SMART HELMET FOR COAL MINES SAFETY MONITORING WITH MOBILE APP

Mir Sajjad Hussain Talpur[1], Amjad Chohan[1], Mashooque Ali Mahar[2], Fauzia Talpur[3], Noor Nabi Dahari[1], Asadullah Kehar[2], Raheel Sarwar[1], Naveed Khan[1]

[1]Information Technology Centre, Sindh Agriculture University, TandoJam, 70050, Sindh, Pakistan.
[2]Department of Computer Science, Shah Abdul Latif University, Khairpur, 66020, Sindh, Pakistan.
[3]University Sindh Laar Campus, Department of Computer Science, Sindh, Pakistan.
Corresponding author: Mir Sajjad Hussain Talpur(mirsajjadhussain@sau.edu.pk).

Abstract: Pakistan is endowed with vast coal reserves, primarily in Sindh, totaling 184.623 billion tons. Our country's market has been rapidly expanding. As we all know, accidents are becoming more often in mines due to a shortage of competent workers, miners' safety cannot be guaranteed, and coal manipulation is impossible. Men who are currently employed in coal mining must confront environmental constraints. Temperature, carbon dioxide, and methane are all threats to them. As a result, we must provide security for the men and women who are now employed in coal mining. The goal of this study is to provide a solution to mining through communication and security monitoring. Coal mining has a unique function in the modern world; it has the potential to save the lives of coal miners by creating particular gadgets that can be extremely beneficial to the industry's workers. People working in underground coal mines must utilize several characteristics such as smart helmets with sensors such as removers, collision detectors, gas detectors, and the helmet. Here, we must organize our circuit within the Smart Helmet in order to provide security to the man who is now employed in coal mining. Coal mining remains a hazardous activity that can have a variety of negative environmental implications, such as the discharge of hazardous gases during mining operations. The helmet is equipped with a Wi-Fi-based monitoring system that communicates with all of the trackers via Wi-Fi networks to provide data. As a result, the Smart Helmet indication takes the required precautions to avoid any potentially dangerous situations and sends out an alert through buzzer and Cloud Based Monitoring. The data is collected using ESP32 Arduino created tracker circuitry. It aids in the mapping of worker locations.

Keywords: Smart Helmet, IoT, coal mines safety monitoring, mobile application

1. INTRODUCTION

Mining is very important for the economy of any country as it generates various opportunities for many sectors [1]. As a society, we are blessed to appreciate the benefits that this sector manufactures by processing these materials and products that supply us [9], [11], [12]. Working on the ground presents many different safety and health risks. The environment is disagreeable or shaky. The deeper the mines are, the more harmful it might be to conduct tasks. There are challenges there. So here we suggest a security system in addition to a mining monitoring system for the mining sector using microcontroller-based circuits. We utilize circuitry to discover employees moving through the mining website. The helmet includes a monitoring system that communicates with all of the trackers via Wi-Fi techniques to help provide information. The system uses "mega microcontroller-based Wi-Fi tracker circuitry" to get the data. This helps to map the location of employees. Each employee's helmet circuit has been incorporated using a button. This button shows a crisis indication. This may be used for almost any type of crisis, like poisonous gas inhalation, cave-ins, bodily harm, etc. Hence, mining employee safety is ensured by the IoT. Pakistan has vast coal deposits, primarily in Sindh, with estimated reserves of 184.623 billion tons. Our country's market has been expanding rapidly, resulting in an increasing supply of raw materials. New foreign firms are assisting in the discovery of coal reserves. As we all know, tragic accidents in mines are on the rise due to a lack of competent personnel, and miners' safety cannot be guaranteed, nor can coal manipulation be carried out. Men working in coal mining must contend with environmental factors. Fever, carbon dioxide, and methane pose a harm to them. As a result, we must provide security for the men and women who are now employed in coal mining. The goal of this study is to provide a solution to mining through communication and security monitoring. The helmet must be worn by the individual when performing underground work. Here, we must organise our circuit inside the kit in order to provide security to the man who is currently working in coal mining. In late times' coal mining continues to be a dangerous activity that can lead to many negative consequences on the environment such as during mining operations dangerous gases are released. The most significant part of the business is security. In the mining sector security and safety' is the component of all. Each mining business follows some precaution to prevent some kinds of conditions. IoT has a special role in information technology; it can save the life of coal miners by developing certain devices which can be very helpful for the workers in the coal. Different parameters like collisions and helmet remover constantly using detectors like collision detector, gas detector, and Smart Helmet detector to take crucial actions therefore to prevent any kinds of hazardous circumstances and provides an alert with the buzzer. To achieve security in a communication system has to be made involving moving from the mine employees, along with a base station. The communication

system technology' system that is wired will probably be not so helpful. Underneath the mines because of the situation, upkeep cost, in addition to the setup cost, is high for communication systems. For the wireless data transmission that is effective, within this work a Wi-Fi transmitter and receiver. Wireless that is cheap based mine supervising system. The helmet is incorporated using a Wi-Fi based monitoring system, which is communicating with all the tracker Wi-Fi systems help supply information [2]. The system uses ESP32 Arduino established tracker circuitry to get the data. The Helps map workers' location. Additionally, each employee's helmet circuit has been incorporated using a panic/emergency button. This button shows a crisis indication. This may be used for almost any type of crisis, like poisonous gas inhalation, cave-ins, bodily harm, etc. Hence, mining employee safety is ensured by the IoT.

2. RELATED WORK

Abid et al. [3] and Mustafa Abro et al. They introduced an IoT-based jacket that can be worn. It is made for the safety of people or labour who work in coal mines and are regularly exposed to risks. This prototype is made in a way that senses many things, such as the occurrence of dangerous gases, the heartbeat of a worker in coal, underground environmental conditions, and pinpoints the location of the miner through GPS. These parameters will probably be transmitted via a Wi-Fi protected channel to a dynamic internet protocol. [4] Formalized paraphrase This group of students developed a device that pinpoints the exact location of the coal miner. The exact location of the person is obtained, which will save the precious life of any worker during any calamity. This system uses RFID for tracking and locating. As soon as an incident is reported, the pinpoint location will help them in the rescue. D. Kock et al. [5] formed automation which serves coal miners in a very productive way. It was developed for the miners of South Africa. They conjointly researched the (CID) coal port detection. To do so, they employed two popular methods, like natural gamma radiation vibration and analysis. Gaidhane et al. [6] suggested a system of safety for workers in mines, and it is based on Zig Bee technology. It also monitors gas levels, which are dangerous because most of the deaths that occur in mines are due to the deposition of hazardous gases in mines. As soon as the value crosses the threshold, the alarm is routed through ZigBee by blowing the alarm and lighting up different LEDs. Cheng Qiang et al. [7] suggested a wireless communication system for coal miners that works on the IoT; it senses humidity, CH_4 (Methane), and temperature levels for coal miners. The man who's tracking in the floor channel alarms the miner via voice communication regarding the incident that happened.

Guo Feng and Yongping Wu et al. These researchers developed a device that is very useful for risk mitigation in areas where there is mineral exploration activity, such as coal, gold, etc. This system is best for finding the exact location of the coal worker. With this device, tracking is easy, and any help in an emergency can be delivered very quickly. The primary drawback of the system is that Bluetooth is a short-space wireless technology, and the usage of cabling is tough. Al-Suwaidi & Zemerl (2009) [8]. They have suggested a system that has a remedy for various issues with the help of GPS. This application will search for a pinpoint location, and any missing coal worker can be traced easily with the help of GPS. In this system, the client-server architecture approach is utilized. The server allows the mobile phone of the client to register and login, and it saves its password and credentials in the database of the server. Pranjal Hazarika and colleagues [8]Designed for coal workers, this helmet is very suitable for underground coal exploration where there is a risk of dangerous gases such as methane and carbon, etc. This helmet contains sensors for the aforementioned harmful gases, and information is sent to the control room wirelessly, via a wireless module named ZigBee, linked with the helmet.

3. RESEARCH METHODOLOGY

The proposed study consists of an IoT-based smart helmet, which helps underground workers in many ways. It tells the predetermined services of coal miners, such as the gas sensor, temperatures, humidity, and many other things that are essential for the safety of the miners. This helmet is made up of a helmet with detectors. The transmitter segment has a microcontroller which receives input from several sections such as a helmet remover sensor, collision sensor, and gas sensor. At a particular instance, when a harmful event happens, the helmet transfer alert towards the application is fixed on several different areas of the coal mine. The helmet remover, gas sensors, and collision sensors will feel the corresponding parameters.

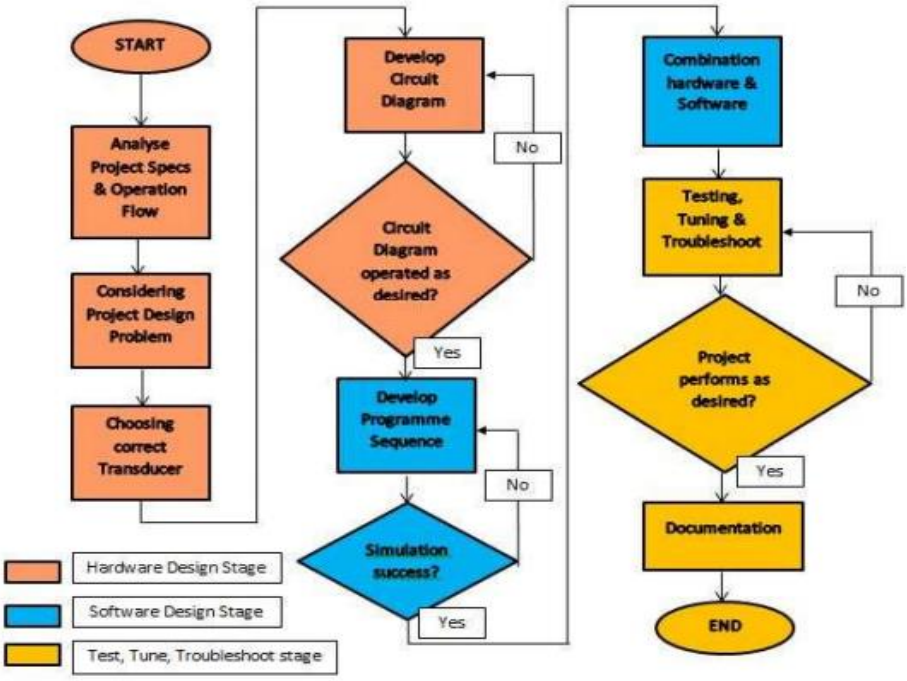

FIGURE 3.1: Flow of Study.

The design specification, as depicted in Figure 3.1, is decided by the project's goal. There are three stages to the project. Begin with the hardware design stage, then the software design stage, and finally the project design testing, tuning, and debugging. The hardware design stages serve as checkpoints to see if the transducer is right and compatible with the circuit schematic. The transducer is chosen at this stage based on experimental features such as accuracy, precision, measurement factors, and performance under forced situations.

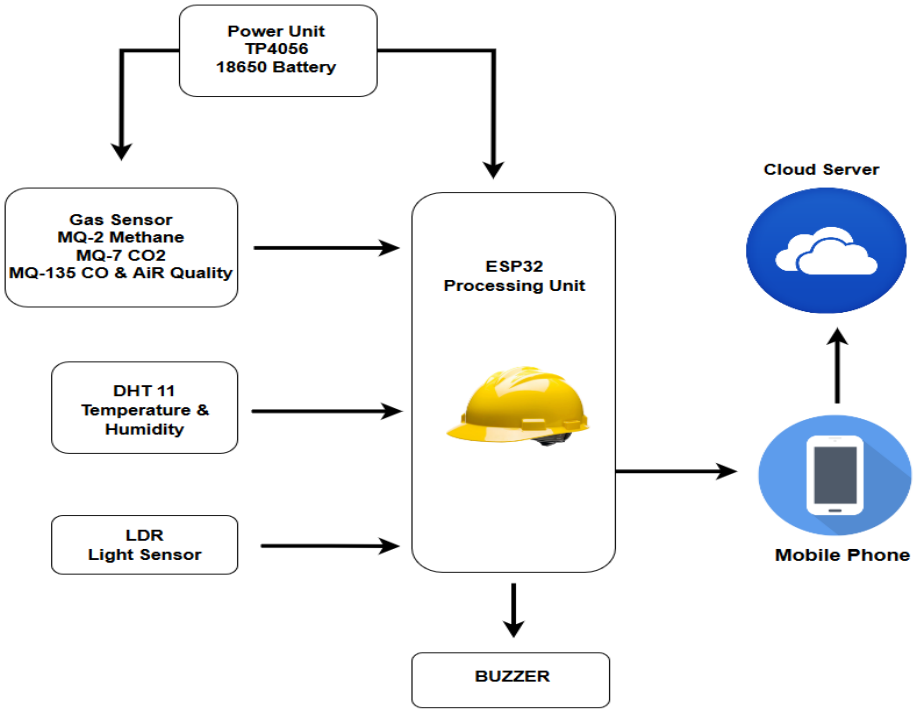

FIGURE 3.2: Hardware & Software Used

The software design stage is created in accordance with the study's operating flow. Sequence programming and interface programming are the two categories in which the software is split. In order to achieve the project's approved goal, both sections must be connected and run at the same time. The steps of testing, adjusting, and troubleshooting are crucial in the design process. These steps occur after the hardware and software components have been combined. As a result, even a minor design flaw might be time-consuming, requiring retracing back to earlier stages for confirmation.

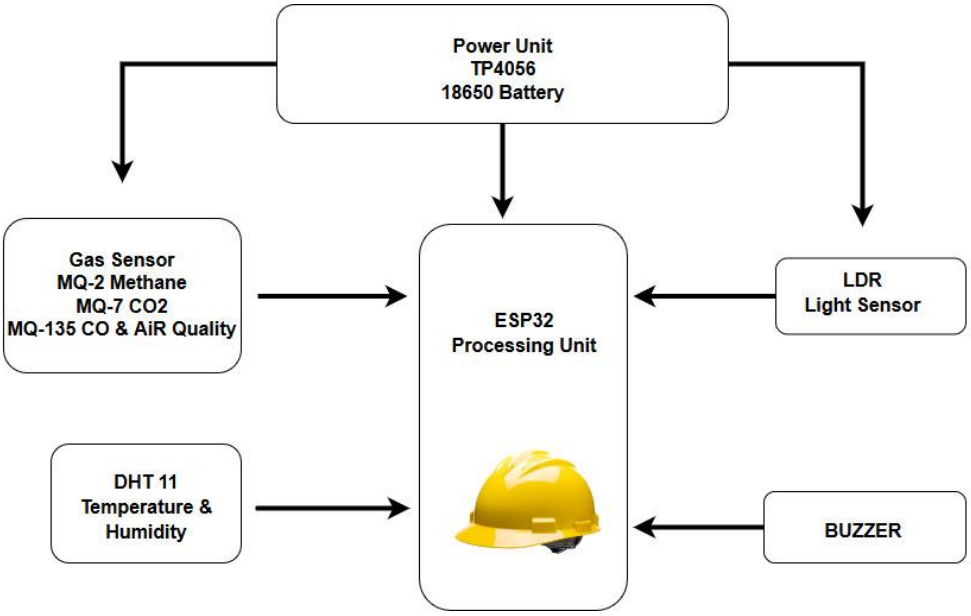

FIGURE 3.3: Flow of Hardware Section

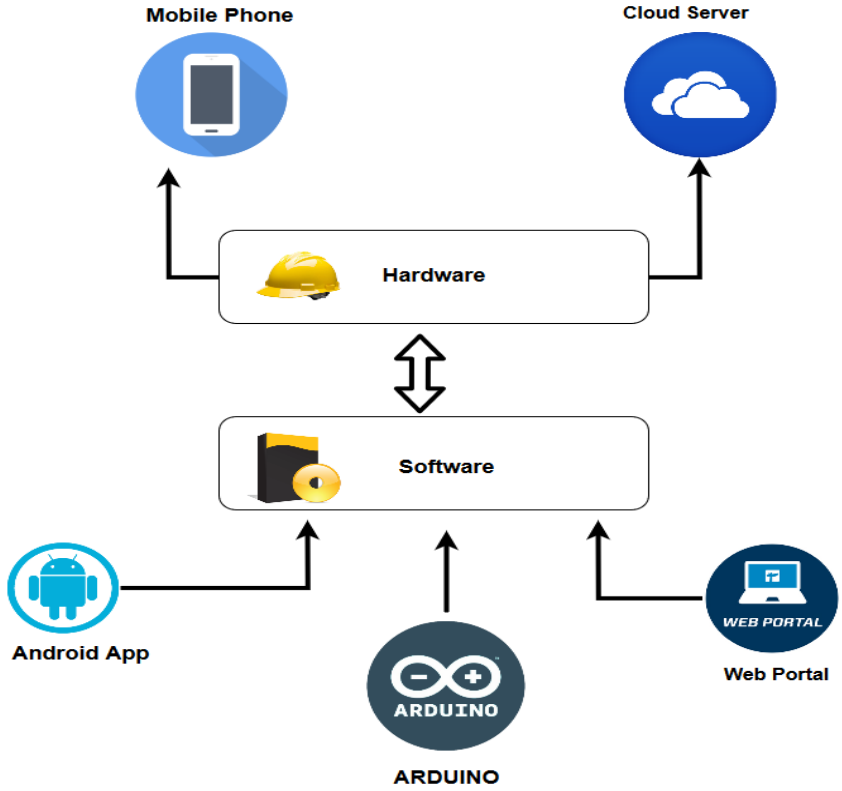

FIGURE 3.4: Flow of Software Section

3.1. CASE STUDIES IN OBJECT ORIENTED & DESIGN

I. Case Study no 1: How to Mine Gas Monitoring Dangerous level

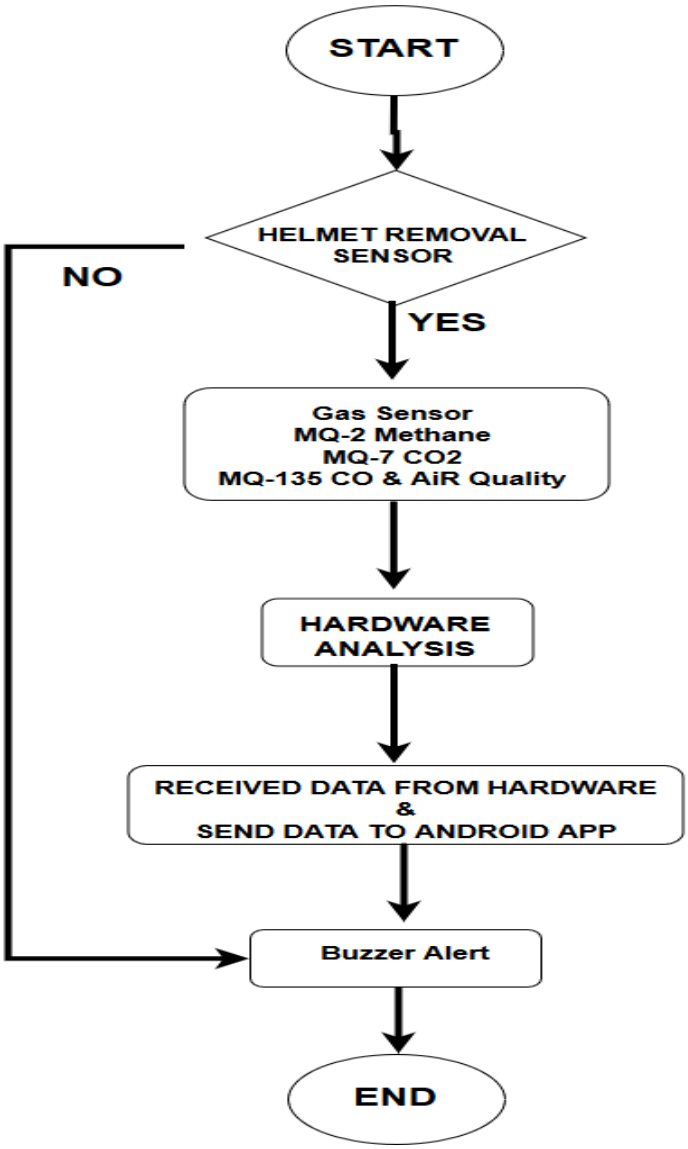

FIGURE 3.5: Mine Gas Monitoring Dangerous level.

II. Case Study no 2: How to Mine Humidity, Temperature and Light Monitoring

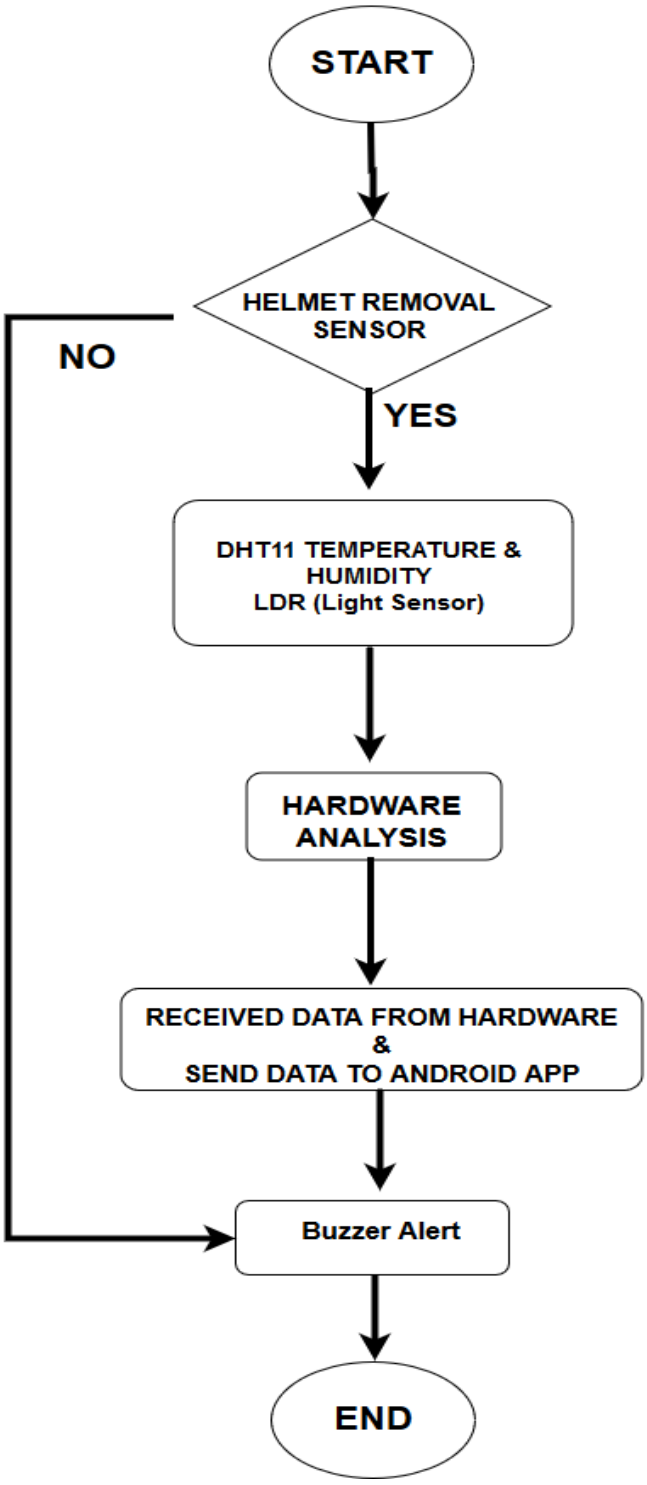

FIGURE 3.6: Mine Humidity, Temperature and Light Monitoring

III. **Case Study no 3: Press SOS button System send Location with Internet**

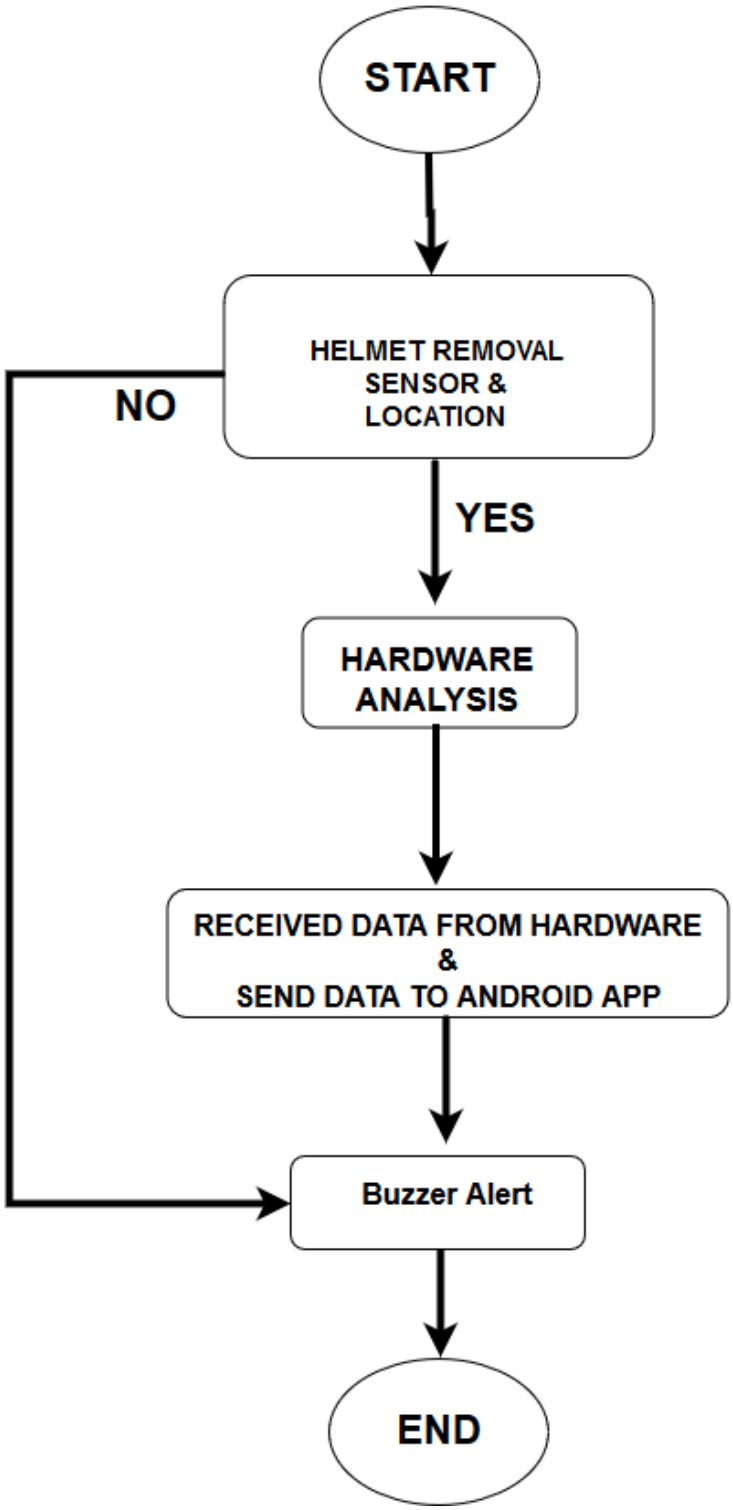

FIGURE 3.7: Press SOS button System send Location with Internet

4. EXPERIMENTAL RESULTS & DISCUSSION

This system connects the Arduino to the computer. To build this system, open-source solutions were provided, and components used in the proposed safety alert system, such as the MQ-2, MQ-7, MQ137 Gas Sensor, ESP32, IR Sensor DHT11, LDR, and others, can be easily connected with the Arduino platform.

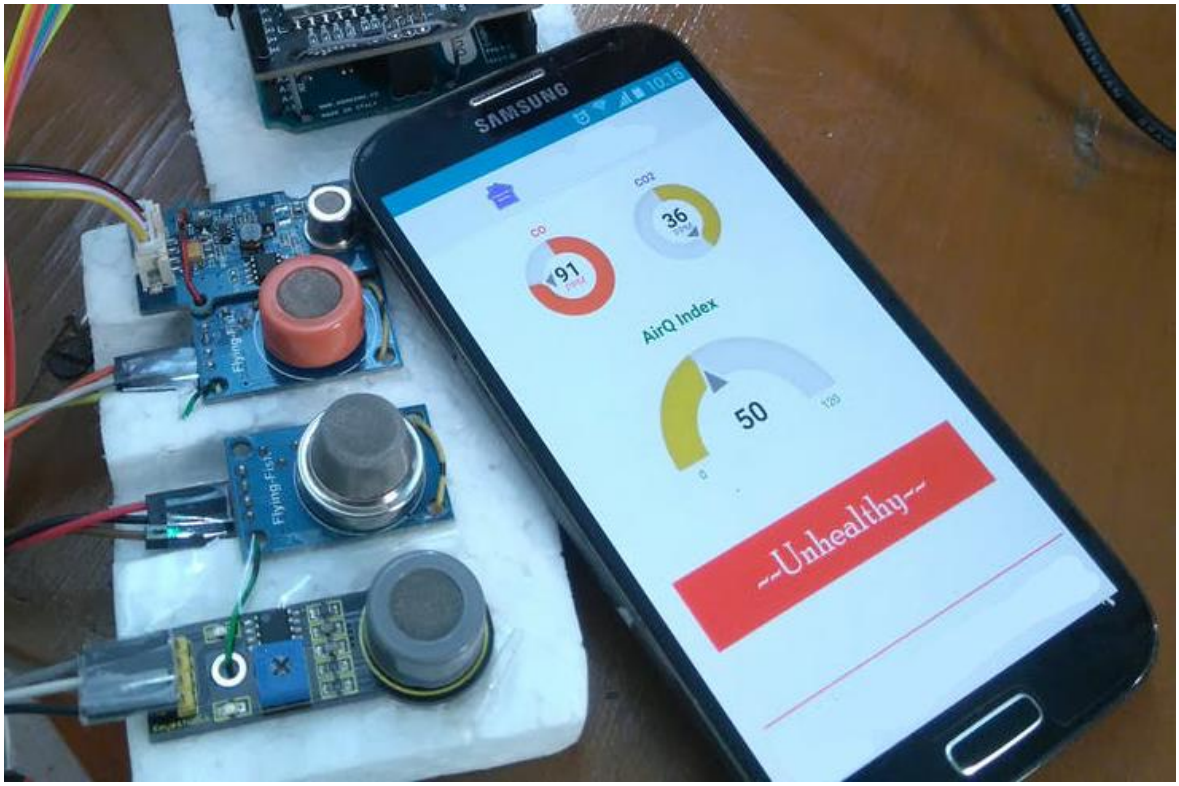

FIGURE 4.1: Interface Android Application & Software Serial

FIGURE 4.2: Interface Android Application & Software Serial

Smart Helmet Design

The ESP32 has a faster Wi-Fi, a CPU core, more GPIO pins, and Bluetooth low energy capabilities. The ESP32 also has a temperature sensor, touch-sensitive pins, and a hall effect sensor built in. Both boards are very cost-effective. The ESP32 has more pins than the ESP8266, and you can pick whether the pins are UART, SPI, or I2C — all you have to do is specify this in the code. This is feasible because to the multiplexing feature of the ESP32 processor, which allows various purposes to be assigned to the single pin. If you don't put them on the code, they'll be around the pins that are defined by default, as seen in the diagram below.

Table 4.1: Specification of ESP32 vs ESP8266

Specifications	ESP8266	ESP32
MCU	Xtensa Single-Core 32-bit L 106	Xtensa Dual-Core 32-bit LX6 600 DMIPS
802.11 b/g/n Wi-Fi	Yes, HT20	Yes, HT40
Bluetooth	N/A	Bluetooth 4.2 and below
Typical Frequency	80 MHz	160 MHz
SRAM	160 kBytes	512 kBytes
Flash	SPI Flash up to 16 MBytes	SPI
GPIO	17	36
Hardware / Software PWM	None / 8 Channels	1 / 16 Channels
SPI / I2C / I2S / UART	2/1/2/2	4/2/2/2
ADC	10-bit	12-bit
CAN	N/A	1
Ethernet MAC Interface	N/A	1
Touch Sensor	N/A	Yes
Temperature Sensor	N/A	Yes
Working Temperature	-40° C – 125° C	-40° C – 125° C

The MQ2 gas sensor can detect the presence of Hydrogen, LPG, and Propane, as well as Methane and other combustible steam. It is low-cost and suited for a variety of applications. Power is given 5 volts for the smoke sensor. The voltage output by a smoke sensor indicates the presence of smoke. More smoke is produced. To change the sensitivity, a potentiometer is included. Once the air is pure, the SO2 (Sulfur Dioxide) detector is utilized, which has a low conductivity. VCC and GND provide power to the heater from the electricity supply. A variable resistor is included in the circuit. The resistance throughout the pin is determined by the amount of smoke in the sensor's environment. The resistance throughout the pin is determined by the amount of smoke in the sensor's environment. If the content is more, the resistance will be lessened. In addition, the voltage between the sensor and the load resistor is increased. The MQ-7 semiconductor sensor is primarily used for carbon monoxide detection (CO). Tin Dioxide SnO2 (Tin(IV) Oxide) and micro Al2O3 (Aluminum oxide) ceramic tubes make up the MQ-7 gas sensor. A crust has been established between the heater and the electrode. After the sensor has been heated to a higher temperature by 5V, it cleans another gas that has been adsorbed at a lower temperature. The MQ-7 has six pins, four of which are used to bring signals and two of which are used to supply heating current. Sensor module for air quality MQ135 It is a dangerous gas detection element for the family and the environment, and it is ideal for ammonia, Sulphur, aromatic compounds, smoke, benzene vapor, and other gases harmful gas detection, as well as the evaluation of gas-sensitive components. Nitrogen oxide, ammonia, benzene, alcohol, carbon dioxide, and smoke are among gases that can be detected by an air quality sensor. It works well in a manufacturing or office setting with a simple drive and monitoring circuit. Infrared sensor, A helmet removal technique based on an infrared ray sensor is used to determine whether or not a mine employee has removed his protective helmet. When an infrared sensor transmits a continuous signal from one end to the other, the sign is blocked, indicating that the miner is wearing a helmet. This DHT11 Temperature and Humidity Sensor is equipped with a condition and moisture sensor, as well as a survey mac cue harvest. It ensures high trustworthiness and attractive global establishment by accepting the fashionable numerical-alarm-acquisition routine as well as heat and moisture sensing mechanization. This sensor connects to a high-speed 8-bit microcontroller and comprises a resistive-type steaminess measurement segment and an NTC climate assessment piece, resulting in a completed condition rapid response, anti-interference strength, and cost-effectiveness. When the sensor output exceeds the threshold quantity detected by the sensor, the buzzer will sound. It makes use of a piezoelectric sensor. The Piezo buzzer is a handy sound generator that can be used to provide a sound indicator in digital circuits. It's extensively utilized in digital gadgets as an alarm. A Piezo buzzer is made up of a Piezo disc and an oscillator. A standard Piezo buzzer is powered by 3 to 12 volts DC.

The safety of mine workers is assured, according to our research, by monitoring psychological variables at high altitude. We can continuously monitor the physical condition of the mine using sensors and inform personnel during disasters before a life is lost. Using IoT and a wireless network, we can save the life of a coal mine worker. It will send the information about each person to the monitoring unit. The project also assists in contacting emergency numbers in order to alert paramedics to assist workers in the event of a tragedy. The vital amounts of these toxic gases from the mining industry, such as CH4 (Methane), NO2 (Nitrogen Dioxide), CO (Carbon monoxide), CO2 (Carbon dioxide), and SO2 (Sulfur Dioxide), were signaled through an alerting device. Using an off-the-shelf IR distance sensor, the helmet removal evaluation was successful. The IR sensor was a working gadget that was built from the ground up. After the system was fully integrated, it was discovered that the sent IR signals reflected off the head and continued to reflect off the helmet surface until they reached the receiver. The signal received on the receiver side was nearly identical in magnitude to the signal received when the helmet was removed from the head.

5. CONCLUSION

A clever mining A helmet has been designed that can detect three types of potentially dangerous events: toxic gas levels, mining helmet removal and collision, and effect. A miner pulling their mining helmet from their head was classified as a hazardous incident. Another dangerous event is when miners are struck by an object that is opposed to their will and has a force greater than 1000 on the HIC (Head Injury Criteria). It's also possible to measure gas concentrations.

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