SMART HELMET AUTOMATION

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Certificate

It is certified that the following students have completed their project work on **"Smart Helmet Automation"** We, hereby declare that this submission is out own work and to the best of my knowledge it contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any degree or diploma at adviser Affiliation at school or at any other educational institute, except where due acknowledgement has been made in the thesis. Any contribution made to the research by others, with whom I have worked at school or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except for the assistance from others in the project's design and conception or in style, presentation and linguistics which has been acknowledged.

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Abstract

Safety is determined as a critical theme in industry.As we know, due to lack of workers safety many incidents are happening in mines and there is no guarantee of worker's safety. The workers must have to face environmental conditions who are working in mining industries.Temperature, carbon dioxide,methane etc. are major risks for them .To address these challenges it is essential to provide coal miners with the means to monitor the presence and level of gases,temperature and humidity to enhance their safety.

We should impose preventive measures for mining workers.Some preventive steps have been imposed by times.The proposed project involves transforming the traditional miners helmet into a smart helmet.As coal miners already wears helmets to protect themselves from falling objects, rocks or debris,this project leverages this existing safety gear.

The helmet is designed to sense temperature,humidity,toxic gases and oxygen levels in the underground environment. When these sensors detect values exceeding the safety limits, the helmet alert he miners through buzzer and vibration motor applied to their body.The system depends on various sensors including temperature sensor such as DHT22, gas sensor such as MQ9, humidity sensor such as DHT22, Light dependent resistor (LDR), sensor for the light, Arduino Uno (AU). Microcontroller is at the main component of system. It processing sensor inputs and generate appropriate alerts.

By providing real time alerts and information this project aims to significantly enhance the safety of coal miners and allowing them to work securely in challenging underground condition. These sensors will insert in helmet. Besides this, they will give awareness about environmental conditions to workers.

When workers wear this helmet to work and any hazardous situation occurs during work they are get alerted in the form of vibration and buzzer and thus workers can protect themselves from certain incidents. This system is very cost-effective and user friendly.

Undertaking

We certify that the work titled "Smart Helmet Automation" is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged and referred.

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List of Abbreviations

LED	Light Emitting Diode
AU	Arduino Uno
IOT	Internet Of Things
LCD	Liquid Crystal Display
AO	Analogue Output
LDR	Light dependent resistor
DO	Digital Output
REQ	Functional Requirements
GPS	Global Positioning System
MS	Microsoft
GND	Ground
AI	Adobe Illustrator
VP	Visual Paradigm
CEP	Complex Engineering Problem
FYP	Final Year Project
NFR	Non Functional Requirements
ILO	International Labour Organization
UI	User Interface

Chapter 1

INTRODUCTION

1.1 Introduction

Mining is one of multifaceted industry. Miners bring coal to the ground. Many toxic gases are present in underground which cause problems for those working there. Minors are facing health problems due to these toxic gases [1]. Some people develop respiratory problems, anxiety due to low oxygen level and many workers lose their lives due to lack of timely help. For this, sometimes the values of temperature and humidity are also different. Environmental conditions are also different above and below ground. Thus, when the minors work underground mines they are not familiar about environmental conditions there and they face hazard incidents.

We should have a technique so that the workers can know the oxygen level in place where they are working and that there is no toxic gas, and the values of temperature and humidity. In this way, workers can protect themselves from accidents and do their work without any fear. Where mining industries play important role in the economy, the countries also at forefront of development. But no special measures for those working in mining. During work in mines due to change in environmental conditions sometimes it becomes dark and workers cannot see the way and they collide with big rock and get serious injuries.

We are living in a development country. We have many advancement technology. By using these we can save the workers from such problems. We have many Internet Of Things (IOT) techniques using which we will develop smart helmet which will protect workers from such problems.

In such cases, workers wear helmet during work but it only protect them from head injury. The helmet that we will make will have features that will alert the workers about environmental conditions [2]. One thing about our helmet is, it will be able to sense value of gases, humidity, temperature etc.. It will also have such feature that if it sudden gets dark light will be turned on automatically. We will use MQ2 sensor to detect gases that will measure the ranges of underground gases.

If any gas exceed its limit and it is a loss for the workers then helmet timely alert the miner through vibration motor or buzzer. We will also use DHT22 sensor to measure the value of humidity and temperature. For light we will install LDR sensor. The LDR sensor works by looking at dependency gauge of light.

Smart helmet will have direct contact with workers and will not need of any control room. We will insert a vibration motor and buzzer in smart helmet which will alert the workers in case of any accident.

1.2 Goals

Our aim is to develop a smart helmet for safety of underground workers. Workers are unfamiliar about underground situations such as gas explosion, health issues and temperature changes and they even don't have any proper solutions to protect them from that situation and sometimes many workers lost their lives [3]. This smart helmet can save worker's lives and to alert them from such type of hazardous situations.

1.3 Motivation

We have developed smart helmet so that coal miners can work fearlessly in underground and coal miners have to wear this helmet for their safety. What motivated us to develop this smart helmet is its non-presence in our country. There were also some other reasons for choosing this project. For example, workers are unfamiliar about underground situations such as gas explosion, health issues and temperature changes and they even don't have any proper solutions to protect them from that situation [4]. In future this individual who work in different coal mining can recognize the different gases and temperature and also unexpected normal mishaps which happen by and large in coal mining.

1.4 Methods

This smart helmet is designed using agile model because in agile model we divide the tasks into small segment of work, frequent assessment and adaption to plain. I was exceptionally intended to meet the necessities of the quickly changing condition by grasping the possibility of gradual turn of events and build up the real final time. Another reason is that this technique is quick and iterative. In this project we design four modules [5]. With the help of agile module, we design first module in first iteration after the completion of first module, and we can show it to our customer and get feed back. Frequently changings are possible at any time. By using this model we can build our project very quickly as it takes less time.

1.5 Sustainability development goals

Good health and well being

This smart helmet is designed for the health and safety of coal miners. It alerts the miners by detecting the coal environment as gas level, humidity and temperature.

Industry, innovation and infrastructure

This smart helmet system is an example of new use of technology in mining industry. It improves the framework by automating the observation of environmental conditions and providing immediate communication and providing abilities of crisis reporting.

Sustainable cities and communities

This smart helmet involves in creating a more secure and maintainable mining communities. It ensures the security of coal miners by minimizing accidents and improving crisis reports.

Decent work and economic growth

The smart helmet provides better environment for coal miners to work in mines as it reduces the risk of injuries, accidents etc. It creates a safe environment and provides better economic growth.

1.6 Report overview

This report has introduced a system that allows a reader to explore the initial concepts of the system. The report consists of eight chapters.

Chapter 1 reviews about the introduction and basic motives of the system. It is the overview the whole system and about the factors involving in developing the system. Main ideas and abstraction of the system are carried out in this chapter.

Chapter 2 reviews the background of the project. Problem statements which we found to develop this system. This section will review literature that will provide the understanding and explanation of critical success factors in project management and discussion system. The literature review will include Project success factors, critical success factors and social interaction among users.

Chapter 3 reviews the plan through which the project is carried out. Methods and approach used to develop the project are discussed the section. Gantt charts are made to show the work plan in which the system is developed.

Chapter 4 reviews the requirements of the system. Functional and non-functional requirements are discussed. Use cases for different users are discussed and their functions are discussed.

Chapter 5 and 6 reviews the design and architecture of the system. Features that the product have been discussed and explored in the section. User interfaces are shown in the section. System

architectures and designs are designed in this section.

Chapter 7 reviews the coding methods and techniques and testing of the product. Test cases are designed to check the product.

Chapter 8 reviews the overall system and different key point observed in developing the system. References are discussed using which we got help.

Chapter 2

BACKGROUND AND PROBLEM STATEMENT

2.1 Background

In early days people used to work in the underground using helmets with very less protection and they use to contain a light to see the path due to the increase in accidents in coal miners. For example, on April 5, 2010 upper big branch mine accident has occurred in the Pakistan. The safety and health administration released its statement concluding that interruption of safety convention led to a major accident.

According to International Labour Organization (ILO), mining employs about 1 percent of labor force and produces 81 percent of fatal accidents [6]. Pakistan have the biggest mining industry who created about 3 billion tons of coal every year. Although Pakistan accounts for 40 percent of global coal production, responsible for 80 percent of mining deaths worldwide every year. This survey clearly shows that we have to increase the safety measures to save the lives of coal miners.

For example, there was a disaster in a mine in America and safety adhere released a statement in which they said that violation of safety protocol led to a major accident. They also announced that many people lost their lives due to the noxious gases. The problem would have been minimized if they had detected it at an earliest stage. Due to improvement in technologies living in the modern era we can get rid of such problems easily. Considering this problem we designed a smart helmet which can be very effective with least weight also with enlarged security.

2.2 Literature review

A literature is a survey or a discussion of literature in a given area of study.

2.2.1 A smart helmet for improving safety in mining industry

In this research paper a smart helmet for hazardous event detection, monitoring the surrounding environmental conditions and updating information like Global Positioning System (GPS) location and sensor data to the central console for easy tracking and providing oxygen supplements to avoid the inhalation of poisonous gases is designed [7]. This will help the coal miners to communicate with the outside world. Whenever helmets is removed it will notify that the helmet is removed by the minors.

2.2.1.1 Tools

The tools used in this research are:

•**IR sensor:**It is used to detect that the minors wear the hamlet or not.

•**Gas sensor:**Gas sensors is used to detect poisonous gases like CO2, CO, methane, hydrogen in air etc.

•**GPS tracking location:** GPS is used to track the location of coal miners.

• **Oxygen supplements:** Oxygen supplements are provided to coal miners and they take these supplements in case of any suffocation.

• **Temperature sensor:** Temperature sensors are used to detect temperature and make alert when the temperature is raised.

• **Force sensor:** Force sensitivity is used in human touch, control of electronic devices such as medical system etc.

• **Audio Bluetooth:** It is used to receive signals

•**PIC MCU:** It is a microcontroller in which we designed our circuits.

2.2.1.2 Draw Back

Sometime in mining industries there will be the possibility of the system error in which GPS cannot track the location of workers. And it is poisonous and harmful for worker and swear condition may occur [8]. The pic microcontroller memory is not accessible and only one single accumulator is present. The range of Bluetooth is very low as 50m and it not secure as other wireless technologies.

2.3 Iot based smart helmet for air quality used for the mining industry

In this research paper we have studied that an IOT based helmet is created that can prevent coal miner from dangerous gases. We analyze that they consider the primary danger that is air pollution that can cause death of miners as we saw that the air pollution is increased day by day and in mining industries miners remove their helmet because of heavy weight of helmet.

2.3.1 Technologies used

• **IR sensors:** It is used to detect that the minors wear the helmet or not.

• **Air quality sensor:** It is used to detect air pollution.

• **Arduino Uno:** It is used to get all the information from above all sensors.

• **GPRS module:** Wireless transmission can be achieved through GPRS module.

• **Alerting unit:** It is used to give the alarms.

• **Wireless transmission GSM** : A GSM modem is a wireless modem that works with a GSM wireless network. It is a specialized type of modem which accepts a SIM card and operates over a subscription to a mobile operator.

• **Liquid Crystal Display (LCD) :** LCD is used that tell us that the minors wear the helmet or not.

2.3.2 Results

Safety helmet removal test is done by using infrared sensor. When helmet is removing then helmet removal event is detected and displayed in LCD as "HELMET REMOVED" and it has been indicated through alerting unit [buzzer].

2.3.3 Draw backs

This system used GSM that has limited cell site range of 120km. and The depth of mining is more than 120km so behind 120km this system will not work and we cannot detect any danger after 120km. GSM lack some of the advance features and technologies.

2.4 A smart helmet for coal miners

In this research paper we studied about the device can be used to monitor the safety standards of the working conditions for coal miners. This device detects the temperature, humidity, harmful gas, concentration, vibration. The data is analyzed and sent to the control room and the control room decides which action to take based on the parameters sent.

2.4.1 Tools

The tools used in this research paper are:

• **Lora** communication technology

• **GSM** to send and receive information.

• **Arduino** to process the information.

• **Gas sensor** to detect gas, humidity and gas concentration.

2.4.2 Draw backs

This system is monitor by control room. There will be possibility of connection failure between workers and control-room. If any hazard situation occur in mining area it is important to take quick action .If the control room cannot take the quick action or in case of any connection failure workers

may die.

2.5 Smart helmet for detection of unsafe events in mining industry based on iot

This research paper is designed to develop a clever helmet [9]. Clever helmet is design for underground mining risks that encompass suffocation, roof fall , poisoning and explosion. This system will focus on 3 foremost varieties of danger consisting of air quality, helmet removal, and collision.

2.5.1 Goal and objective

• Stay away from accident event

• It offer high security

• It offer unique layout.

• It protect the minors from poisonous gases.

Tools and Techniques

• A **microcontroller** is used for accumulating facts and making selection.

• A module of **MEMS** primarily based totally sensors are used for underground surroundings tracking and automating development of dimension facts via virtual **Wi-Fi** communique method.

• The assignment makes use of **ZigBee** for lengthy variety dependable communication.

• **IR sensor** for detecting falling rocks.

• **Gas sensors** for detecting stage of poisonous gases within the mine.

• **Atmospheric Pressure sensor** for detecting growth or lower in atmospheric strain that could bring about dangers for the mine worker.

• A **temperature and humidity sensor** also are used.

• **ZigBee** forums are used at each end mine worker's helmet in addition to supervising unit.

• **Alerts** at each ends are given the usage of buzzer and LED indications.

2.5.3 Draw backs

MEMS designed very complex procedure and it is very expensive during research and development stage. ZigBee are low bit rate transmission rate of technologies are also low. ZigBee has many security threats like stealing of nodes and loss of service.

2.6 Problem statement

In the existing system, mining helmet make sure to save the miners head from many injuries. Nowadays awareness about environmental condition become a difficult part of existing system. As the workers wears helmet during work but this helmet only protects them from head injuries and due to unawareness about environmental conditions, workers have to face too many challenges. It is difficult for them to work with such challenges. As the helmet is too heavy, uncomfortable to work with the miners tend to remove the helmet off their head. In such cases of its removal miners are vulnerable to unsafe condition. There is no existing smart helmet that can study the environment and make decisions to encourage worker's preservations. Oxygen supply is not provided for the miners in case of toxic gas leakage, due to which many coal miners face suffocation problems and lost their lives. To initiate a barrier free communication environment is the biggest challenge the mining organizations face.

2.7 Proposed solution

To overcome these hazard situations we decided to build a smart helmet for the safety of coal miners.We research different mining industries and conclude their problems.These problems were no proper safety, no proper emergency facilities, gas explosion, high or low temperature, high level of humidity, no proper light in underground.

So we deign this smart helmet to overcome all these problems. We use different sensors as temperature sensor, humidity sensor, gas sensor, light sensor etc [10]. We use DHT22 sensor for the detection of temperature and humidity both, MQ9 for the concentration level of different gases, LDR sensor for light. AU is the main component of the system. We insert all these sensors in AU is also connected with Arduino Ide with the help or USB port.

We integrate these sensors in Arduino Ide. After the completion of sensor integration we insert these components in helmet. We don't need any control room because helmet will have a direct interaction with coal miners.

It will be beneficial for them because if any hazard situation occurs, helmet will timely alert them. They can protect themselves from different problems by wearing this helmet and they can work fearlessly and they don't need any special training to use this.

Chapter 3

PROJECT MANAGEMENT

3.1 Project management

For smart helmet we adopted agile model because it was exceptionally intended to meet the necessities of the quickly changing condition by grasping turn of events and build up the real final item. This technique is quick and iterative.

3.2 Approach

Innovation in this current time is advancing quickly than any time in recent memory, implementing the worldwide programming organizations to work in a relentless evolving condition [11]. Since these organizations are working in an ever evolving condition, it is difficult to accumulate a total and thorough arrangement of programming necessities.

Without these pre-requisites it turns out to be for all intents and purposes hard for any customary programming model to work. The ordinary programming models for example , the waterfall model that rely upon totally determining the necessities, and testing the framework are not outfitted towards quick programming improvement. As an outcome, a traditional programming advancement model neglects to convey the necessary item.

This is the pace where agile approach can be used. Agile technique is quick and iterative. The task is divided into the segment of work, frequent assessment, and adaption to plan. Frequently changings are possible at any time. It was exceptionally intended to meet the necessities of the quickly changing condition by grasping turn of events and build the real final item.Agile method as shown in figure in 3.1

In the development of small helmet automation used in safety of coal miners it means that the development process is divided into small chunks called phases. Each phase focuses on delivering a specific set of features or functionalities related to smart helmet. During each phase the development team collaborate with stakeholders, industry expects including miners who are working in the mines to get feedback in make necessary transformations [12]. This allow for quick adaptions to changing requirements and ensures that the final product meets the specific need of the mining industry.

By using agile model the development of small helmet automation system can progress efficiently with regular updates and improvements based on real world feedback. This approach has to enhance the safety of coal miners by continuously refining and enhancing the systems capabilities.

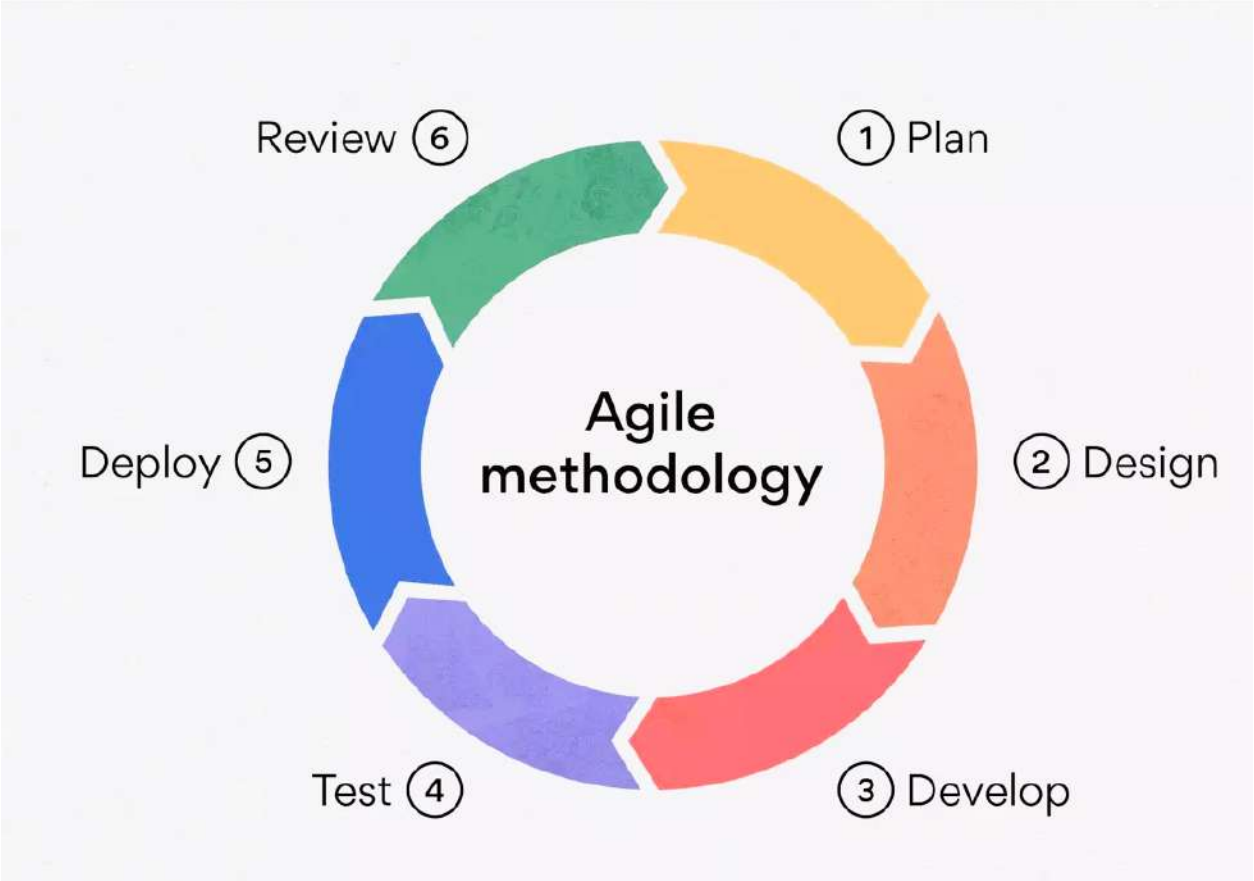

Figure 3.1: Agile model

3.3 Initial project plan

Table 3.1 shows the initial project plan. In this table we divided our project plan . Total for smart helmet project we had 231 days during which we have to manage our complete project.

Thus we divided this time period according to our project needs so that we can complete our project on time.

For this we divided 56 days for project planing, 2 weeks for requirements definition,2 weeks for requirements gathering, 2 weeks for requirements analysis, 2 weeks for research in mining industry, 56 days for system design, 1 week for understanding of hardware, 2 weeks for prototype, 3 weeks for architecture design of small helmet, 2 weeks for interface, 84 days for development, 6 weeks for implementation, 2 weeks for design helmet for sensor, 4 weeks for testing and debugging, 35 days for deployment and documentation etc.

Table 3.1: Initial schedule plan

Task / Name	**Duration**	**Start**	**Finish**
Smart Cap Automation	231 days	Mon 12-12-22	Sun 30-07-23
Project planning	56days	Mon 12-12-22	Sun 05-02-23
Req definition	2weeks	Mon 12-12-22	Sun 25-12-23
Req gathering	2weeks	Mon 26-12-22	Sun 08-01-23
Req analysis	2weeks	Mon 9-1-23	Sun 22-01-23
Research in mining industry	2weeks	Mon 23-1-23	Sun 05-02-23
System design	56days	Mon 6-2-23	Sun 02-04-23
Understanding of hardware	1week	Mon 6-2-23	Sun 12-02-23
Prototype	2weeks	Mon 13-2-23	Sun 26-02-23
Architectural design	3weeks	Mon 27-2-23	Sun 19-03-23
Interface	2weeks	Mon 20-3-23	Sun 02-04-23
Development	84days	Mon 3-4-23	Sun 18-06-23
Implementation	6weeks	Mon 3-4-23	Sun 14-05-23
Design helmet with sensor	2weeks	Mon 15-5-23	Sun 28-05-23
Testing and debugging	4weeks	Mon 29-5-23	Sun 25-06-23
Deployment and documentation	35days	Mon 26-6-23	Sun 30-07-23
Deployment	2weeks	Mon 26-6-23	Sun 09-07-23
Documentation	3weeks	Mon 10-7-23	Sun 30-07 -23

3.4 Project gantt chart

Gantt chart is a widely used project management tool that provides a visual representation of a project schedules, tasks and timelines. It helps project managers and team plans, track and manage project activities efficiently.

By visualizing task dependencies and critical paths the gantt chart helps to identify potential risks in a project.The gantt chart helps in scheduling charts and setting timelines to ensure that the project stays on track.

Project gantt chart as shown in figure 3.2 shows project management to plan schedule and activities. They are essential for planning, scheduling, communicating project progress effective and a widely used in various industries for effective project management.

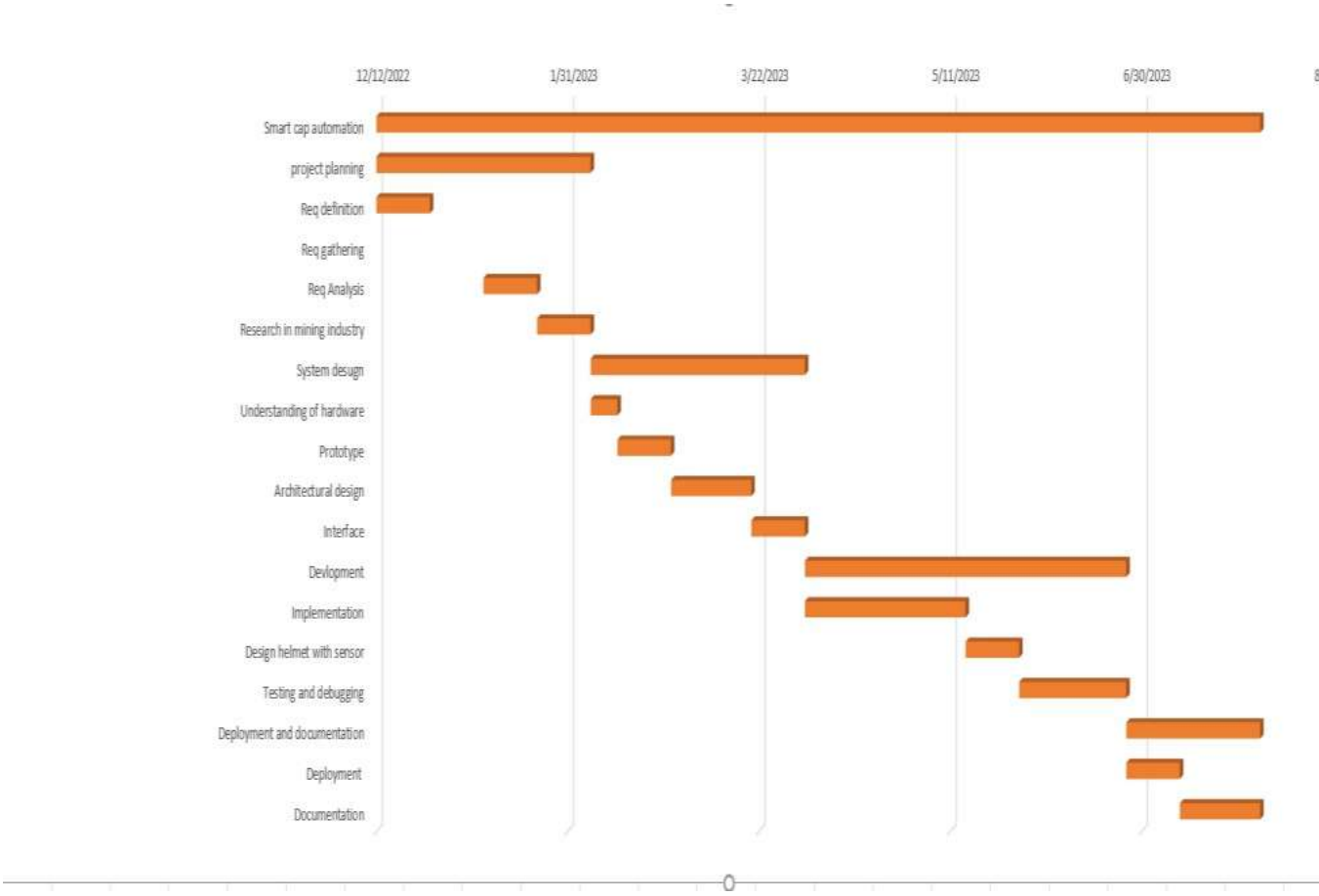

Figure 3.2: Project gantt chart

3.5 Problems and change to the plan

We faced too many problems during the development of the project.We faced some technical issues during the development of smart helmet as our LCD was not working properly. We changed it again and again. We also faced many issues during testing when any of our sensor was not working properly. Now after complete testing and debugging our smart helmet is free of errors and this is reliable and easy to use and if any organization would like to use this helmet we need to customize it according to their more specific needs. But for this Final Year Project (FYP) we worked according to our provided requirements. Our smart helmet is completely in working condition.

3.6 CEP mapping attributes

The attribute mapping for Complex Engineering Problem (CEP) related to a smart helmet system.

3.6.1 Preamble

The development of a smart helmet automation demands a high level of engineering expertise.

Engineers must possess extensive knowledge of hardware development, including proficiency in programming languages such as Arduino Id and C++ [13]. They need to have a deep understanding of how to connect devices with each other and system performance. Furthermore, expertise in hardware integration is essential to connect sensors, and other components effectively with the AU.

3.6.2 Depth of analysis required

The development of a smart helmet automation involves a profound level of analysis. Engineers must thoroughly evaluate various components including sensor data processing algorithms, user interface design for the smart helmet, communication protocols, and data synchronization mechanisms [14]. Multiple design and implementation solutions may be explored for each of these components requiring careful analysis to select the most suitable approaches based on factors like responsiveness, efficiency, and user experience.

3.6.3 Depth of knowledge required

Building a smart vehicle control system necessitates a deep reservoir of knowledge, often grounded in ongoing research. Engineers must remain updated with the latest features of different sensors, IOT integration and keen knowledge of mining industry. Research-based knowledge is indispensable for addressing challenges such as sensors integrations, environmental conditions, and workers safety. Ensuring that the system adheres to safety and reliability standards demands ongoing research and learning.

3.6.4 Familiarity of issues

Familiarity with programming languages used in smart helmet automation is fundamental. Engineers must have a comprehensive understanding of helmet's framework and best practices to create a durable and efficient smart helmet. In addition, a deep knowledge of hardware components and sensors typically used in smart helmets (e.g. AU, jumper wires,battery etc.) is essential to design and integrate these components effectively. Without this familiarity, engineers may encounter difficulties in developing a user-friendly and reliable smart helmet automation system. This detailed attribute mapping underscores the complex nature of the engineering problem associated with a smart helmet automation system. It emphasizes the need for a multifaceted skill set, extensive research, and a comprehensive understanding of both software and hardware components to successfully tackle this CEP.

Various sensors which it consist in block diagram are DHT22 sensor temperature and humidity detection, MQ22 sensor for gas detection and LDR sensor for light dependency [15]. These sensors act as an input to the AU which it used to generate the output process in the form of buzzer or

vibrating motor.

Block diagram of proposed system is as shown in figure 3.3 consists of various sensors arduino is the main component of the system which receive the data from the sensors and compares it with the specific limits and act when sensors crosses the limits.

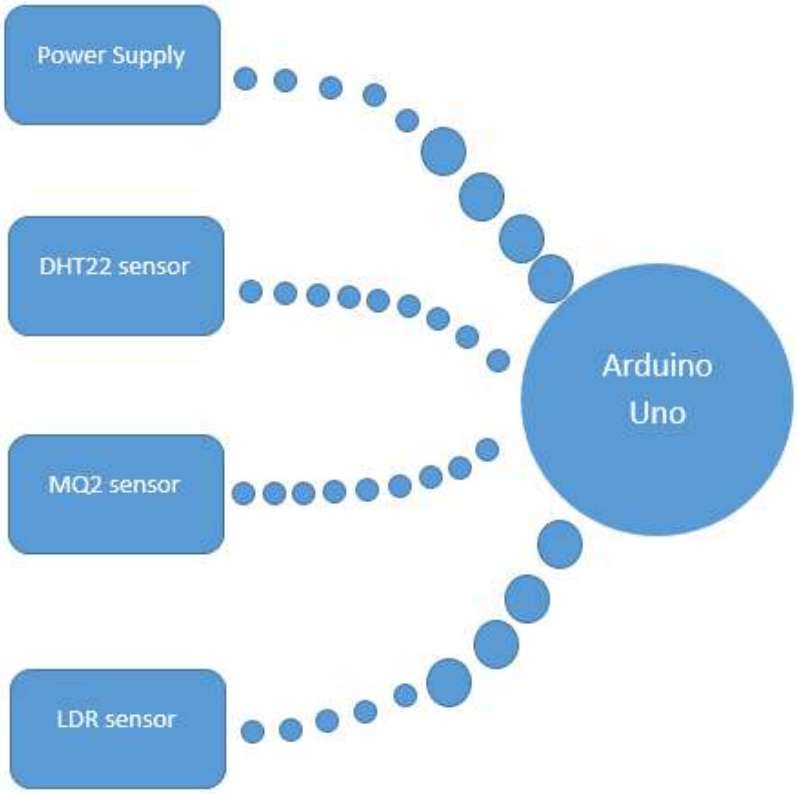

Figure 3.3: Block diagram

This diagram shows the connection between AU and different sensors. For the detection of flammable gases we use MQ9 sensor. MQ9 sensor interface with AU for the measure of gas concentration. The AU integrate the sensor data with the help of arduino ide.

Similarly for the measure of heat we use DHT22 sensor. DHT22 sensor is use for temperature and humidity also. DHT22 sensor interfaced with AU for the measurment of temperature and humidity. AU integrate the sensor data with the help of arduino ide. We set he threshold value of all sensors and if any sensor exceed the limit AU give output to LCD, buzzer and vibration motor.

Chapter 4

ANALYSIS

4.1 Analysis

The main focus of smart helmet automation is to provide safety to coal miners when they enter in non safety area for working. Coal miners can work fearlessly by wearing this helmet, because if any hazard situation occurs helmet will timely alert them [16].

They can protect themselves from different problems by wearing this helmet and they don't need any special training to use this.

To design a smart helmet we draw different diagrams as use case diagram, sequence diagram, activity diagram and class diagram. We use these diagrams as we can clearly propose our idea through these diagrams.

4.2 Use cases

A use case diagram of a software give a graphical overview of actors involved to the system as shown in fig 6.1. Different functions performed by the actors and how functions are interacted.

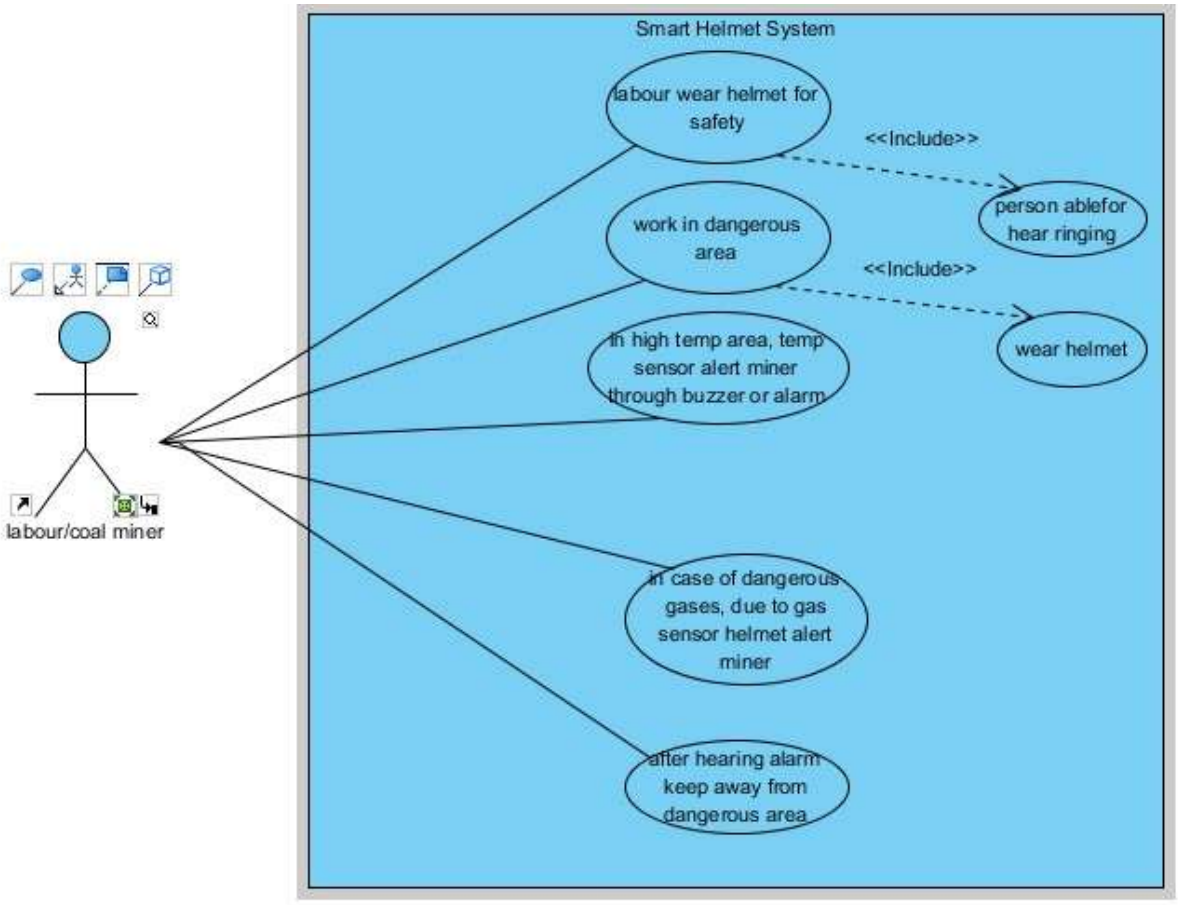

Figure 4.1: Use case diagram

4.2.1 Description

A smart helmet system finds an invaluable use case in the mining industry where it plays an important role for the safety of coal miners. In this scenario, as coal miners enter in the mines for the purpose of working they must wear smart helmet. They wear this helmet for their safety.

In mines if temperature is high temperature sensor alert miners through buzzer or alarm. Sometimes in mining industries flammable gases like methane etc. occurs then in this case helmet alerts miners through gas sensor. The data collected is analyzed in real time and display environmental data on LCD. After hearing the alarm the miners keep away from dangerous areas to protect themselves from danger.

Table 4.1 shows us use case person/use/coal miners as suppose we have a worker having ID : UC-o1 who wears the helmet [17]. The flow of events occurs in such conditions such as coal miners wears helmet. The second one is choose place to wear helmet and stop working after hearing the buzzer or alarm. Then in secondary scenario coal miner can wear helmet.

In post condition, in conditions like low or high temperature, humidity and in case of dangerous gases sensors alert coal miners.

Table 4.1: Use-case person/user/coal minor

Use Case1:	Coal miner wears helmet
ID:	UC-01
Actor:	User/ Coal miner
Pre-condition:	None
The flow of events:	Coal miner wears helmet. Coal miner choose wearing of helmet places. Coal miner stop working after hearing buzzer or alarm.
Secondary scenarios:	Coal miner can wear helmet.
Post Condition:	In high temperature area, temperature sensor alert miners through buzzer alarm. In low or high humidity due to sensor helmet alert miners. In case of dangerous gases due to gas sensor helmet alert miners through buzzer or alarm.

4.3 Functional requirements

The Functional Requirements (REQ) of smart helmet as shown in table 4.2 are:

Table 4.2: Functional requirements

Requirement #	Requirement
REQ-1	Hazard-detecting sensors.
REQ-2	Instant alert generation for hazards.
REQ-3	Interface to allow miners to interact with helmet
REQ-4	Automatic light activation in darkness.
REQ-5	Display environmental data on LCD.

4.3.1 Description

REQ-1: The system must be equipped with sensors that can detect hazard conditions such as high temperature, low oxygen level or the presence of toxic gases, humidity level etc. We use different sensors for the detection of different hazard conditions that occurs in mine.

REQ-2: The system must generate alerts when hazard conditions are detected and these alerts must be communicated to the miners.

For instance, if the level of methane gas exceed the limit then on this case the sensor send data to AU and AU integrate the sensor data and gives output to buzzer and buzzer alert the coal miners.

REQ-3: The system must include a user interface such as buttons to allow miners to interact with the helmet and access its features.

REQ-4: The system automatically turn on light if it sudden gets dark. When workers are working in mines for long shifts and during the night time when it gets dark or they they work on any dark area the helmet automatically turns on light and it is very beneficial for them during working in dark areas.

REQ-5: The system must be equipped with an LCD that will display the values of environmental conditions at any place where miners work.

LCD will be on the hand of worker that will display new results after every 1 second. Workers can easily check environmental conditions any time on it.

4.4 Non-functional requirements

The Non Functional Requirements (NFR) of smart helmet as shown in table 4.3 are:

Table 4.3: Non- functional requirements

Non-Functional Requirement	
Reliability	The system should be reliable and consistent in its performance and must not produce false alarms or fail to detect hazard conditions.
Usability	The system must be easy to use and understandable for the miners and must not required training or technical knowledge.
Maintenance	The system must be easy to maintain and repair and must not require specialized tool.
User Safety	The system should be designed to minimize the risk of injury or accident to the user, with features such as impact protection and hazard detection.
Durability	The system must be durable enough to with stand the harsh and challenging environment of a coal mine including exposure to dust, water and impact.
Battery life	The system must have a battery life that is sufficient to last a full shift or longer and must be rechargeable.
Comfort	The system must be comfortable to wear for extended periods of time and must not cause discomfort to the miners.

4.4.1 Description

Reliability: The system should be reliable and consistent in its performance and must not produce false alarms or fail to detect hazard conditions. Smart helmet gives output within the 2 seconds if any hazard condition occur and generate alarms to alert miners.

Usability: The system must be easy to use and understandable for the miners and must not required training or technical knowledge. It is easy to use that workers can understand its working within the 20 minutes.

Maintenance: The system must be easy to maintain and repair and must not require specialized tool. We don't have to need change the hole system when we add any new module in it.

User safety: The system should be designed to minimize the risk of injury or accident to the user,

with features such as impact protection and hazard detection. User's safety relay 90 percent on it after wearing this helmet.

Durability: The system must be durable enough to with stand the harsh and challenging environment of a coal mine including exposure to dust, water and impact. Its quality should be high.

Battery life: The system must have a battery life that is sufficient to last a full shift or longer and must be rechargeable.

Comfort: The system must be comfortable to wear for extended periods of time and must not cause discomfort to the miners. Its weight must be low so user can easily carry it. Workers can work on long shift easily by wearing this helmet.

Chapter 5

PRODUCT/ SYSTEM DESIGN

5.1 Introduction

The system is developed using the SE software design practices. Different UML diagrams are designed to make system structure and working clear. We used use case diagram which helped in identifying the interaction between the system and the user. We designed sequence diagram to check the sequence in which the actions are performed correctly or not. Schema diagram is used to give the concept of how data will be send to the system. The activity diagram is used to understand the activities being performed by the users and the system. The class diagram is designed to illustrate the relationships between the classes as shown in fig 5.1

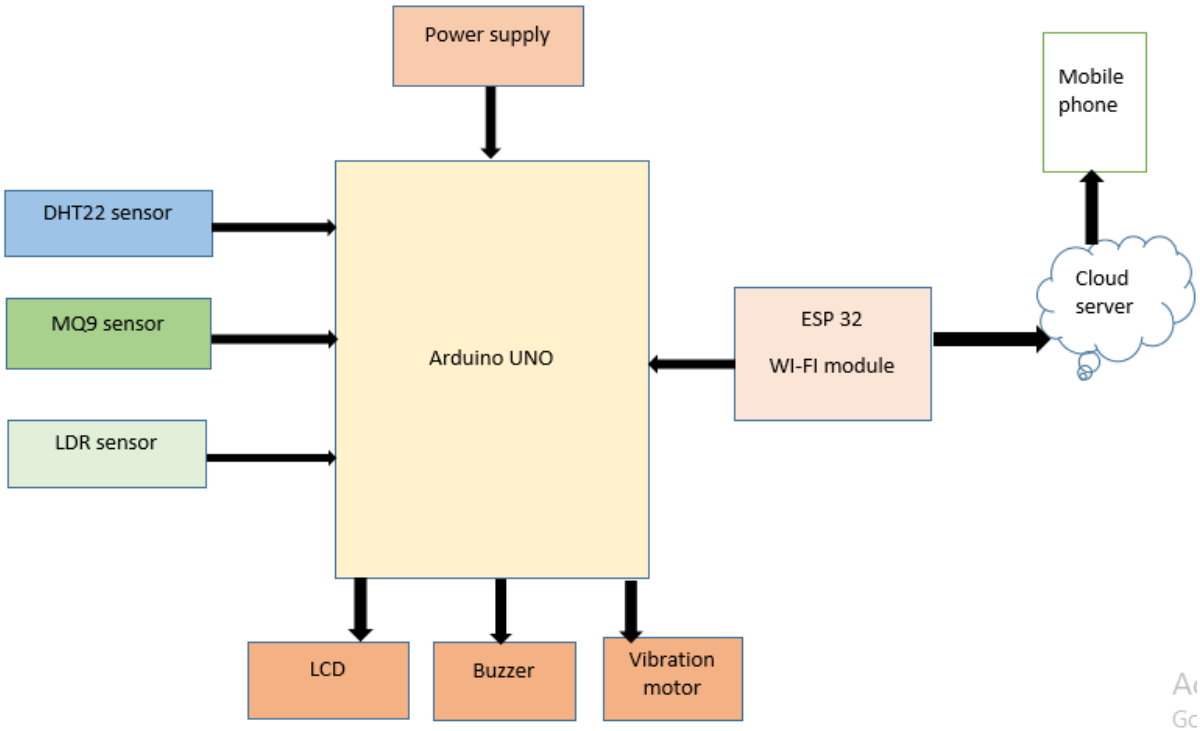

Figure 5.1: System design

The connection of components with Arduino board are as shown in figure 5.2. The architectural design of all system is shown in the below figure. We connect sensors with breadboard and AU. We use battery to give power to the AU. We use the buzzer to alert the miner in the form of vibration motor.

For the connection of devices we use jumper wires. We connect first pin of Light Emitting Diode (LED) with breadboard and second pin is connected with AU. We use different sensors such as DHT22 sensor, MQ9 sensor and LDR sensor which all are connected to the arduino board.For display we use the LDR sensor which is connected to arduino board.

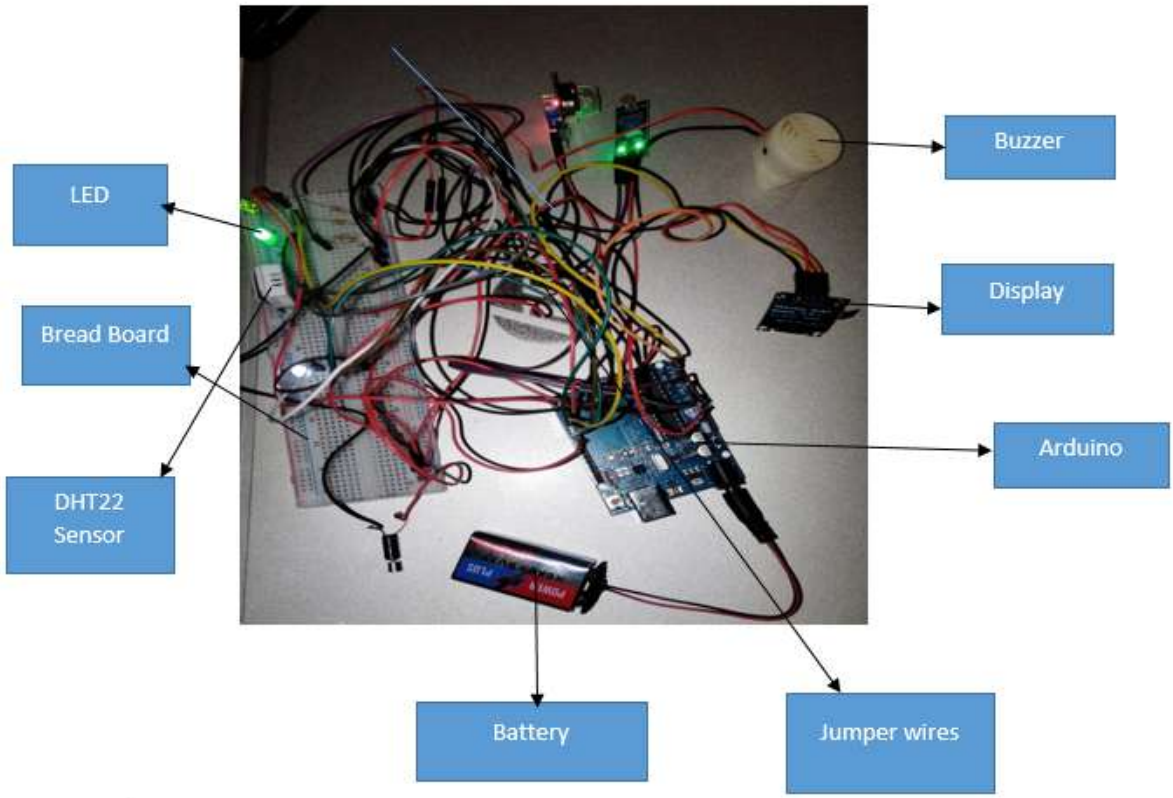

Figure 5.2: Connection of component with Arduino

5.2 Product features

Here are some potential product features for a smart helmet for coal miners:

• **Impact Protection:** The helmet should be designed to protect the wearer's head from impacts, falls, and collisions.

• **Light Source:** Built-in lighting to improve visibility in dark or dimly lit environments.

• **Hazard Detection:** The system continuously monitors various parameters such as temperature, gas levels, and humidity inside the mine. This help in detecting potential hazards and ensuring a safe working environment for miners.

• **Data Logging:** The helmet could include sensors to collect data on environmental conditions such as temperature, humidity, and air quality.

• **Battery Life:** The helmet's battery life should be long enough to last for a full work shift.

• **Comfort and Fit:** The helmet should be comfortable and well- fitted, with adjustable straps and padding to ensure a secure and comfortable fit for a variety of head sizes and shapes.

• **Emergency alert system:** In case of any emergency situations like gas leakage etc. the smart helmet system can instantly send signals to miners. This allows for quick response and timely alert to miners.

5.3 User interface

• **Display:** The helmet should include a display that is easy to read even in low-light conditions and that provides the wearer with the information they need to stay safe and productive. The display shows real time data from temperature, gas and humidity sensors. The display shows new data after every 2 seconds.

The display should be in form of LCD which shows the complete data about environmental condition at the same time they occur.

This data helps miners understand the conditions inside the mine and identify any potential danger. We use three LED's display in our system. If situation is normal then in this case green LED turns on. If any several hazard condition occur then in this case red light will turns on.

• **Menu Navigation:** The User Interface (UI) should be easy to navigate with a clear menu system that allows the user to quickly access different features and functions.

• **Alerts and Notifications:** The helmet should be designed to provide the user with clear, timely alerts and notifications when important events occur such as low battery, hazardous conditions etc. We use buzzer and vibration motor to alert miners if any hazard condition occurs. We use the wifi module to alert control office at the same time.

Also we use an LCD that will be on the arm of worker as watch to display the data of environmental conditions at the same time that environmental conditions occur.

• **Personalization:** The UI could allow users to customize their settings and preferences such as language, display brightness, and alert types.

The prototype of smart helmet system as shown in figure 5.3 shows all the integrated sensors connects with helmet.

This is the final product of our project. After checking that all sensors are working properly, wifi module is working properly and it is sending information to the control room properly we inserted all them on helmet. Now this helmet is known as smart helmet. We tested it by ourselves and then on coal miners and metro construction workers and it was working properly.

Figure 5.3: Proto-type of smart helmet

5.4 Non-functional requirements

Here are some potential REQ for a smart helmet:

• **Reliability:** The system should be reliable and consistent in its performance and must not produce false alarms or fail to detect hazard conditions.

• **Comfort:** The system must be comfortable to wear for extended periods of time and must not cause discomfort to the miners.

• **User Safety:** The system should be designed to minimize the risk of injury or accident to the user, with features such as impact protection and hazard detection.

• **Maintenance:** The system must be easy to maintain and repair and must not require specialized tools or expertise.

• **Environmental consideration:** The system must meet relevant environmental regulations and standards such as those for electromagnetic interference or exposure to extreme temperatures.

• **Usability:** The system must be easy to use and understandable for the miners and must not require training or technical knowledge.

Chapter 6

SOFTWARE DESIGN

6.1 Software design

Smart helmet is a hardware application that is built by using different hardware and software technologies. Different hardware technologies such as AU, sensors, breadboard, wires etc. and softwares such as Arduino ide, wokwii simulator, java, visual paradigm etc. are uesd. Complete smart helmet was designed using various UML diagrams including use-case, sequence, class, activity diagrams. In this chapter we will discuss these different diagrams and their working.

6.2 Introduction

Smart helmet is designed using agile model. We are using this model because in this model we divide the project into small segments. In first iteration, we develop our first module and so on.

After the completion of first module if any error occurs it will be removed at any time . As our project is hardware base so if any sensor generates error at any time we can replace it. That's the reason that we are using agile model.

6.3 High level use case

A use case diagram of a software give a graphical overview of actors involved to the system. A use case is a detailed description of how a system, software application or process interacts with external entities to achieve a specific goal.

The actor in the system represents an external entity that is interacting with the system. Actors can be entity or user that interacts with the system to achieve a specific goal.

A precondition system in use case hat specifies the conditions that must be meet before the use case can be executed. It is the initial stage of system. Post condition is after pre condition.

The post condition is the statement that describes the expected state of system after the use case has been executed.

Different functions performed by the actors and how functions are interacted as shown in figure 6.1

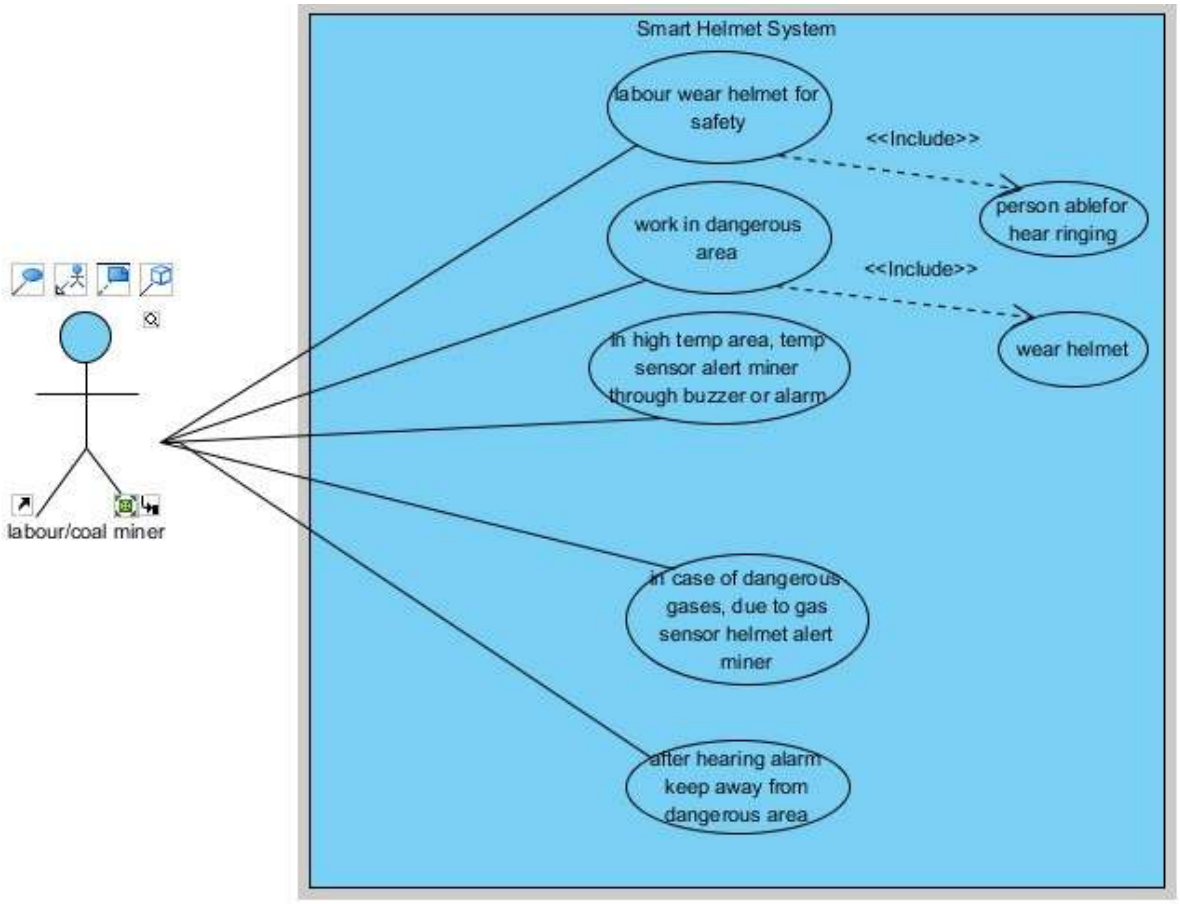

Figure 6.1: Use case diagram

6.4 Sequence diagram

It is an interaction diagram which tells you how and when objects of the system communicate with each other by passing messages [18]. It is a type of interaction diagram because it describes how and in what order a group of objects together.In short, we can say that it shows the sequence of messages between the different objects. Sequence diagrams are also called as event diagrams or event scenarios.

Sequence diagram is use to document a system's requirements and to flush out a system's design.

Straight lines are used to send message straight while dotted lines are used to send back messages. The activation bars shows when object is actively processing a message. They help to visualize the object interaction.

Vertical box are lifelines that represents the objects or components that participate in the interaction. The objects involved in the sequence diagram is represented by a rectangle box. The sequence diagram of smart helmet system as shown in figure 6.2

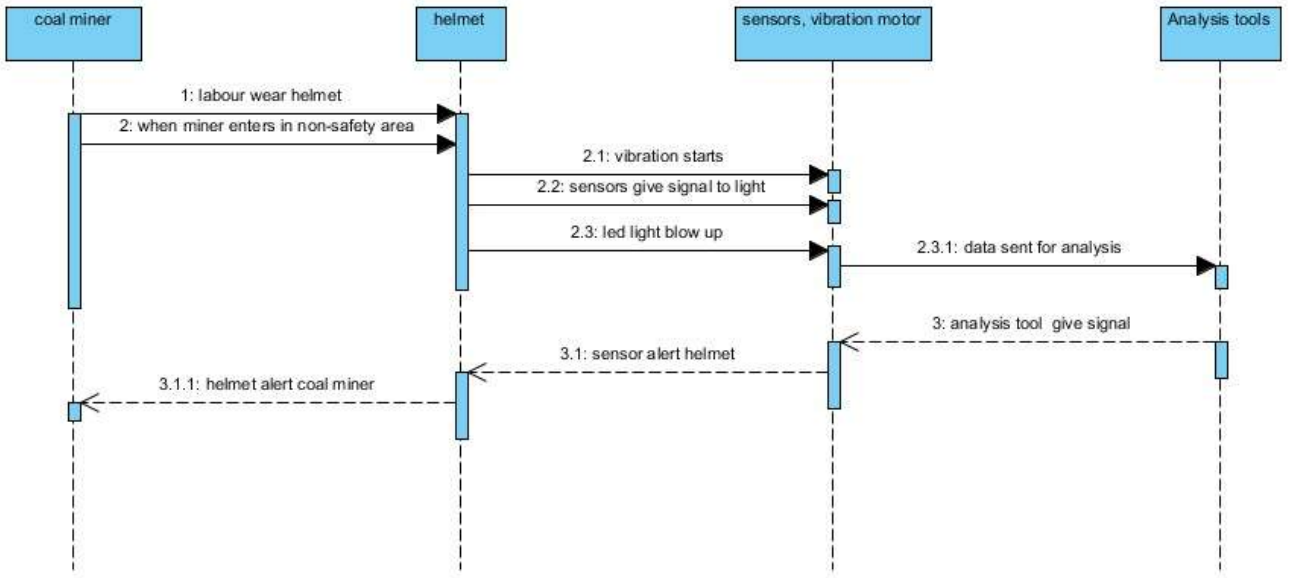

Figure 6.2: Sequence diagram

6.5 Class diagram

Class diagram is one of the important UML diagrams for software development which shows the object classes in the system and the associations between these classes. The class diagram would depict the various classes and their associations.The explaination of the class diagram are as follows:

Smart helmet class

This class represents the smart helmet itself which is worn by the coal miners. It may have attributes such as helmet id, helmet location, helmet wearing size etc.

Coal miner class

This class represents the coal miners. It may have attributes like miner id, miner name, miner age and miner's working area.

Sensor class

This class represents the various sensors integrated into the smart helmet such as temperature sensor, gas sensor, humidity sensor. Each sensor may have attributes like sensor id, sensor type, sensor response rate.

Vibration motor

This class represents the emergency alert system of smart helmet system. It may have attributes like response rate, volume etc.

The class diagram of smart helmet as shown in figure 6.3

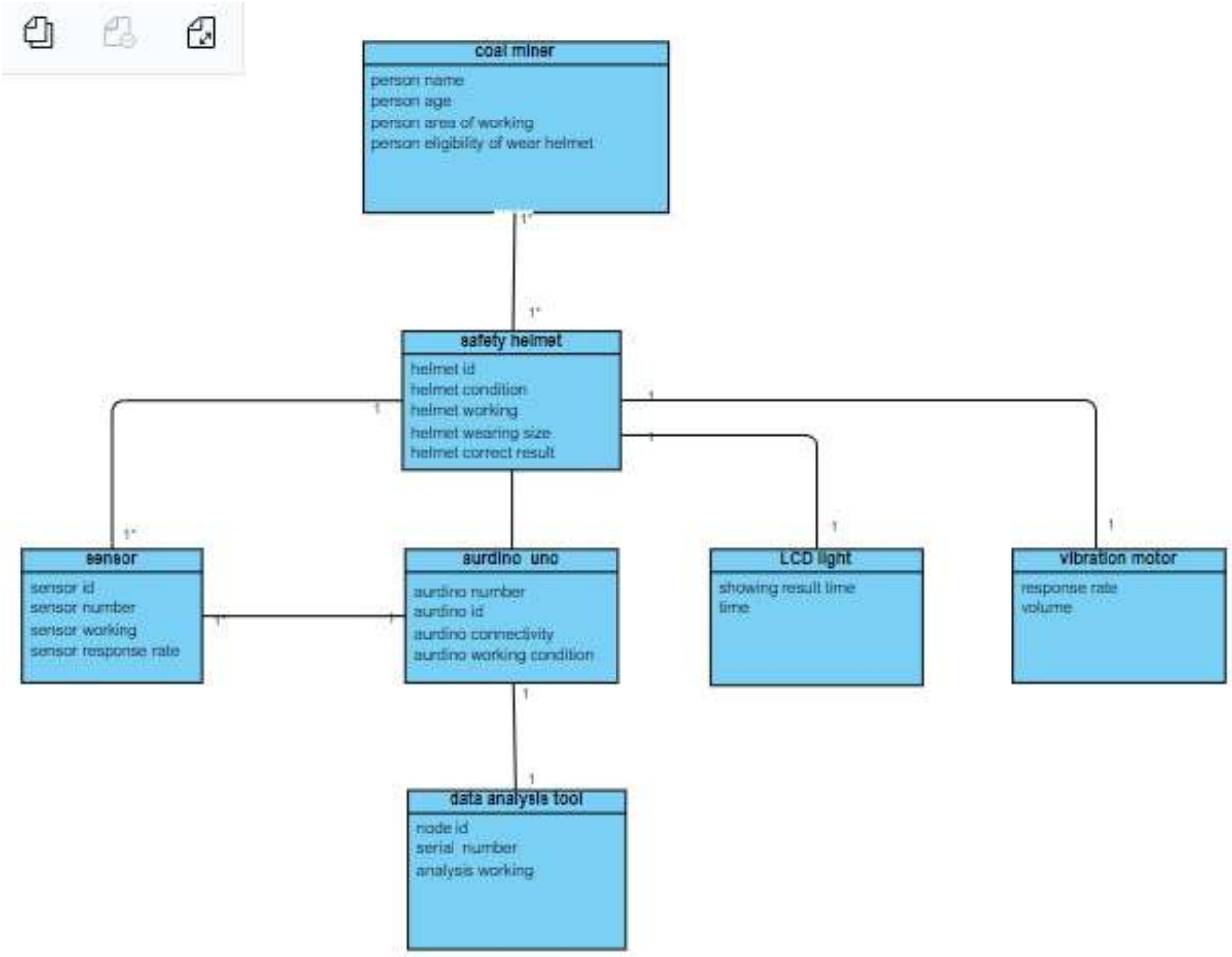

Figure 6.3: Class diagram

6.6 Activity diagram

Activity diagram of a software is a type of unified modeling language flow chart that shows the flow from one activity to another activity in a system or a process.An activity diagram is a visual representation of the flow of activities or processes in a system.

It shows the sequence of actions or steps involved in completing a task or achieving a goal. It is like a flowchart that helps us understand how things work. Sequence diagram show the different states, actions and transitions that occur within a system.

It is a great way to visualize complex processes and understand the flow of activities.

The activity diagram of smart helmet as shown in figure 6.4

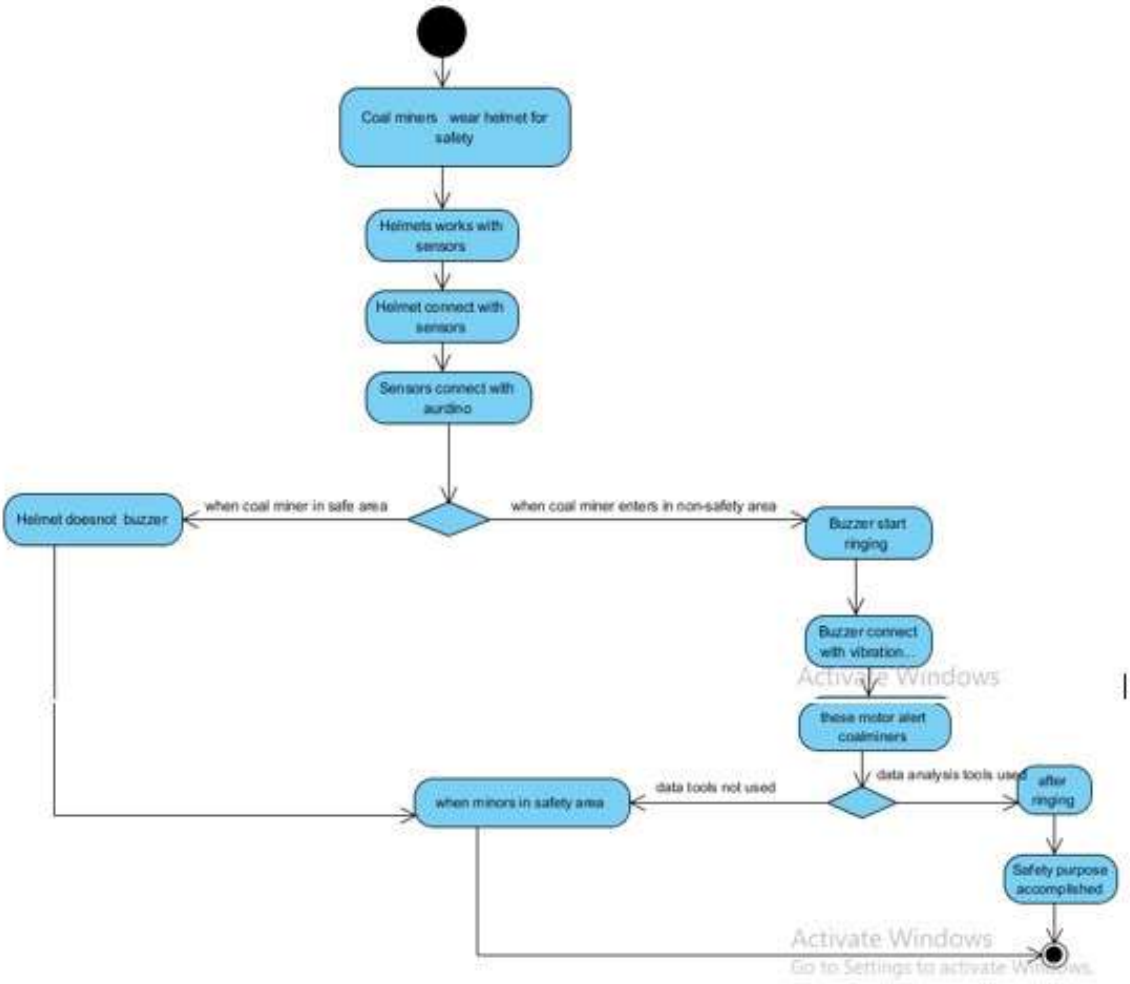

Figure 6.4: Activity Diagram

Chapter 7

IMPLEMENTATION

7.1 Introduction

The implementation of smart helmet system that fits for the safety of underground workers needs to be comprised of the following hardware components.

We use multiple sensors that collect relevant data from the environment. AU is the main component which we used in this project [19]. For the detection of gases we use gas sensor. We select the threshold value of these sensors . If threshold values exceed the limit in this case helmet alert the miners. Similarly for the detection of temperature and humidity sensor, we use DHT22 sensor and other sensor we used our project is LDR sensor.

These sensors connect with Arduino board in the form of input and Arduino board get program from computer regarding these sensors and generate outputs in the form of buzzer or vibration motor [20] . After completion of modules in Arduino board we insert all these modules in helmet to make a smart helmet.

We insert a vibration motor and buzzer in helmet and insert a small LCD with the hand of worker. We set the threshold value of all these sensors according to their specification and if threshold value exceed the limits helmet alert the coal miners in the form of buzzer or vibration motor.

7.1.1 Hardware components

Following hardware components are used while developing smart helmet:

By using these hardware components, we design smart helmet system.

AU: The main component of our project is Arduino Uno. It is a microcontroller board based on AT mega 328. It has many features. It has 13 digital pins which are mostly used to connect the outputs like LED, LCD etc. It has 6 analogue pins labeled as A0 to A5 .

These pins are used to connect directly sensors with Arduino. It has 2 power pins labelled as 5V and ground used to connect inputs and outputs. It has an USB port that is used to upload the program to Arduino. It has one reset button that is use to restart the program. Arduino board and its connections are shown in figure 7.1

MQ9 Gas sensor: It is used to measure the gas leakage detection in industries and home [21]. The gases detected by MQ9 sensor are carbon mono-oxide, LPG etc. MQ9 sensor is sensitive and also fast response time. We use MQ9 sensor in our project to detect carbon mono-oxide .

The features of MQ9 sensor are as following:

• Its operating voltage is 5 volts.

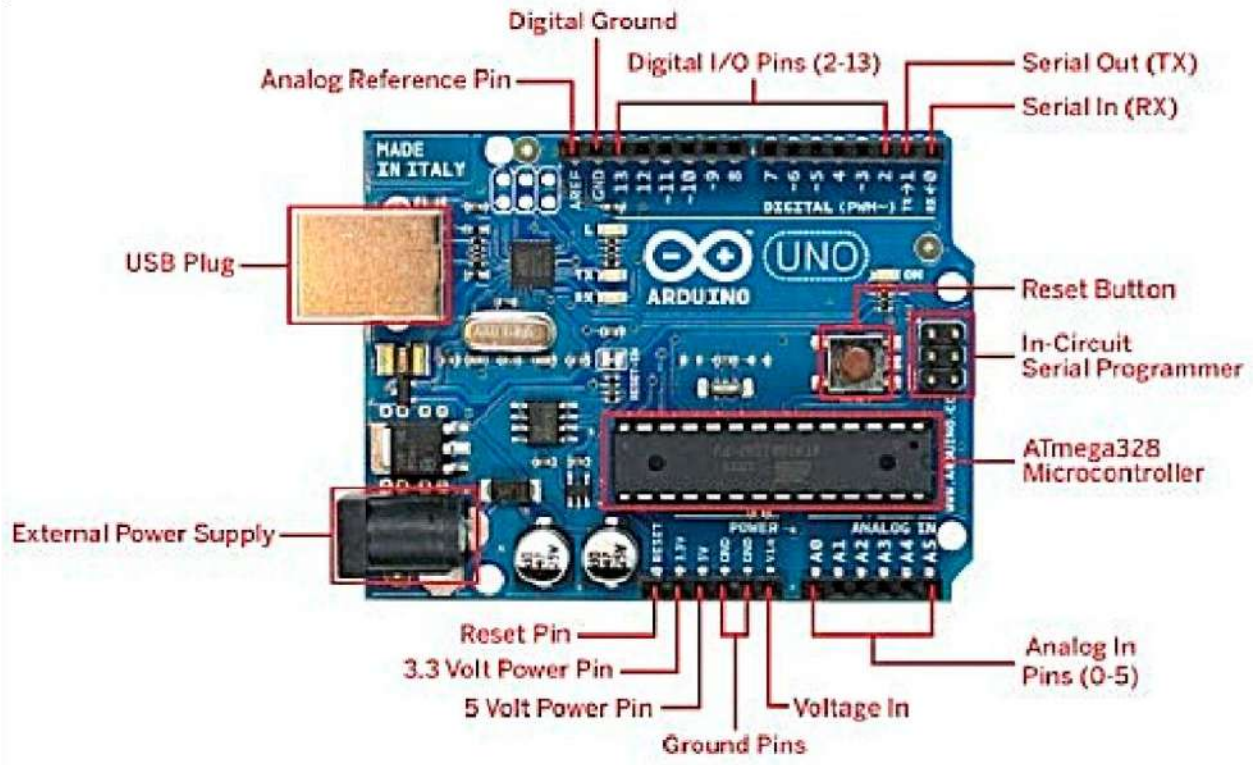

Figure 7.1: Arduino board and its connection

• Its range is 200ppm and 5000ppm.

• It has long life and low cost.

DHT22 sensor: It is used for sensing temperature and humidity and it can interface with any microcontroller and can measure the range of temperature and humidity.

Its have four pins. The specifications of DHT22 sensor are as following:

• Its operating voltage is 5 volts.

• Its measuring temperature range is -40 degree to 80 degree with 0.5 degree accuracy.te22

• Humidity measuring range is 0

• In humidity its accuracy is 2

• In humidity its resolution is 0.1

Jumper wires: These wires are used for the connection between sensors and Arduino board. Black jumper wires are connect with ground, red wires are connect with power supply or voltage and green wires are use to connect with input/output.

LDR sensor: LDR means light dependent resistor. This device change value of resistance according to the light.

The features of LDR sensor are as following:

• It is having 4pins.

• First pin is VCC.

• Second pin is Ground (GND).

• Third pin is Digital Output (DO).

• Fourth pin is Analogue Output (AO).

• This sensor act as analogue or digital sensor.

• Light resistance - 10k to 20 k and dark resistance - 2M .

LCD : LCD stand for liquid crystal display. It is used to display outputs. It is used in many applications like TV, calculator etc. Its price is cheap and easy to use display.

Its features are as following:

• Its display alphanumeric values.

• Its operating voltage is around 4.7 V to 5.3V.

• Its current consumption is around 1Ma.

• It has 2 modes.

• One is 4 bit mode and other is 8 bit model.

Bread Board: Bread board is a important part of electronic circuit design. On the breadboard we make the circuit and test the circuit to see if it is working properly or not. The breadboard is divide into four section. It contain many holes in it. The first section holes are horizontially connected to each other and the second section holes are vertically connected to each other.

Transistor: A transistor is a semiconductor device used to amplify or switch electrical signals and the power.

Buzzer: Buzzer is used to add a sound feature [22]. It is easy to use. The features of buzzer are as follows:

• Its operating voltage is 4-8 V DC. It has 2 pins.

• It is used to get alert workers in case emergency.

Esp32: Esp32 module is the versatile and powerful microcontroller module that is widely used in various IOT applications. The Esp32 module combines a duel core processor, wifi connectivity and making it suitable for wide range of projects.

Table 7.1 shows specification of the selected sensors:

Table 7.1: Specification of the selected sensors

Sr.NO	Parameters	DHT22 sensor	MQ9 Gas sensor	LDR sensor
1	Sensing Variables	Temperature & Humidity	Gas Concentration	Light dependent resistor for light
2	Operating Voltage	3.5 to 5.5 V	5V	3V to 6V
3	Operating Current	2.5 mA	150 mA	50 mA
4	Output Voltage	5.5V	+5V	5V
5	Operating Temperature range	-40°C to 125°C	-10 to 50°C	-30 to 70°C
6	Output Sensing range	0% to 100%	10-10000 ppm	500 to 1023
7	Sampling rate	0.5 Hz(one reading every two second)	2 second	————

Below figure 7.2 shows the gas sensor, temperature sensor, wires and LCD display:

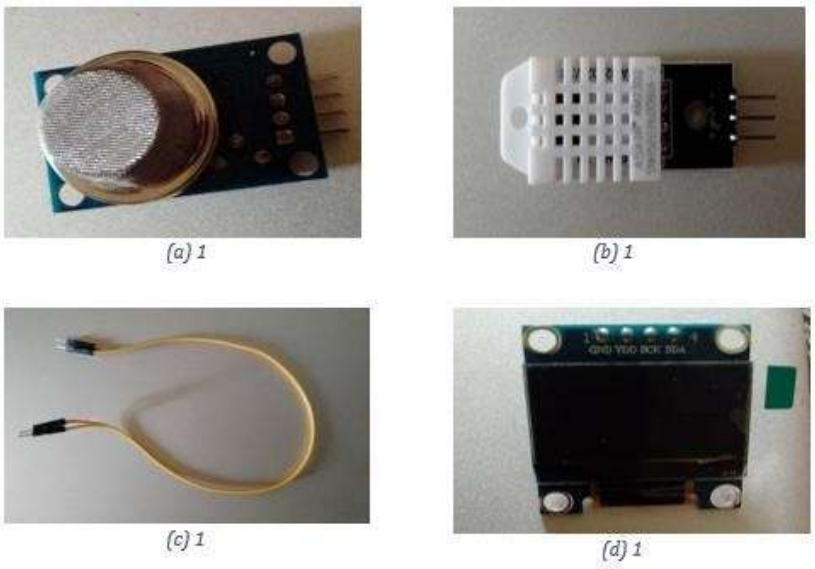

Figure 7.2: (a) gas sensor (b) temperature 1 (c) wires (d) LCD display

Below figure 7.3 shows the LDR module, USB cable, battery and buzzer:

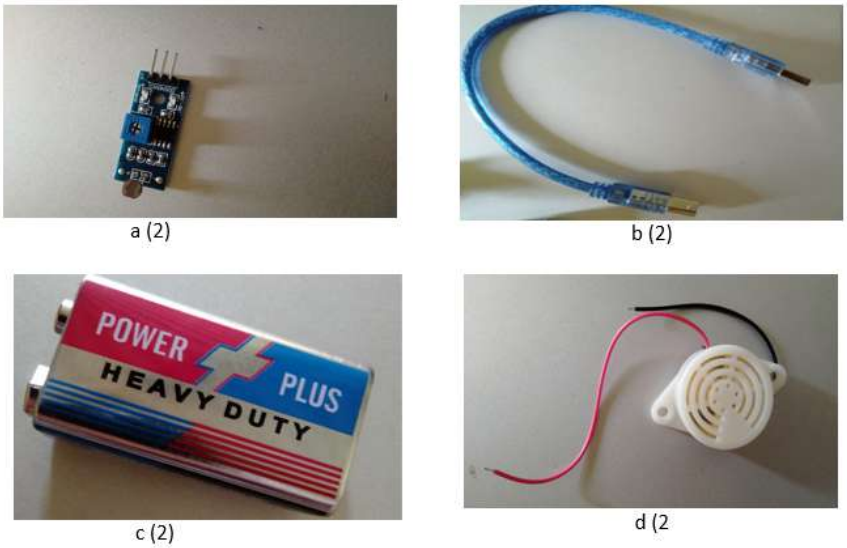

Figure 7.3: (a) LDR module (b) USB cable (c) battery (d) Buzzer

7.2 Software

- Arduino ID
- Wok Wii simulator
- Java
- Android studio
- Microsoft (MS) word
- Adobe Illustrator (AI)
- Visual Paradigm (VP)

Arduino id: It is a software that is connected with Arduino board and communicate with controller. With this we can write, compile and upload program on Arduino board. In Arduino id we can write code in a simple syntax.

Wokwii simulator: is used for online coding. We can write code and share projects and also download large projects. We can use it freely.

Java: Java is a high level object oriented programming language that is designed to be platform independent meaning that java programs can run on any device or operating system that has a java virtual machine installed.

MS word: is use to create files, reports, documents, assignments etc. We can also add images and tables in files.

Android studio: The android studio is an integrated development environment specifically designed for developing android applications. It provides a comprehensive set of tools and features that assist developers in building, testing and debugging android apps efficiently. Android studio includes a powerful code editor with features like syntax highlighting, code completion and refactoring tools.

AI: An illustrator used for graphic designing. We can create drawings, logos, diagrams, graphs etc. We can save our work in different formats in Adobe illustrator AI.

VP: VP is a software construction model which is used to build software and design different models and diagrams such as class diagram, sequence diagram, component diagram, etc.

7.3 Verification

Verification of smart helmet is divided into two techniques one for UI testing and other for functionality testing.

Beta Testing

Beta testing involves user's feedback after using the application [23]. Users report any sort of issues and errors found within the application. These issues can be related to application UI or application functionality.

Smart helmet is tested among smart helmet team members and some fellows. In the beginning a number of issues were found both UI related as well as functionality related. Then after the feedback, those issues were resolved until complete user satisfaction.

Selection of beta tester

We select the group of miners to participate in the beta testing phase. These testers represent longer experience within the mining industry.

Testing objects

The clear objective and the testing scenarios define to ensure beta testers evaluate the system performance. functionality ans usability. This includes various testing features such as real time monitoring and emergency alerts.

Feedback collection

Beta testers are encouraged to provide feedback on their experience with the smart helmet system. Feedback may include bug reports, usability suggestion and performance observations.

Iterative testing

The development team collect and analyze feedback from beta tester, issues are addressed and fixed in the subsequent iterations of the software.

Testing environment

The beta testers may use hardware on various environments and configurations to access compatibility. The testing environments should reflect real world scenarios to uncover issues that might arise in different usage context.

Black Box Testing

Smart helmet features are tested using black box testing. Black box testing is use to verify the overall functionality of the system to ensure system accurately detect the hazard situations and alert the workers when connected to external device.

The black box testing is done by using functional testing. The functional testing involves the system functionality by providing various inputs in verifying if expected outputs are produced. For example tester can simulate emergency situations and check if system send signal to workers.

By using black box testing, we test this smart helmet in different mining industries by giving different inputs to verify how system respond and whether it meets the specific requirements or not.

7.4 Test cases

Table 7.2 shows the temperature sensor type test case in normal condition:

Table 7.2: Select Temperature sensors type test case (Normal)

Test Case No.	**TC-1**
Purpose of the Test	To verify whether temperature sensor is working properly or not
Input	We set the threshold value of sensor “40”
Sensor reading	30
Output	Buzzer off
Remarks	Normal temperature
Pass/Fail	Pass

Figure 7.4 shows the Output of normal temperature.

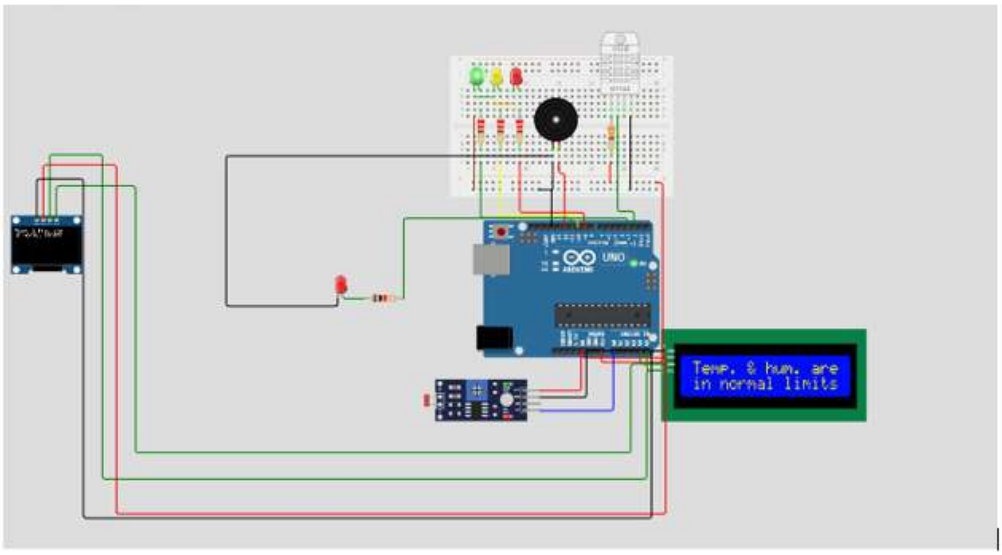

Figure 7.4: Output of normal temperature

The table 7.3 shows the temperature sensor type test case in abnormal condition:

Table 7.3: Select Temperature sensors type test case (Abnormal)

Test Case No.	**TC-2**
Purpose of the Test	To verify whether temperature sensor is working properly or not
Input	We set the threshold value of sensor “40”
Sensor reading	45
Output	Buzzer ON
Remarks	Be aware temperature is too high
Pass/Fail	Pass

Figure 7.5 shows the Output of temperature in abnormal condition.

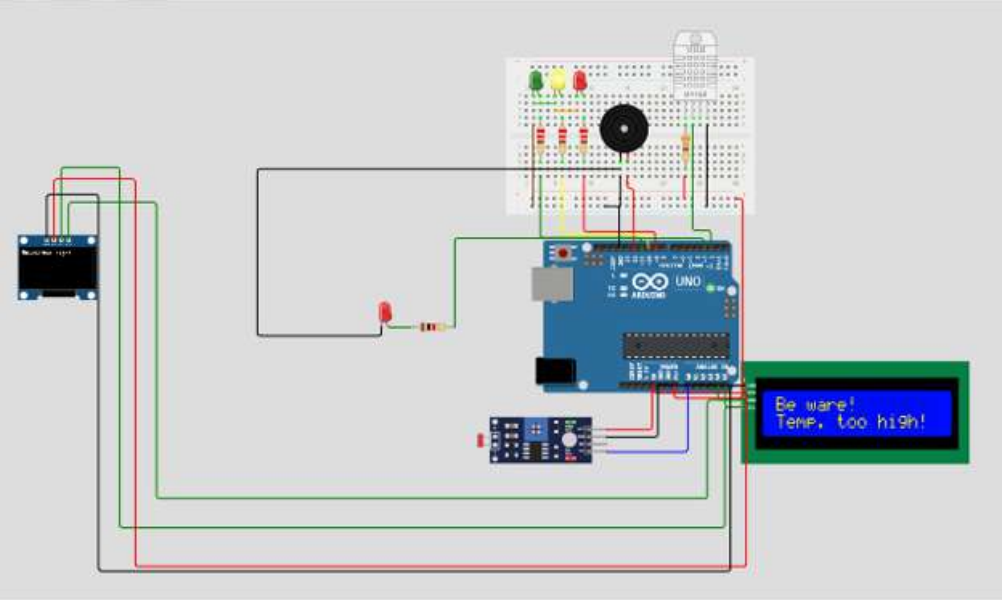

Figure 7.5: Output of temperature in abnormal condition

The table 7.4 shows the gas sensor type test case in normal condition:

Table 7.4: Select gas sensors type test case (Normal)

Test Case No.	**TC-3**
Purpose of the Test	To verify whether gas sensor is working properly or not
Input	We set the threshold value of sensor “200”
Sensor reading	198
Output	Buzzer off
Remarks	Condition safe
Pass/Fail	Pass

The table 7.5 shows the gas sensor type test case in abnormal condition:

Table 7.5: Select gas sensors type test case (Abnormal)

Test Case No.	**TC-4**
Purpose of the Test	To verify whether gas sensor is working properly or not
Input	We set the threshold value of sensor “200”
Sensor reading	250
Output	Buzzer ON
Remarks	Condition Unsafe
Pass/Fail	Pass

The table 7.6 shows the humidity sensor type test case in normal condition:

Table 7.6: Select humidity sensors type test case (Normal)

Test Case No.	**TC-5**
Purpose of the Test	To verify whether humidity sensor is working properly or not
Input	We set the threshold value of sensor “80”
Sensor reading	30
Output	Buzzer off
Remarks	Normal humidity
Pass/Fail	Pass

Figure 7.6 shows the Output of humidity in normal condition.

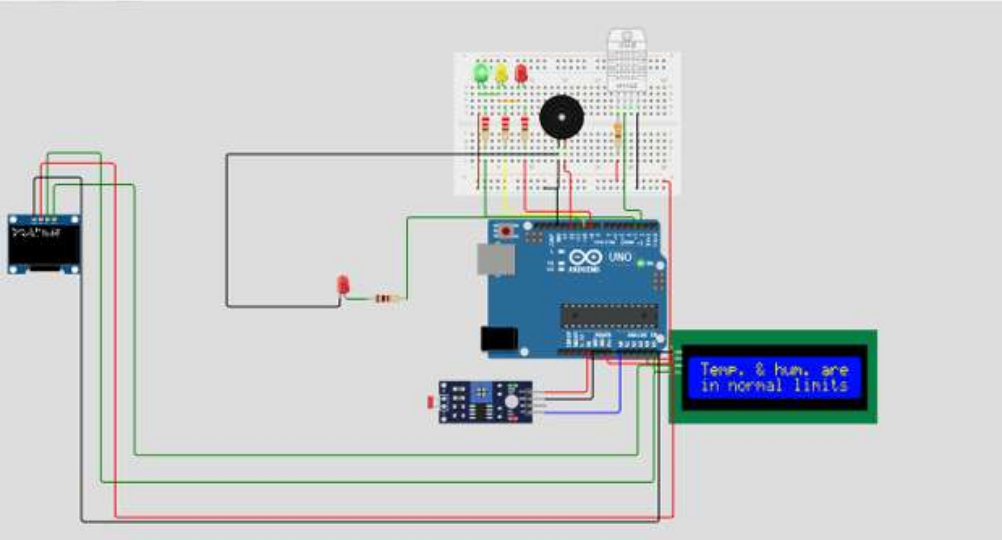

Figure 7.6: Output of humidity in normal condition

The table 7.7 shows the humidity sensor type test case in abnormal condition:

Table 7.7: Select humidity sensors type test case (Abnormal)

Test Case No.	**TC-6**
Purpose of the Test	To verify whether humidity sensor is working properly or not
Input	We set the threshold value of sensor “80”
Sensor reading	65
Output	Buzzer ON
Remarks	Be aware too high humidity
Pass/Fail	Pass

Figure 7.7 shows the Output of humidity in abnormal condition.

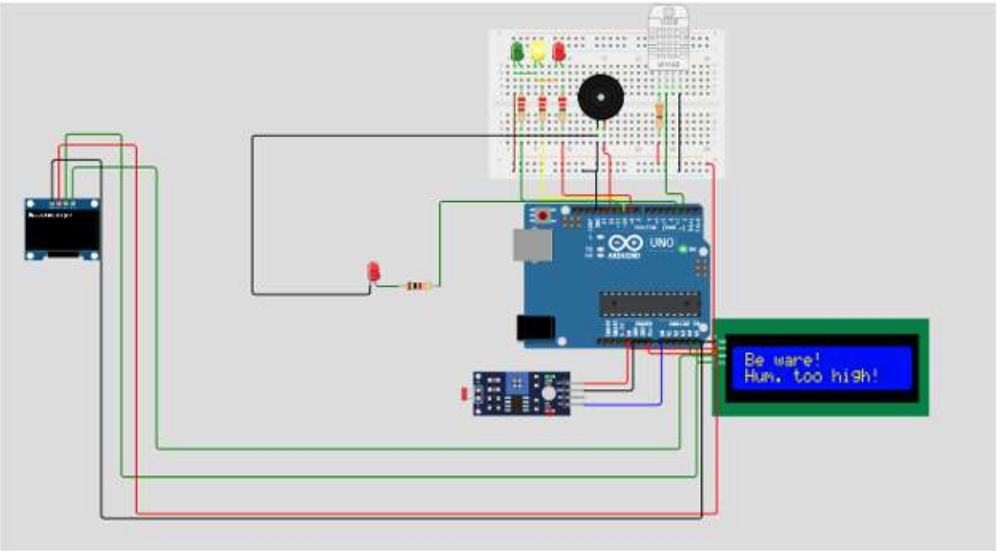

Figure 7.7: Output of humidity in abnormal condition

The table 7.8 shows the LDR sensor type test case in normal condition:

Table 7.8: Select LDR sensor type test case (Normal)

Test Case No.	**TC-7**
Purpose of the Test	To verify whether LDR sensor is working properly or not
Input	We set the threshold value of sensor “500”
Sensor reading	“534”
Output	Light OFF
Pass/Fail	Pass

Figure 7.8 shows the Output of LDR in normal condition.

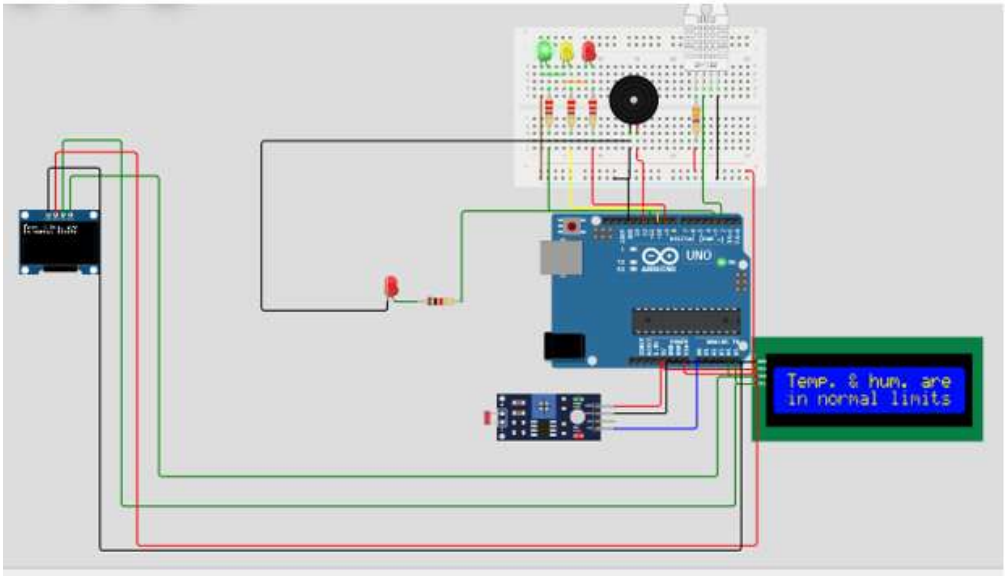

Figure 7.8: Output of LDR in normal condition

The table 7.9 shows the LDR sensor type test case in abnormal condition:

Table 7.9: Select LDR sensor type test case (Abnormal)

Test Case No.	**TC-8**
Purpose of the Test	To verify whether LDR sensor is working properly or not
Input	We set the threshold value of sensor “500”
Sensor reading	“1015"
Output	Light automatically turn ON
Pass/Fail	Pass

Figure 7.9 shows the Output of LDR in abnormal condition.

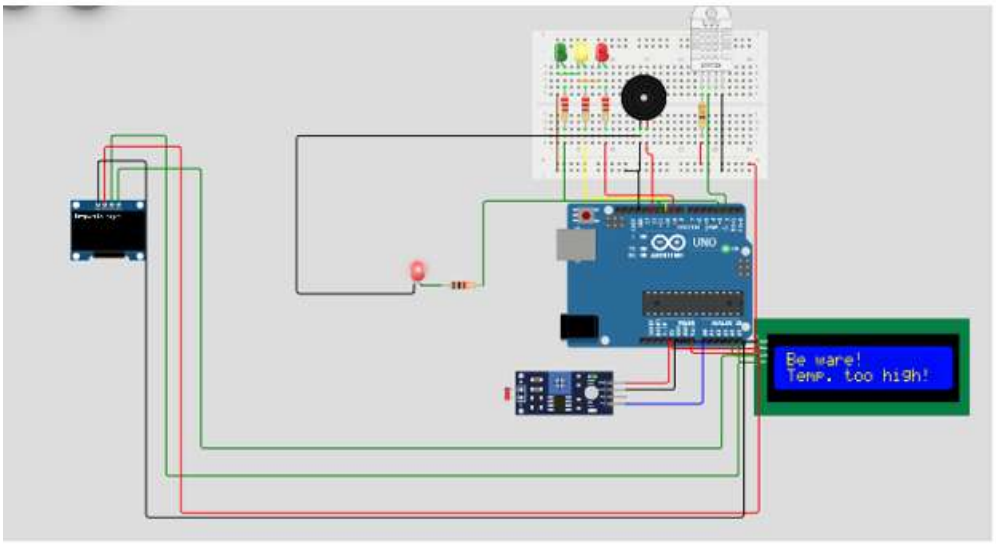

Figure 7.9: Output of LDR in abnormal condition

7.5 Result

Smart helmet automation system is important because it helps to improve the safety of workers. After wearing this helmet coal miners can work fearlessly in mining industries. We set the threshold values of given modules. If the value exceed from its threshold value buzzer will alert the coal miner in the form of vibration motor and miner leave the site at a time.

If threshold value exceed the limits, then in this case helmet gives output to coal miners in the form of buzzer or in the form of vibration motor and coal miners alerted in case of emergency [24]. In this way coal miners save them from many hazardous situation that's Occur in mining.

We set different threshold values for different sensors according to our requirement or knowledge because different environmental conditions have different impacts on different values.

The result analysis of the monitoring system as shown in table 7.10

Table 7.10: Result Analysis

Sr.no	Parameters	Threshold value set	Sensor Reading	Output	Remarks
1	Temperature (degree/ Celsius)	40	30	Buzzer Off	Condition Safe
2	Gas (ppm)	200ppm	198ppm	Buzzer Off	Condition Safe
3	Humidity	80%	75%	Buzzer Off	Condition Safe
4	LDR	500	550	LED light On	Condition Safe

Figure 7.10 shows the Result analysis of monitoring system in normal condition.

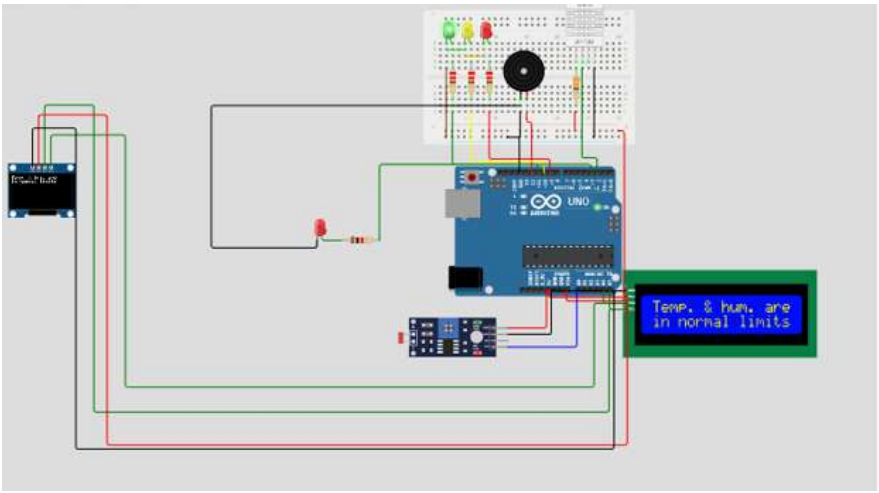

Figure 7.10: Result analysis of monitoring system in normal condition

Result analysis of monitoring system for unsafe condition is shown in table 7.11

Table 7.11: Result Analysis of monitoring system

Sr.no	Parameters	Thresh hold value set	Sensor Reading	Output	Remarks
1	Temperature (degree/ Celsius)	40	55	Buzzer On	Unsafe Condition
2	Gas (ppm)	200ppm	250ppm	Buzzer On	Unsafe Condition
3	Humidity	80%	85%	Buzzer On	Unsafe Condition
4	LDR	500	550	LED light ON	Condition Safe

Figure 7.11 shows Result analysis of monitoring system in abnormal condition.

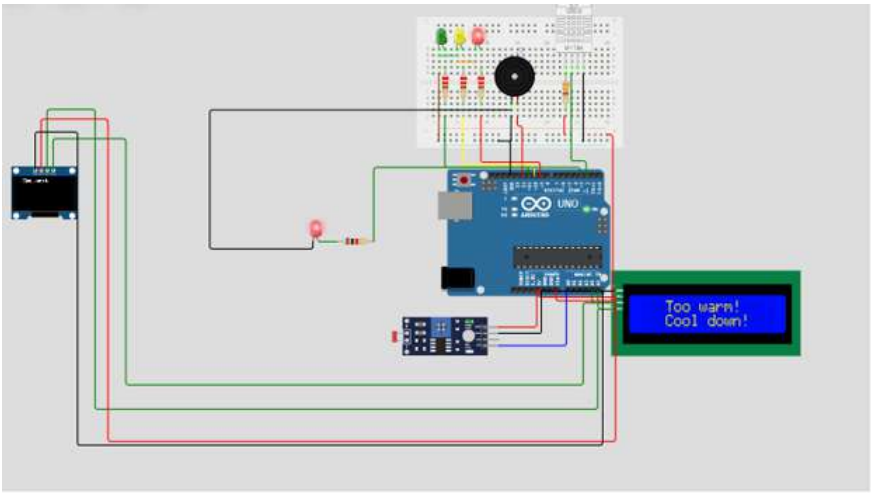

Figure 7.11: Result analysis of monitoring system in abnormal condition

7.6 Validation

Every system has some validity criteria so smart helmet also has some. For the validity of application module every module is passed through validation testing [25]. The modules for validation are highlighted in the application and a validity criterion is created according to the requirement of that specific module. Smart helmet validation test is conducted between FYP team. All modules

are validated and approved by the team.

Here are some key aspects of the validation process:

Safety standards compliance

The smart helmet system should meet relevant safety standards and regulations specific to the mining industry. This includes compliance with guidelines for personal protective equipments and any specific requirements for mining operation.

Field testing

The system should undergo rigorous field testing in real mining environments. This involves deploying the smart helmets to coal miners and monitoring their performance and functionality in various conditions.The system should be evaluated for its ability to detect and respond potential safety hazardous such as gas leakage, falls or collisions.

Data accuracy and reliability

The collected data from the smart helmet system such as environmental conditions should be accurate and reliable [26]. Validation involves verifying the accuracy of sensors and the system's ability to provide real time information to miners.

User feedback and acceptance

Gathering feedback from coal miners and other stakeholders is crucial. User acceptance testing insures that the smart helmet system is user friendly and aligns with the needs of coal miners.

Integration with existing safety measures

The validation process should consider how the smart helmet system integrates with existing safety protocols and measures in mining operations. It should enhance the overall safety work ensuring integration with their safety equipments and procedures.

Chapter 8

DISCUSSION AND CONCLUSION

8.1 Solution review

We addressed the problem effectively [27]. Our proposed solution is highly durable, safe and secure. It helps the workers in hazard situations and its battery life is long lasting and durable. It is cost effective, repairable and easy to use.A device that we design is known as smart helmet automation.

This device was able to detect four type of hazardous situation such as presence of toxic gases, temperature ranges, humidity values, and automatically turn on the light in case of darkness. By using this helmet workers can work in mining without any fear. It is easy to use and cost effective.

It is not only use in mining industries but also use in construction sites, metro stations , weather stations etc. It has wireless connection. Smart helmet direct interface with workers [28]. For using this smart helmet, workers need no special training. It has long lasting battery life. It can be rechargeable. A smart helmet for hazardous detection monitoring the environmental conditions and in case of emergency smart helmet alert the miners .

8.2 Key skills

Key skill learned are improved in this project's design and development are stated below:

• Technical skills such as hardware design, sensors integration etc.

• Software skills such as arduino ide

• Problem solving skills

• Project management skills

• User centered design

• Collaboration and team work.

8.3 Future work

This project was a great learning opportunity and it helped us to learn new technologies that have great demand in the industry nowadays. As for concerned with job, I thing this tech stack will be quite helpful to get a newbie job right after our completion of degree.Future work related to our project can focus on several areas to enhance safety and efficiency.

Here are some potential areas for future development.

Smart Predictions

Use smart technology to predict dangers before they happen [28]. Develop algorithms and models to analyze the collected data and predict potential safety hazards.

By leveraging machine learning and predictive analytics, the smart helmet system can provide early warnings and preventive measures to risks.

Better Communication

Improve ways for miners to talk to others while underground. Additionaly, explore localization technologies such as GPS or indoor positioning systems to track miners location accurately in real time.

More Comfortable Design

Make the helmet more comfortable for miners to wear for long periods [29]. It is lightweight that the workers can work easily while wearing it and don't feel uncomfortable.

Industry Collaboration

Work together with others in the industry to keep making the technology better based on what's needed.

8.4 Conclusion

This smart helmet is useful as it will introduce a new and improved way of coal miner's safety by conducting different IOT techniques. This smart helmet is very beneficial for the workers. Its improve the safety of workers.

To detect hazardous situations that occurs in mining industries we install different sensors like temperature, humidity, gas sensors etc. in our smart helmet [30]. By wearing this smart helmet workers can work fearlessly in mining industries.One advantage will be that this system will minimize the fear of workers. After wearing this smart helmet workers can work in mining industries without any fear because our smart helmet will detect many types of hazard situations and alert the miners. Another big advantage is that by improving the efficiency and reducing the risk of accidents and injuries the smart helmet system can help reduce the costs associated with mining operations. Additionally the system can help minimize downtime due to equipment failure, resulting in even more significant cost savings.

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