet can be equipped with GPS and other location sensors to track the miner's location in real-time, allowing for better situational awareness and emergency response.
2. Environmental monitoring: The helmet can be fitted with sensors to monitor temperature, humidity, air quality, and other environmental factors to alert miners to potential dangers such as poor air quality or extreme temperatures.
3. Health monitoring: The helmet can be integrated with sensors to monitor vital signs such as heart rate, blood pressure, and oxygen levels, alerting miners and their supervisors to any signs of distress or injury.
4. Communication: The helmet can have a built-in microphone and speakers to allow for hands-free communication between miners and their supervisors, as well as with other miners.
5. Hazard detection: The helmet can be equipped with sensors to detect hazards such as gas leaks or unstable ground conditions, alerting miners and their supervisors to potential dangers.
6. Emergency response: The helmet can have a panic button or other emergency features that allow miners to quickly summon help in case of an emergency.

Real Time Monitoring of Environmental Parameters

Real-time monitoring of environmental parameters is a critical feature for many applications, including industrial processes, environmental monitoring, and safety applications. Some possible parameters that can be monitored in real-time include:

1. Temperature: Temperature sensors can be used to monitor the ambient temperature in a given location. This can be useful in industrial processes to ensure that equipment is operating within acceptable temperature ranges.
2. Humidity: Humidity sensors can be used to measure the moisture content in the air. This can be important in environments where humidity can affect the performance of equipment or the health and safety of workers.
3. Air Quality: Sensors can be used to measure air quality parameters such as particulate matter, volatile organic compounds, and carbon monoxide. This can be important in applications such as indoor air quality monitoring, industrial process monitoring, and environmental monitoring.
4. Light: Light sensors can be used to measure the amount of light in a given location. This can be important in applications such as lighting control, plant growth monitoring, and security monitoring.
5. Sound: Sound sensors can be used to measure the level of noise in a given location. This can be important in applications such as noise pollution monitoring, building acoustics, and safety monitoring.
6. Pressure: Pressure sensors can be used to measure the pressure of gases or liquids in a given location. This can be important in industrial processes, environmental monitoring, and safety applications.
7. Radiation: Radiation sensors can be used to measure the levels of radiation in a given location. This can be important in applications such as nuclear power plants, medical facilities, and environmental monitoring.

Gas Detection System

A gas detection system in an IoT-based mining helmet is a valuable safety feature that can help protect miners from harmful gases and prevent accidents. The system works by detecting the presence of gas in the surrounding environment and alerting the miner to take appropriate action, such as evacuating the area or putting on a gas mask.

To implement such a system, the mining helmet would need to be equipped with a gas sensor that can detect the specific types of gases commonly found in mining environments, such as methane, carbon monoxide, and hydrogen sulfide. The sensor would be connected to a microcontroller or IoT device, which would process the sensor data and send alerts to the miner's smartphone or a centralized monitoring system.

The gas detection system could also be integrated with other sensors in the mining helmet, such as temperature and humidity sensors, to provide a comprehensive picture of the mining environment and help miners make informed decisions about their safety.

In addition to detecting gas, the IoT-based mining helmet could also incorporate other safety features, such as location tracking, emergency communication, and impact detection. By combining multiple sensors and communication technologies in a single device, the mining helmet can provide miners with a powerful tool for staying safe and preventing accidents in hazardous work environments.

GPS Tracking System

A GPS tracking system in an IoT-based mining helmet can provide valuable location information for miners and enhance safety in mining environments. The system works by using GPS technology to track the location of the miner wearing the helmet and transmitting that information to a central monitoring system

To implement such a system, the mining helmet would need to be equipped with a GPS module and a microcontroller or IoT device. The GPS module would receive signals from GPS satellites and use them to determine the miner's location, which would then be transmitted to the microcontroller or IoT device. The device would process the location data and send it to a centralized monitoring system, where it could be used to track the movements of miners and ensure their safety.

The GPS tracking system could also be integrated with other sensors in the mining helmet, such as temperature and humidity sensors, to provide a comprehensive picture of the mining environment and help miners make informed decisions about their safety. For example, if the temperature in a particular part of the mine becomes too high, the GPS tracking system could alert miners to move to a cooler area.

In addition to enhancing safety, the GPS tracking system could also improve efficiency in mining operations by providing real-time location data for miners and equipment. This information could be used to optimize mining routes, track equipment utilization, and improve overall productivity.

Fall Detection and Alert System

A fall detection and alert system in an IoT-based mining helmet can provide a critical safety feature for miners working in hazardous environments. The system works by detecting when a miner has fallen and automatically sending an alert to a central monitoring system or emergency responders.

To implement such a system, the mining helmet would need to be equipped with an accelerometer or gyroscope sensor that can detect sudden changes in movement or orientation. When the sensor detects a fall, it would trigger an alert to the microcontroller or IoT device in the helmet, which would then initiate an emergency response.

The alert could take several forms, depending on the specific requirements of the mining operation. For example, it could trigger an audible alarm in the helmet to alert nearby miners, or it could send a message to a centralized monitoring system that could then dispatch emergency responders to the miner's location.

In addition to fall detection, the IoT-based mining helmet could also incorporate other safety features, such as gas detection and GPS tracking, to provide a comprehensive safety solution for miners. By combining multiple sensors and communication technologies in a single device, the mining helmet can provide miners with a powerful tool for staying safe and preventing accidents in hazardous work environments.

A fall detection and alert system in an IoT-based mining helmet is a critical safety feature that can help protect miners from injury and improve response times in emergency situations. By leveraging sensor technology and communication systems, the system can provide an advanced level of safety and protection for workers in the mining industry.

Communication System

A communication system in an IoT-based mining helmet is a valuable feature that can improve safety and efficiency in mining operations. The system works by enabling miners to communicate with each other and with a central monitoring system using voice, data, or text messages.

To implement such a system, the mining helmet would need to be equipped with a communication module, such as a Bluetooth or Wi-Fi module, and a microcontroller or IoT device. The communication module would enable the helmet to connect to other devices in the mining operation, such as other helmets or a central monitoring system.

The communication system could provide several benefits for miners, including:

1. Real-time communication: Miners could use the system to communicate with each other in real-time, enabling them to coordinate their activities and respond quickly to emergencies.
2. Remote monitoring: A central monitoring system could use the communication system to remotely monitor the location and status of miners, providing valuable information for safety and efficiency.
3. Data transmission: The communication system could also be used to transmit data from sensors in the mining helmet, such as temperature or gas sensors, to a central monitoring system.

A communication system in an IoT-based mining helmet is a powerful tool for improving safety and efficiency in mining operations. By enabling real-time communication, remote monitoring, and data transmission, the system can help miners stay safe and make informed decisions in hazardous work environments.

Increased Efficiency

IoT-based mining helmets can also be designed to increase efficiency in mining operations. Here are a few ways to increase the efficiency of IoT-based mining helmets:

1. Monitoring equipment performance: IoT-based mining helmets can be equipped with sensors that monitor the performance of mining equipment. This can help to identify potential issues or maintenance needs before they cause downtime.
2. Asset tracking: By incorporating GPS sensors, IoT-based mining helmets can also be used to track the location and movement of mining equipment. This can help to optimize equipment usage and minimize downtime.
3. Condition monitoring: IoT-based mining helmets can be equipped with sensors that monitor the condition of the mine, including the walls, roof, and floor. This can help to identify any potential hazards, such as collapses or unstable ground, and prevent accidents.
4. Remote monitoring: IoT-based mining helmets can be used to remotely monitor the mine and the activities of the miners. This can help to identify potential issues early on and make quick decisions to prevent accidents or downtime.
5. Automated alerts and notifications: IoT-based mining helmets can be programmed to send automated alerts and notifications to relevant stakeholders, such as maintenance teams or supervisors. This can help to ensure timely action and prevent downtime.
6. Data analysis: IoT-based mining helmets can collect large amounts of data, which can be analyzed to identify patterns and trends. This can help to optimize mining operations, improve safety, and reduce costs.

CHAPTER 3

THEORY AND WORKING

The theory underpinning this project revolves around the fusion of IoT technology and wearable devices to enhance safety and operational efficiency in the mining industry. The integration of IoT-enabled sensors, communication modules, and data analysis mechanisms within the safety helmet serves as a pivotal advancement. This amalgamation leverages the interconnectedness of devices and the power of real-time data processing to provide a comprehensive solution for mining workers' safety.

At the core of the project's theory is the concept of continuous environmental monitoring. Environmental sensors embedded in the safety helmet enable the real-time collection of critical parameters such as temperature, humidity, and gas concentrations. This data is then relayed through wireless communication protocols to a cloud-based platform for analysis. This step embodies the principles of IoT, where data is seamlessly transferred and processed to provide actionable insights.

Furthermore, the integration of physiological sensors within the safety helmet brings a new dimension to worker safety. These sensors monitor vital signs such as heart rate and body temperature, reflecting the wearer's physical state. The collected physiological data, combined with environmental data, forms the basis for early hazard detection and alerts. This theory aligns with the IoT concept of data-driven decision-making, where sensor data is translated into meaningful information that guides worker actions and operational decisions.

The GPS technology integrated into the safety helmet extends the theory to include location tracking. This component enhances worker accountability, aids in efficient resource allocation, and facilitates rapid response during emergencies. By merging real-time location information with environmental and physiological data, the project transforms theory into tangible solutions that redefine safety protocols and operational practices within the mining environment.

Sensor

An IoT-based mining helmet typically integrates various sensors to monitor the environment, the miner's health and safety, and other relevant data. Here are some of the sensors commonly found in an IoT-based mining helmet:

1. Gas sensors: Gas sensors are used to detect harmful gases, such as methane or carbon monoxide, that may be present in the mining environment. These sensors help prevent gas-related accidents and injuries by triggering alarms or alerting miners to evacuate the area when gas levels exceed safe limits.
2. Temperature sensors: Temperature sensors monitor the temperature in the mining environment and can alert miners or the central monitoring system when temperatures reach unsafe levels.
3. Humidity sensors: Humidity sensors measure the humidity in the air, which is an important factor in mining safety, as high humidity can cause dehydration and heat exhaustion.
4. Accelerometers and gyroscopes: These sensors are used to detect sudden changes in motion or orientation, which can indicate that a miner has fallen or been injured.
5. Light sensors: Light sensors measure the amount of light in the mining environment, which can help miners see and navigate in low-light conditions.
6. GPS module: A GPS module is used to track the location of the miner wearing the helmet, which can be used to optimize mining routes and monitor the movements of miners.
7. Heart rate monitors: These sensors can be used to monitor the miner's heart rate and alert the miner or central monitoring system if the heart rate exceeds safe limits.

Server

An IoT based mining helmet may or may not have a server, depending on the specific requirements of the application. However, if a server is needed, it would typically be used to store and analyze data from the helmet's sensors and provide real-time alerts to the wearer or other stakeholders. Some common types of servers that can be used in an IoT based mining helmet are:

1. Cloud Server: A cloud server is a virtual server that is hosted on a cloud computing platform. It can be used to store and analyze data from the helmet's sensors and provide real-time alerts to the wearer or other stakeholders. Cloud servers can be easily scaled up or down based on the needs of the application and can be accessed from anywhere with an internet connection.
2. Edge Server: An edge server is a local server that is deployed closer to the source of the data. It can be used to store and process data from the helmet's sensors in real- time, without the need for a cloud server. Edge servers can reduce latency and bandwidth usage by processing data locally, but they may have limited storage and processing capabilities compared to cloud servers.
3. Mobile Server: A mobile server is a server that is deployed on a mobile device, such as a Smartphone or tablet. It can be used to store and process data from the helmet's sensors in real-time, without the need for a cloud or edge server. Mobile servers can provide mobility and flexibility, but they may have limited processing and storage capabilities compared to cloud and edge server.

Processing Unit

An IoT based mining helmet may have various processing units depending on the specific requirements of the application. However, some common processing units that can be used are:

1. Microcontroller: A microcontroller is a small computer on a single integrated circuit that can be used to control various functions of the helmet. It can perform tasks like data acquisition, sensor interfacing, and actuator control.
2. Digital Signal Processor (DSP): DSPs are specialized microprocessors that are designed to process digital signals in real-time. They are used to filter, amplify, and analyze sensor data from the helmet to detect various events like gas leaks, temperature changes, and falls.
3. System on a Chip (SoC): An SoC is a complete computer system on a single chip that includes a microprocessor, memory, and other peripherals. It can be used to run more complex algorithms and perform tasks like machine learning and artificial intelligence.
4. Field-Programmable Gate Array (FPGA): FPGAs are reconfigurable chips that can be programmed to perform specific functions. They can be used for tasks like image processing and video analytics in the helmet.

Improved Safety

IoT-based mining helmets can be designed to improve safety in mining by incorporating various sensors and communication technologies. Here are a few ways to improve the safety of IoT-based mining helmets:

1. Real-time location tracking: GPS sensors can be integrated into the helmets to track the location of miners in real-time. This can be useful in case of an emergency as it can help rescue teams locate miners quickly.
2. Gas detection: Sensors for detecting toxic gases such as carbon monoxide and methane can be installed in the helmets to alert miners of any danger. The helmet can be programmed to trigger an alarm or warning signal when the concentration of these gases exceeds the safe limit.
3. Temperature monitoring: Temperature sensors can be used to monitor the temperature in the mine. This can be useful in case of fire or overheating of equipment. The helmet can be programmed to alert miners when the temperature reaches a certain threshold.
4. Communication: IoT-based mining helmets can be equipped with communication technologies such as Wi-Fi, Bluetooth, or cellular networks. This can allow miners to communicate with each other or with the surface in case of an emergency.
5. Impact detection: Helmets can be equipped with sensors to detect any impacts or collisions. This can help to identify any injuries that may have occurred and alert the rescue team.
6. Health monitoring: IoT-based mining helmets can also be used to monitor the health of miners. Sensors can be used to monitor heart rate, blood pressure, and other vital signs. This can help to identify any potential health issues early on.

Reduced Downtime

IoT-based mining helmets can be designed to reduce downtime in mining operations. Here are a few ways to reduce downtime using IoT-based mining helmets:

1. Predictive maintenance: IoT-based mining helmets can be equipped with sensors that monitor the performance of mining equipment. These sensors can detect any signs of wear or impending failure, allowing maintenance teams to take action before the equipment breaks down. This can reduce unplanned downtime and prevent costly repairs.
2. Real-time monitoring: IoT-based mining helmets can provide real-time data on the condition of the mine and the performance of equipment. This can help to identify potential issues early on and make quick decisions to prevent downtime.
3. Remote troubleshooting: IoT-based mining helmets can be used to remotely troubleshoot equipment issues. This can reduce the need for maintenance teams to travel to the mine, saving time and reducing downtime.
4. Automated alerts: IoT-based mining helmets can be programmed to send automated alerts and notifications to relevant stakeholders when issues are detected. This can ensure that the right people are notified quickly, reducing response times and minimizing downtime.
5. Improved communication: IoT-based mining helmets can be equipped with communication technologies such as Wi-Fi, Bluetooth, or cellular networks. This can enable miners to communicate with each other and with the surface in real-time, allowing issues to be identified and addressed quickly.

Block Diagram

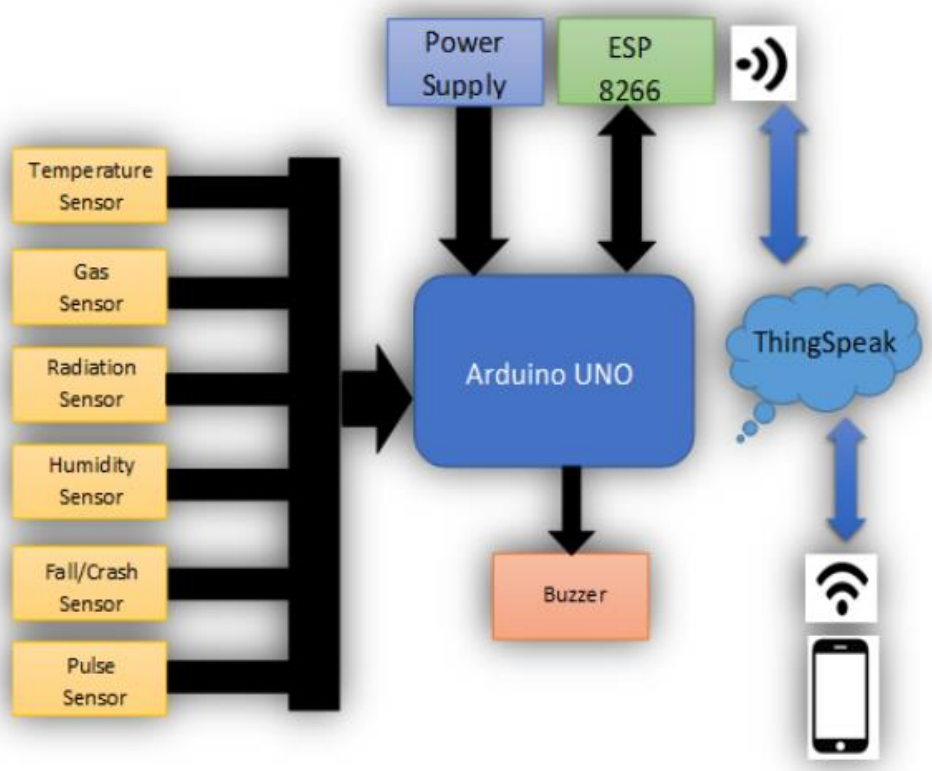

Fig 3.1 Block Diagram of the proposed system

Algorithm

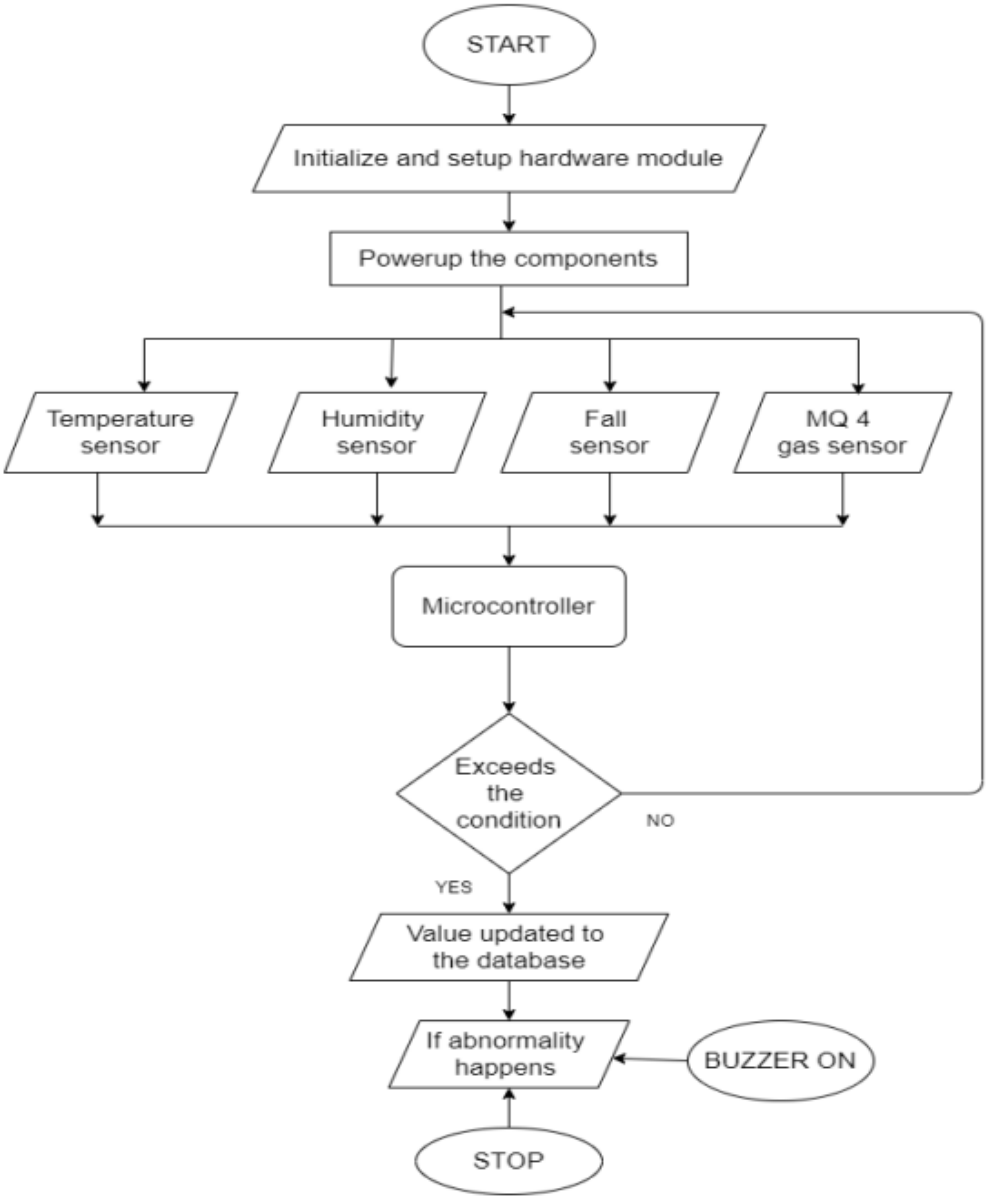

Fig 3.2 Algorithm of the proposed system

CHAPTER 4

DESIGN AND IMPLEMENTATION

The Mining Industry requires a range of high-quality CE certified miners safety helmets (hard hats) suitable for mining, construction and utility companies. Carbide lamps were used with hard protective helmets, but helmets that used electric lamps would have a cord holder to keep the cord out of the miner’s way. A form of this helmet and electric lamp combination is still worn today, with improvements in the area of battery life and weight, a change to tungsten and LED bulbs, and breakaway or segmented cords to allow the miner to be less inhibited by the battery pack. The safety Standards should not be compromised.

The outer top of the shell has an fall detection sensor socket (for detecting falling debris) , the sides have a compartment for the Temperature and Humidity sensor, the back of the helmet is supposed to have gas sensor, Our 4th and the important pulse sensor is placed on the strap of the helmet which starts from behind the ear and ends at the chin.

Apart from these the helmet has a normal design including the typical safety brackets under the shell this suspension system not only fasten the mining helmet to miners' heads, but also provide excellent shock resistance by keeping an empty space between miner's head and the hard shell of the helmet, Built-in light bulbs make the miners easy to see in the darkness. Maybe we can have provision for a metal bracket on the helmet for easy attachments.

The design of the IoT-based safety helmet involves a sophisticated integration of hardware components to establish a comprehensive safety solution tailored for the mining sector. At its core, the design incorporates a durable and protective safety helmet that serves as the foundation. Embedded within this helmet are environmental sensors, including those for temperature, humidity, and gas concentrations, which continuously monitor atmospheric conditions in real time. Additionally, physiological sensors for tracking heart rate and body temperature are seamlessly integrated to ensure miners' well-being. The inclusion of a GPS module enables precise location tracking within the mine, enhancing situational awareness and response capabilities.

Helmet Design

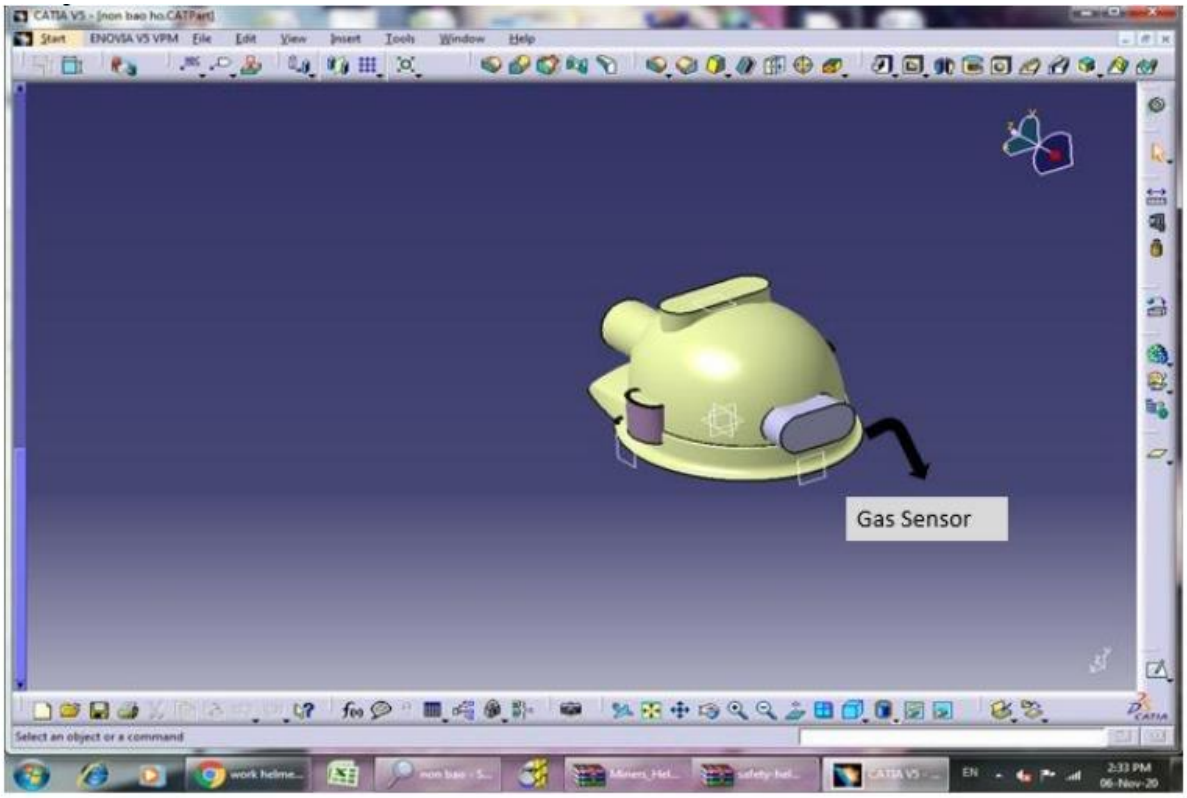

Fig 4.1 Back view of the helmet design

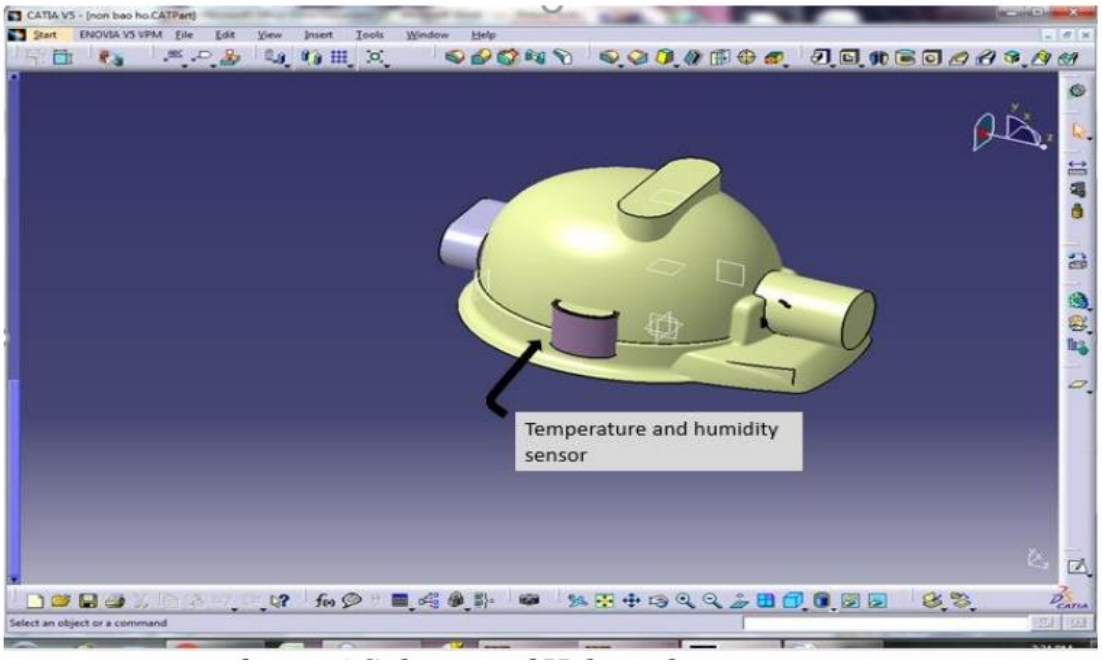

Fig 4.2 Side view of Helmet design

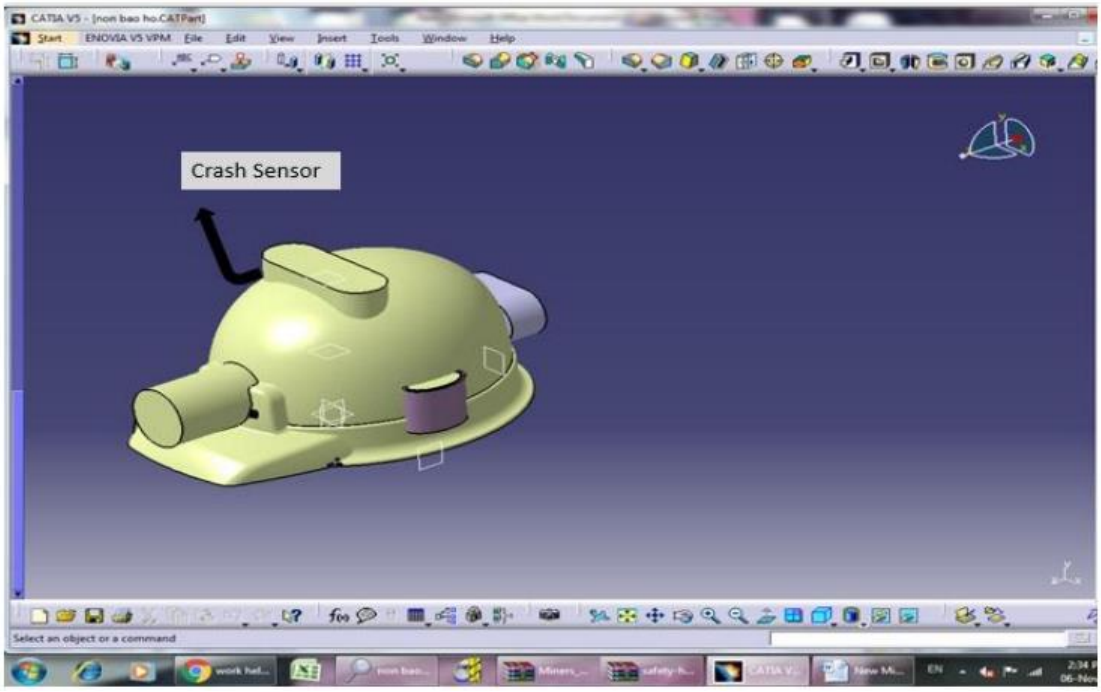

Fig 4.3 Front view of helmet design

Schematic of helmet

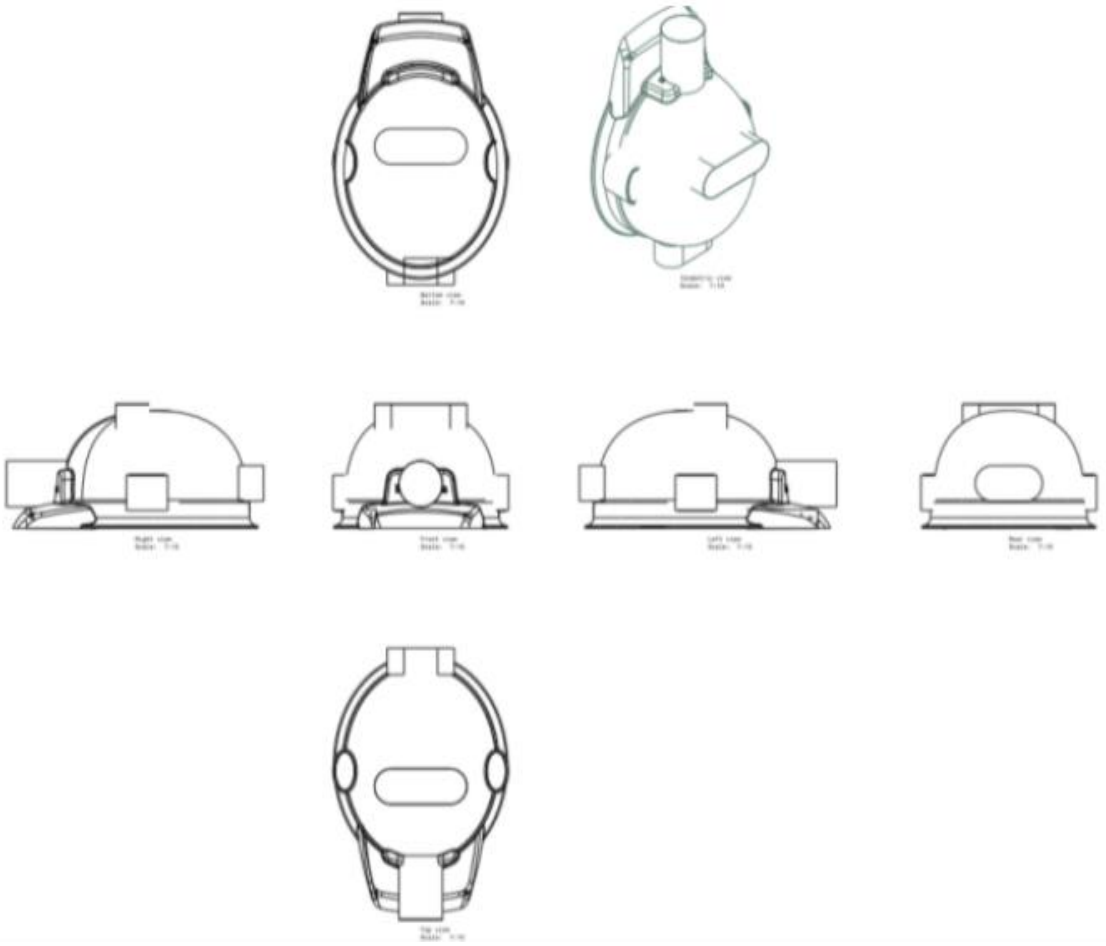

Fig 4.4 Schematic of helmet

Implementation

The project prototype is implemented in Tinkercad and the circuit includes gas sensor and temperature sensor with buzzer, green and red led. The WIFI module (ESP8266) is used for communicating with the WIFI network inside the industry or factory. It will send the real time data to the cloud. During normal conditions the green led will glow and buzzer will be off. Whenever the smoke or temperature value cross the threshold level the red led will glow and the buzzer inside the factory will switch on and also an email will be sent to the supervisor alerting against the unsafe condition inside the factory.

Circuit Diagram

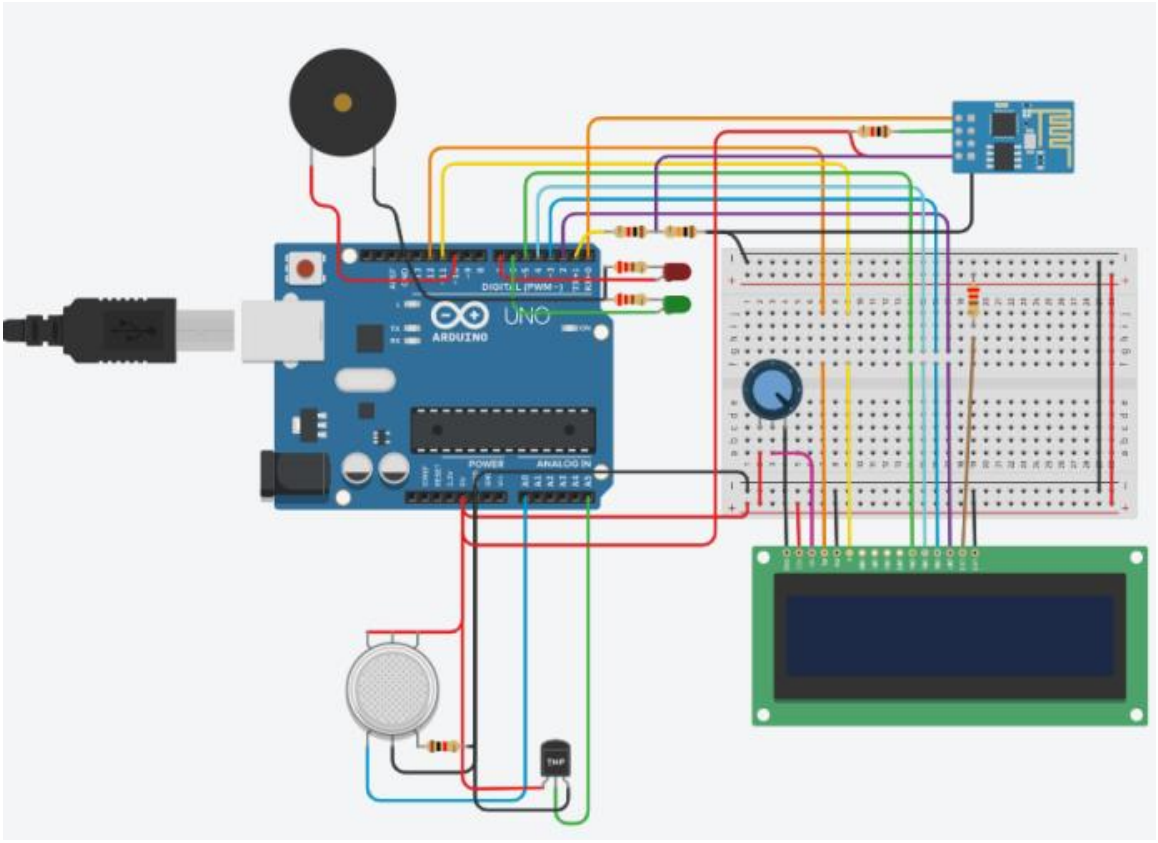

Fig 4.5 Circuit Diagram of the helmet circuit

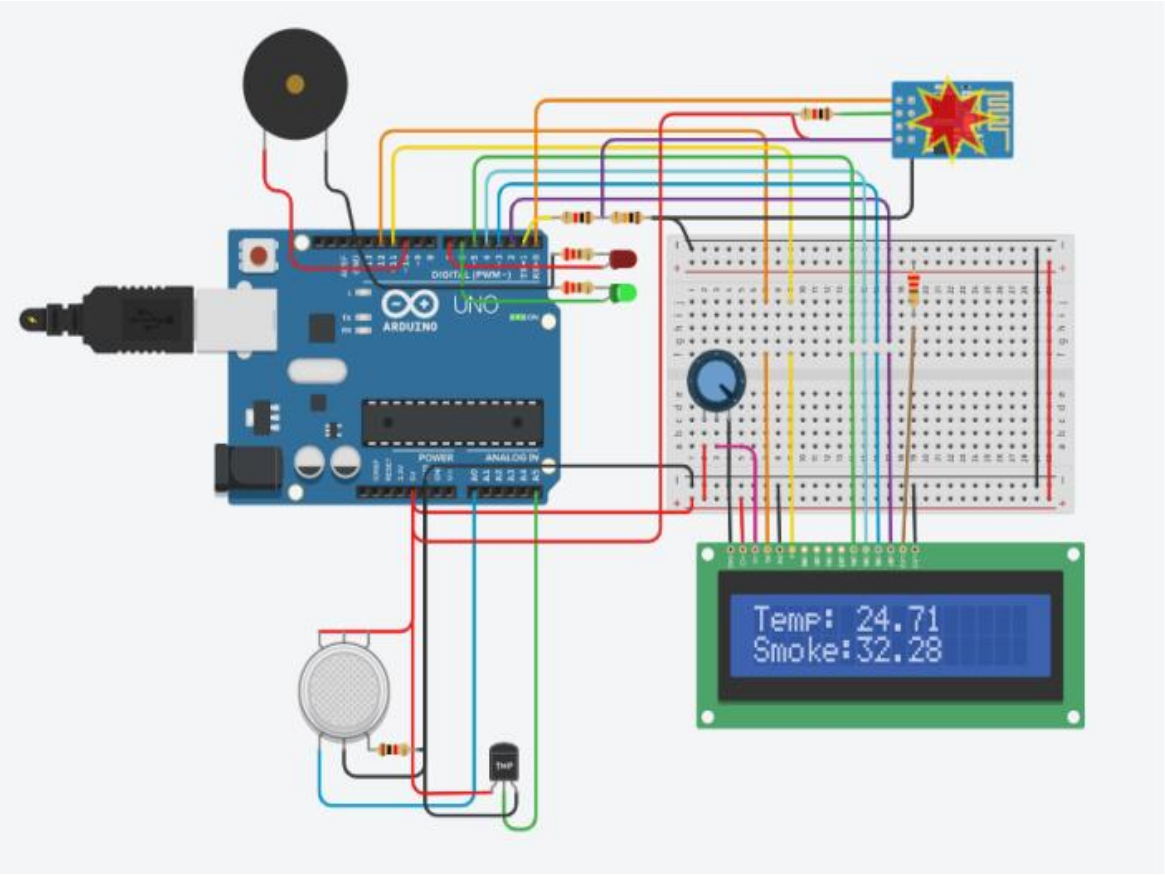

Fig 4.6 Working of the circuit in the normal conditions of temperature and smoke

The figure given below demonstrates the circuit during the unsafe condition of temperature. The threshold set for temperature is 45ºC and the measured temperature was 56.93ºC so the buzzer is on and red led is glowing.

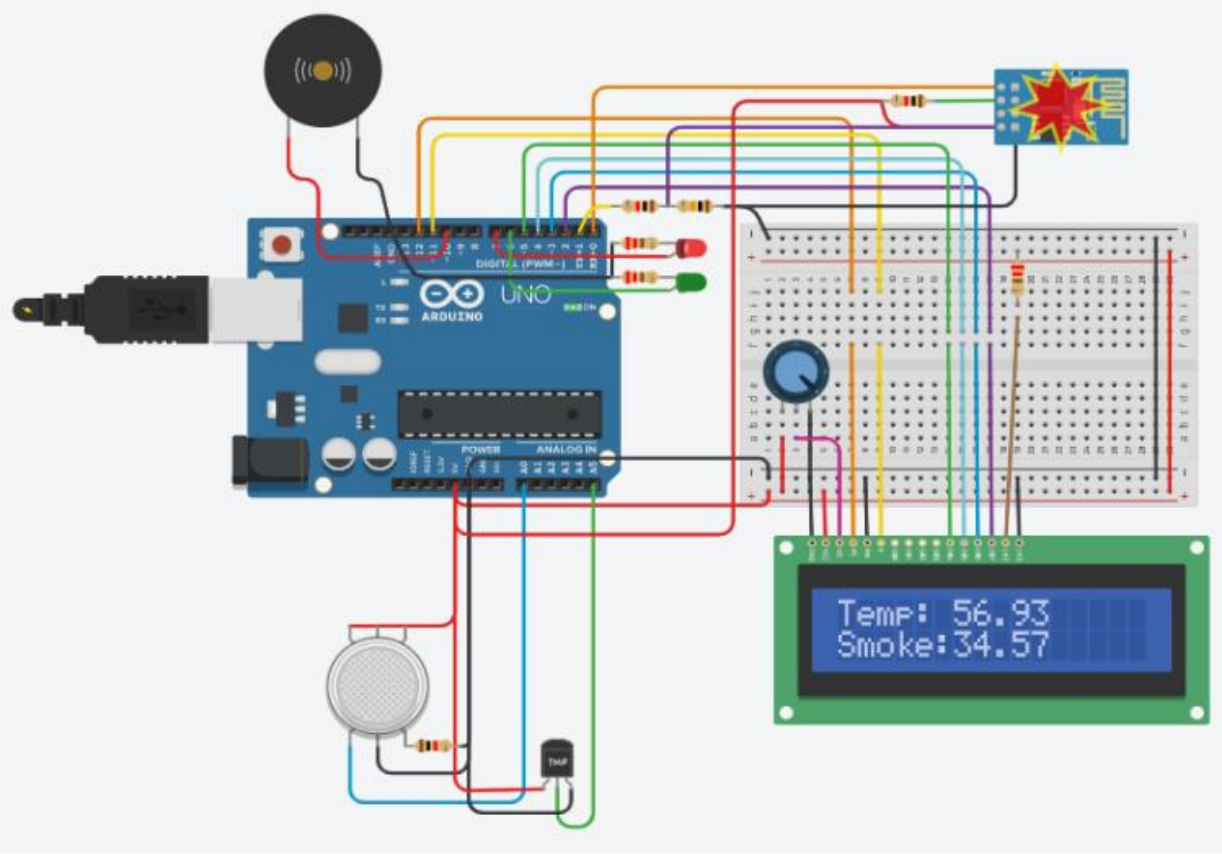

Fig 4.7 Working of the circuit when the temperature is above the threshold level

The working of circuit in unsafe condition of smoke is show below. The threshold set for temperature is 40 and the measured smoke value was 43.43, so the buzzer is on and red led is glowing.

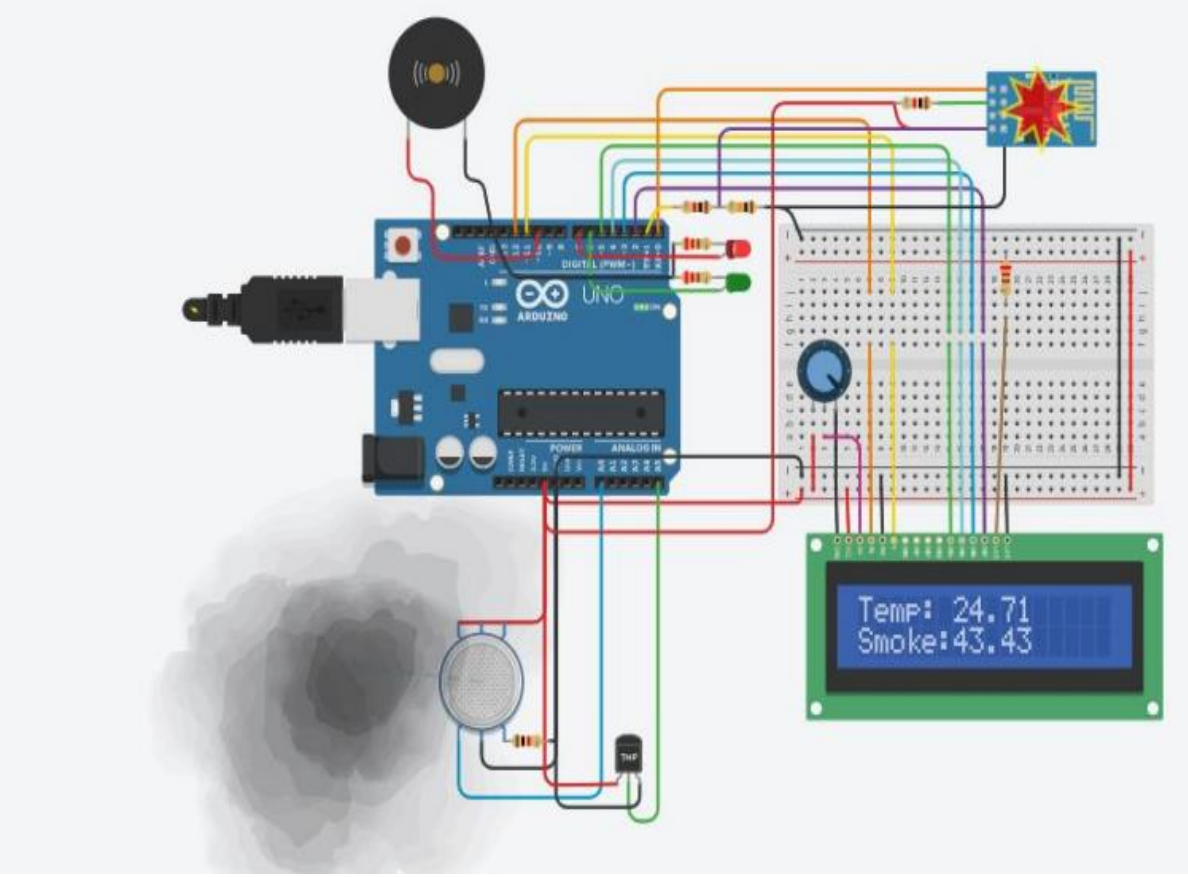

Fig 4.8 Working of the circuit when the smoke is above the threshold level

Cost Analysis

To determine whether a price is fair and reasonable in a hazardous working environment, it is essential to know how to identify and utilize the correct resources during the assessment process. Identifying the best price involves using the price analysis strategy, which requires performing a workplace competition comparison. Cost analysis, a more complex process, is a thorough assessment of the direct and indirect costs leading to the final price of the product or service, an Industrial Helmet in our case. Once either of these strategies is applied and expenses are identified, negotiation and hence the implementation may be necessary to ensure the best price.

We with our prototype and idea of a large scale making of these helmets plan on establishing an open line of communication with the manufacturer in the early stages of the contract process so that they are aware that a request for individualized prices on items will be an ongoing process.

Safety is our main and only major concern followed by others.

We aim to convince our mining industry or more specifically our targeted mine managerial body that our intent in obtaining costing information is not to reduce their profit or an unnecessary deal but it is primely for the safety of the workers and reduction in the cases of accidents and accidental deaths. To understand the cost analysis behind our product prototype, we have identified direct costs and indirect costing.

Direct Costing, which we describe as elements—the helmet, the sensors, the wiring, the servers, the assembly or otherwise—and profit, which can be attributed to the final cost of the product. This list includes base salary, labor, materials, and workers such as subcontractors, fringe benefits, which we may cites as 30- 33%, travel, and all that can be billable to the final SMART HELMET.

CHAPTER 5

RESULT AND CONCLUSION

Result

The real time data of smoke and temperature are sent to the ThingSpeak cloud and displayed in form of graphs. Field 1 shows the Smoke Value and Field 2 shows Temperature values in (ºC).

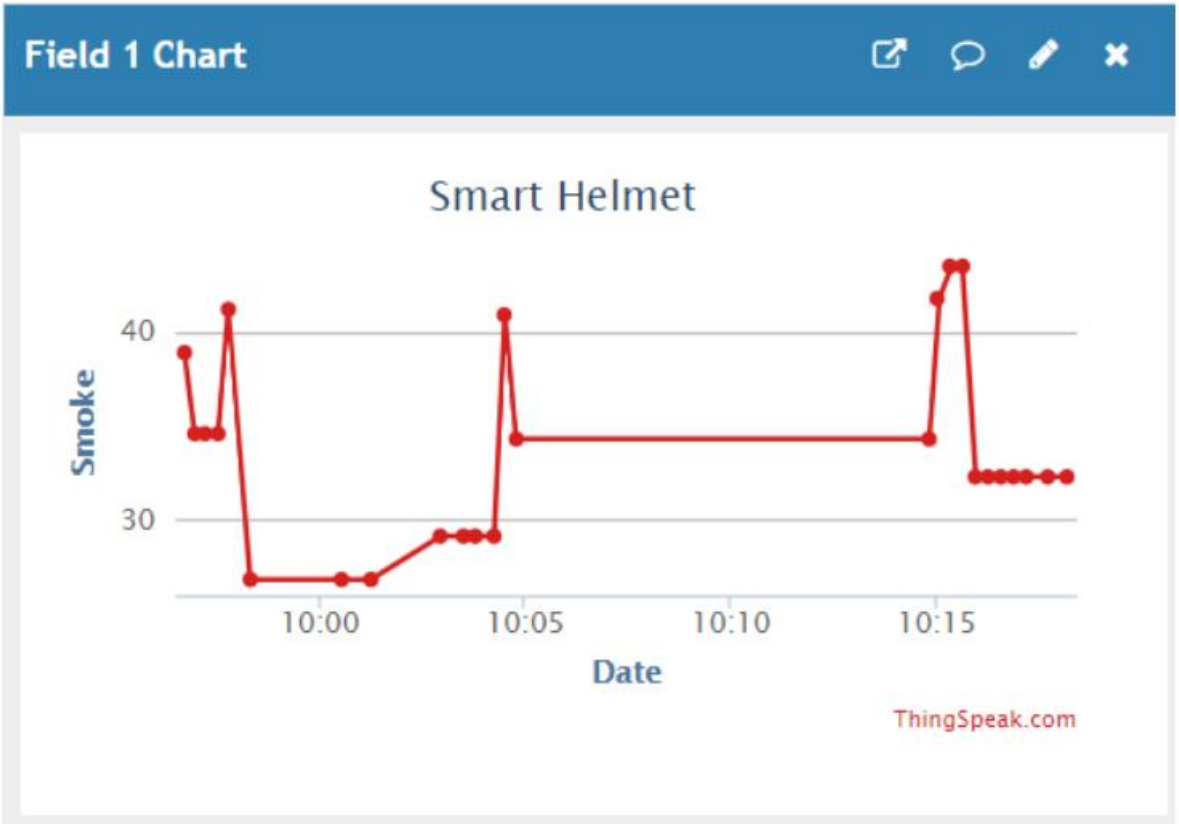

Fig 5.1 Smoke chart

When the received value of smoke and temperature exceeds the threshold value, the ThingSpeak will trigger the corresponding react. For smoke, smoke_alert will be triggered and for temperature, temp_alert will be triggered.

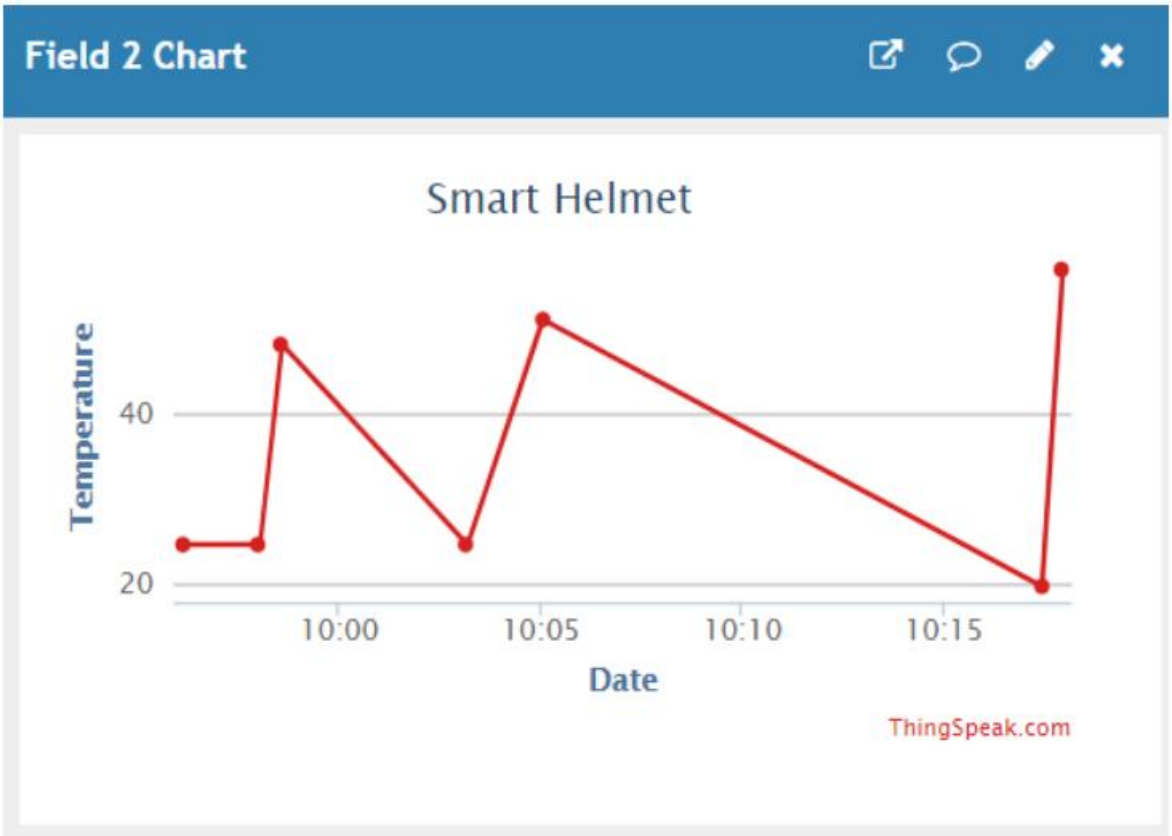

Fig 5.2 Temperature chart

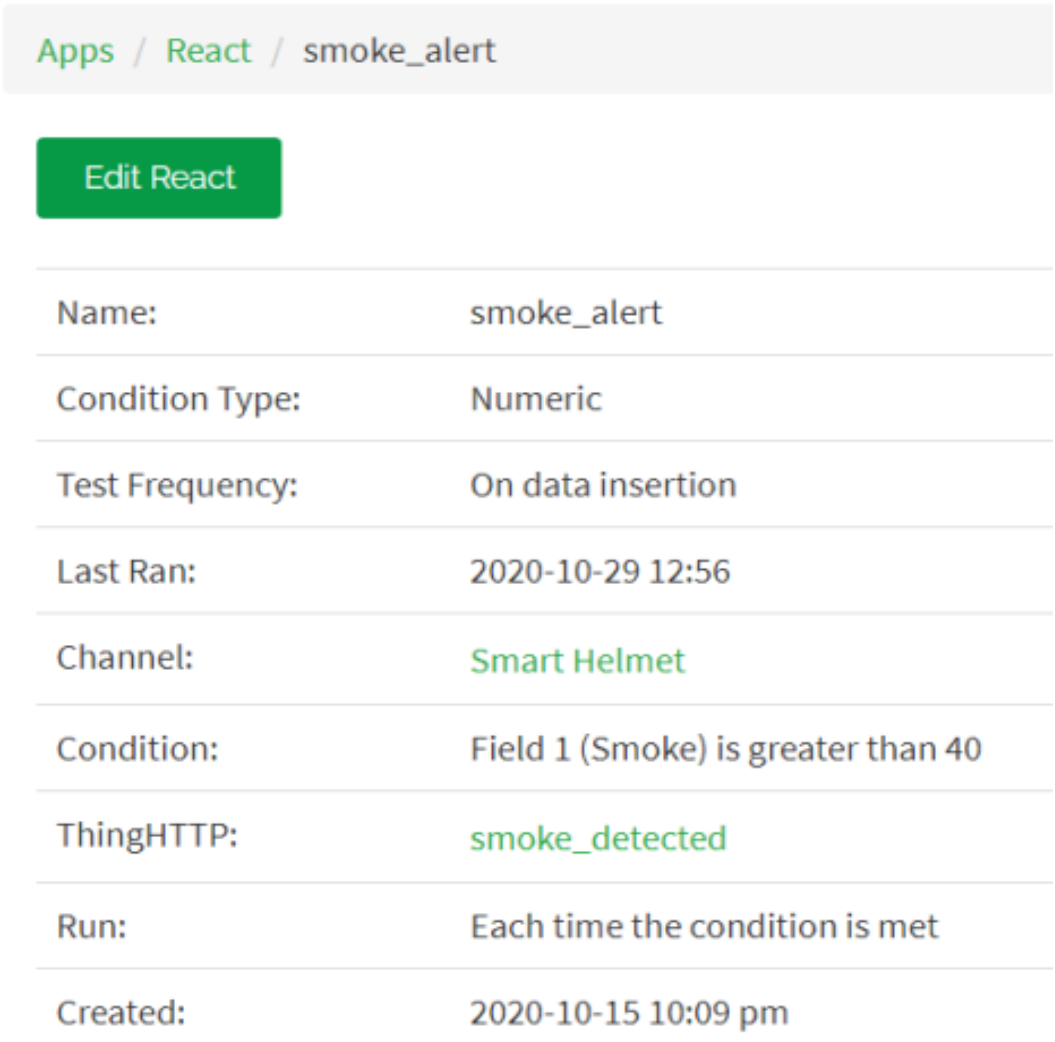

Fig 5.3 Settings of smoke_alert

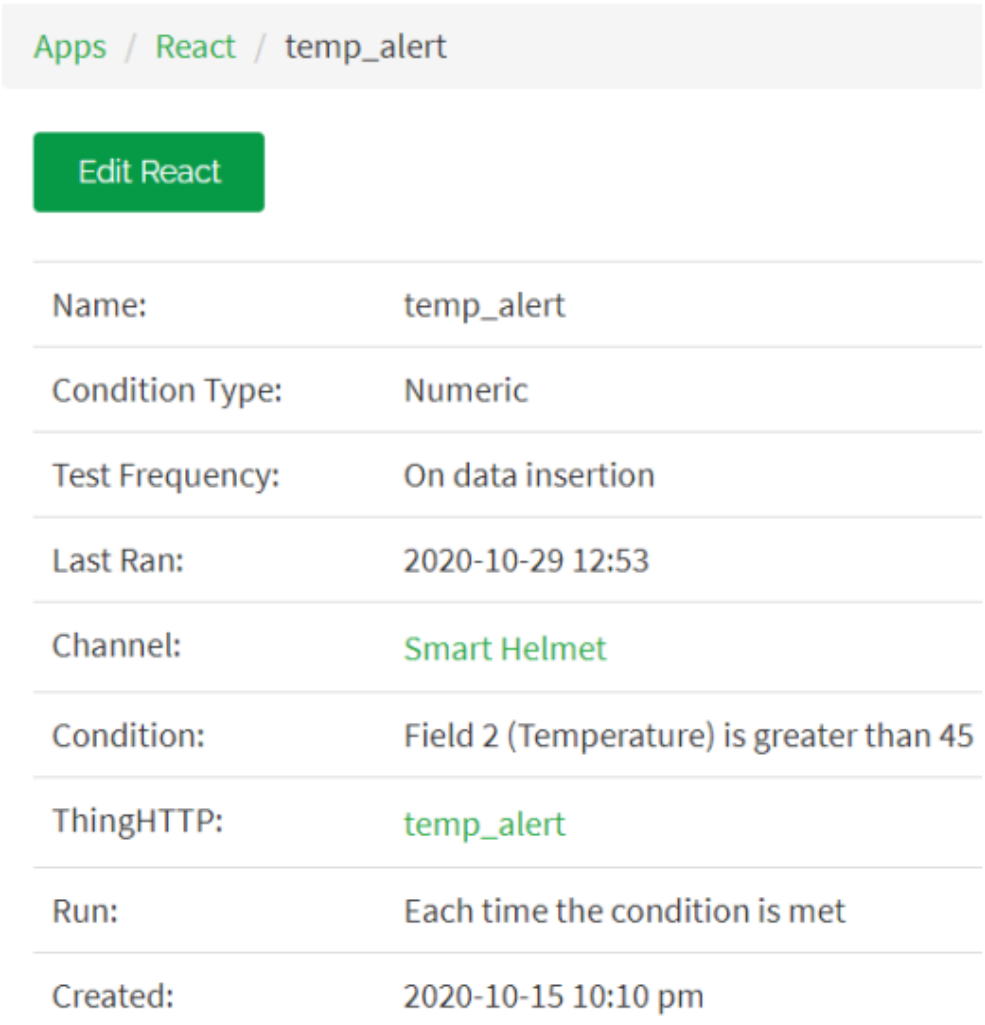

Fig 5.4 Settings of temp_reacts

Future Recommendations

Machine Learning Integration: Incorporating machine learning algorithms into the safety helmet's data analysis processes can elevate the system's effectiveness. Machine learning can enable predictive analytics by recognizing patterns in sensor data, thereby anticipating potential hazards and health risks. This enhancement would empower the system to proactively generate alerts and recommendations based on historical data trends.

Enhanced Wearable Interface: Further developing the wearable interface to include augmented reality (AR) or virtual reality (VR) elements could revolutionize worker training and guidance. AR/VR overlays could provide real-time visual cues, instructions, and safety guidelines directly within the helmet's visor, aiding miners in navigating hazardous conditions more effectively.

Multisite Compatibility: Expanding the system's compatibility to cover multiple mining sites and locations would extend its applicability across a broader range of operations. Implementing centralized monitoring and control for remote sites could enable management to access data and insights from various locations, streamlining decision-making and resource allocation.

Collaborative Data Sharing: Introducing a feature that allows the sharing of anonymized data across mining companies could contribute to industry-wide safety improvements. Collaborative data sharing could enable the identification of industry trends, best practices, and emerging risks, leading to a collective effort to enhance mining safety standards.

User Feedback Incorporation: Encouraging feedback from mining workers, supervisors, and safety officers who interact with the system on a daily basis can provide valuable insights for refinement. Their experiences and suggestions can drive iterative improvements, making the safety helmet more user-centric and effective.

Potential for Advancements

There is significant potential for advancement in IoT-based mining helmets, with new technologies and innovations continually emerging. Here are some potential areas for advancement:

1. Sensor Technology: There is potential for further advancements in sensor technology, including the development of new sensors that can detect a wider range of health and safety conditions. For example, sensors that can detect the presence of hazardous gases, dust, and other particles could provide more comprehensive monitoring of mining environments .
2. Data Analytics: Advances in data analytics can enable more sophisticated analysis of data collected by IoT-based mining helmets. This can include the use of machine learning algorithms to detect patterns and anomalies in the data, as well as predictive analytics to identify potential hazards and prevent accidents before they occur.
3. Power Management: There is potential for further advancements in power management technologies, such as the use of more efficient batteries or energy harvesting techniques. This can extend the battery life of IoT-based mining helmets, reducing the need for frequent battery replacements and improving overall reliability.
4. Wireless Communication: There is potential for advancements in wireless communication technologies, including the development of new protocols that enable faster and more reliable data transmission. This can improve the responsiveness of IoT-based mining helmets, reducing the risk of delayed or missed alerts.
5. Integration with Other Technologies: There is potential for further integration of IoT-based mining helmets with other technologies, such as wearable robotics or augmented reality. This can enable more advanced and complex mining operations, while also improving overall safety and productivity.

Conclusion

A mining helmet has been developed which detect different types of hazardous events such as, humidity, temperature, concentration of combustible gases and many more parameters. The helmet sends the readings of the parameters to the base station PC through cloud which is being inspected continuously. If any reading exceed its limit the helmet sends information through IoT to the base station and alert the miner through buzzer. As the system requirement and the required components can be easily made available and this project can be implemented easily. It will provide safety to worker and change the way of their working, as well as system controlling the various environmental changes in mines. It is reliable system with quick response and easy installation. And the helmet has a flexible design where different sensor can be added or removed according to different industrial use.

The development and implementation of the IoT-based safety helmet for mining workers mark a significant stride towards transforming safety measures and operational efficiency within the mining industry. Through the fusion of cutting-edge technology, intelligent data processing, and real-time communication, this project has yielded a pioneering solution that directly addresses the formidable challenges posed by the mining environment.

The cloud-based platform and user-friendly mobile application foster remote access to real-time data, historical trends, and alerts, empowering both miners and supervisors to make informed decisions promptly. This project's success underscores the potential of technology to redefine safety protocols and operational practices, enabling mining companies to cultivate a culture of proactive safety and efficient resource allocation.

REFRENCES

1. Report of industriALL, a global union of workers, "India's safety crisis: industrial accidents during Covid-19 kill at least 75".
2. Report of The Hindu, "Data | Industrial accidents claimed over 6,300 lives between 2014 and 2017".
3. Report of Deccan Herald, "32 accidents in industrial units in last two months; 75 killed".
4. Report of industriALL, "Six workers killed at Indian steel plant"
5. Sreenithy Chandran, Sneha Chandrasekar, Edna Elizabeth N, "Konnect: An Internet of Things (IoT) based smart helmet for accident detection and notification" Published in: 2016 IEEE Annual India Conference (INDICON).
6. JesudossA, Vybhavi R, Anusha B "Design of Smart Helmet for Accident Avoidance" Published in: 2019 International Conference on Communication and Signal Processing (ICCSP). Added to: IEEE Xplore.
7. K.M. Mehata, S.K. Shankar, Karthikeyan N, Nandhinee K, Robin Hedwig P "IoT Based Safety and Health Monitoring for Construction Workers. Helmet System with Data Log System", Published in: 2019 1st International Conference on Innovations in Information and Communication Technology (ICIICT). Added to: IEEE Xplore.
8. Some websites :-
    - www.google.co.in
    - www.microsoft.com
    - www.stackoverflow.com
    - www.chat.openai.com

APPENDICES

Code :-

```
#include <LiquidCrystal.h>


LiquidCrystal lcd(12, 11, 5, 4, 3, 2);
String ssid     = "Simulator Wifi";
String password = "";
String host = "api.thingspeak.com";
const int httpPort   = 80;
String uri=
"/update?api_key=ZXAQDPJSA6KLI8IG&field1=";


int red = 13;
int green = 6;
int yellow = 7;
int buzzer = 10;


int value=0;
int echoPin = 8;
int trigPin = 9;
int distance;
```

```
int setupESP8266(void) {


  Serial.begin(115200);

  Serial.println("AT");

  delay(10);

  if (!Serial.find("OK")) return 1;

  Serial.println("AT+CWJAP=\"" + ssid + "\",\"" +
password + "\"");

  delay(10);

  if (!Serial.find("OK")) return 2;

  Serial.println("AT+CIPSTART=\"TCP\",\"" + host +
"\"," + httpPort);

  delay(50);

  if (!Serial.find("OK")) return 3;

  return 0;

}


void anydata(void) {


  digitalWrite(trigPin, LOW);

  delayMicroseconds(2);

  digitalWrite(trigPin, HIGH);
```

```
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  distance = 0.01723 * pulseIn(echoPin, HIGH);



  String httpPacket = "GET " + uri +
String(distance) + " HTTP/1.1\r\nHost: " + host +
"\r\n\r\n";
  int length = httpPacket.length();
  Serial.print("AT+CIPSEND=");
  Serial.println(length);
  delay(10);
  Serial.print(httpPacket);
  delay(10);
  if (!Serial.find("SEND OK\r\n")) return;
}

void setup()
{
   Serial.begin(9600);
   setupESP8266();
   lcd.begin(16, 2);
```

```
   pinMode(red, OUTPUT);
   pinMode(yellow, OUTPUT);
   pinMode(green, OUTPUT);

   pinMode(trigPin, OUTPUT); // Sets the trigPin as
an OUTPUT
   pinMode(echoPin, INPUT); // Sets the echoPin as
an INPUT

}

void loop()
{
  lcd.setCursor(0,0);
  lcd.print("");
  lcd.setCursor(0,1);
  lcd.print("");
  anydata();
  delay(500);

  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
```

```
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
distance = 0.01723 * pulseIn(echoPin, HIGH);



if (distance > 250) {
  digitalWrite(red, LOW);
  digitalWrite(yellow, LOW);
  digitalWrite(green, LOW);
}
if (distance <= 250 && distance > 150) {
  digitalWrite(red, LOW);
  digitalWrite(yellow, LOW);
  digitalWrite(green, HIGH);
  lcd.setCursor(0,0);
  lcd.print("");
  lcd.setCursor(0,1);
  lcd.print("");
  lcd.setCursor(0,0);
  lcd.print("DUSTBIN EMPTY");
}
if (distance <= 150 && distance > 50) {
```

```
    digitalWrite(red, LOW);
    digitalWrite(yellow, HIGH);
    digitalWrite(green, LOW);
    lcd.setCursor(0,0);
    lcd.print("");
    lcd.setCursor(0,1);
    lcd.print("");
    lcd.setCursor(0,0);
    lcd.print("HALF_FILLED");
  }
  if (distance < 50) {
    digitalWrite(red, HIGH);
    digitalWrite(yellow, LOW);
    digitalWrite(green, LOW);
    lcd.setCursor(0,0);
    lcd.print("");
    lcd.setCursor(0,1);
    lcd.print("");
    lcd.setCursor(0,0);
    lcd.print("DUSTBIN FULL");
  }
}
```