IoT BASED SMART HELMET FOR COAL MINE WORKERS

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A. ABSTRACT

There are various kinds of hazards like earthquakes, landslides, tsunamis etc. But the most important and crucial disasters are man-made. Coal mines have proven to be very dangerous and have caused many accidental deaths over the years. In this project, we bring up an IOT based smart safety helmet equipped with a network of sensors like gas sensor, temperature sensor, humidity sensor and light sensor. Sensor data is used for real time monitoring of working conditions remotely. Authorised person is alarmed when there is any abnormality, by which quick and necessary actions can be taken in case of an emergency.

B. LIST OF FIGURES

1. INTRODUCTION:

Demand of coal as an energy resource is always important and significant. But thousands of people have lost their lives in mining accidents, all over the world. Conventionally, helmets with minimal protection and LED lighting are used in underground coal mines because of their lightweight and low power consumption. However, with the evolving VLSI technology and development of embedded intelligent systems, it is possible to design a smart, compact and efficient electronic system which can be embedded into these helmets to provide better security without compromising on the weight and power consumption requirements of them. The proposed system uses an air quality sensor, a humidity and temperature sensor and a light sensor to monitor various parameters in real-time and to feed the data to a microcontroller. The microcontroller then analyses these parameters and initializes the alert system if any of those parameters exceeds the threshold value. The data is then wirelessly communicated using the Wi-Fi module to the control room for real-time surveillance.

1.1 MOTIVATION:

Mines are one of the most dangerous workplaces with a greater possibility of accidents and difficulty in rescue operations. The major risk factors in a mine are mine fires, explosions, leakage of explosive or toxic gases, physical ailment of workers and many more. We aim to develop a smart helmet to improve the safety of mine workers.

1.2 PROBLEM DEFINITION:

Safety of mineworkers is still a concern. To ensure this, we need to develop a smart helmet for mineworkers with features like a temperature monitoring system, humidity sensor, air quality sensor, light sensor and smart torch, which senses various parameters and updates the control unit in real-time. The system also provides a feature for the individual workers to call for help if necessary.

1.3 OBJECTIVE OF THE PROJECT:

The ultimate objective of this project is to design an efficient system to enhance the safety of mineworkers by monitoring and reducing the number of casualties and providing immediate help to miners in distress. All the desired features would be embedded to the worker's helmet without compromising on the weight, cost and power requirements of the same.

1.4 LIMITATION OF THE PROJECT:

Here we are using Wi-Fi for wireless communication purposes. Hence the range of Wi-Fi may affect the real-time monitoring of data. This can be resolved by using developing technologies like Li-Fi for faster transmission of data and better coverage.

2. LITERATURE SURVEY:

2.1 INTRODUCTION:

Smart helmet using the Internet of Things for coal mine workers consists of various sensors to monitor parameters like temperature, humidity, concentration of harmful gases and to detect the intensity of light in the mines. It also has an alert system to alert the workers in case of any hazardous events and a wireless communication network to the control room to call for help and also to monitor real-time data.

2.2 EXISTING SYSTEM:

In the existing system, the helmet is fixed with the temperature and humidity sensor and the gas sensor which could sense hazardous gases like carbon monoxide and methane. In the occurrence of a hazardous event, the microcontroller sends an alarm to the control room. Here the data transmission is done using ZigBee, which has low power consumption, affordable price and low maintenance.

2.3 LIMITATIONS OF THE EXISTING SYSTEM:

The main limitation of the existing system is scalability. ZigBee tends to transmit the data over a smaller distance. The low data coverage will lead to inefficient data transmission, which in turn leads to the delay of the data transmission at the receiver end. This degrades the efficiency of the system.

2.4 PROPOSED WORK:

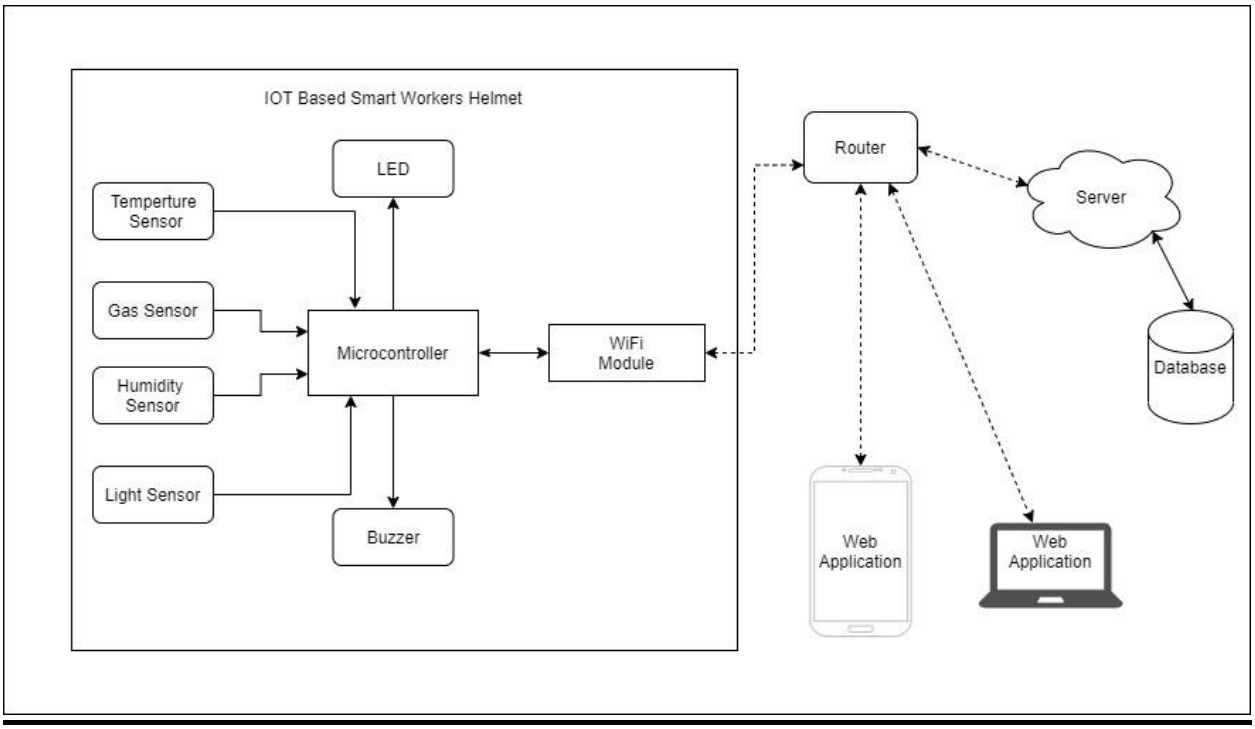
Our proposed system is an improved version of this helmet with added sensors like temperature sensor which collects data regarding the workplace temperature, humidity sensor which monitors the moisture concentration within the mines, gas sensor which monitors the concentration of harmful gases and a light sensor to monitor the intensity of light. All these data will be collected by the Arduino microcontroller and will be communicated wirelessly to the control room using Wi-Fi technology. In the existing system, the data is transmitted using ZigBee technology and here by using Wi-Fi, we are trying to improve the efficiency of the system. Wi-Fi communication has better data coverage and is faster when compared to ZigBee technology. Other than the sensors, the helmet comes with the feature of a push button which can be used by the miner in case of an emergency to call for help. Moreover, it also has an alert system consisting of a buzzer and red LED to alert the worker in case of any accidents and an emergency lighting system.

3. DESIGN PHASE

3.1 INTRODUCTION:

The smart helmet makes use of a DHT11 sensor for measurement of temperature and humidity, MQ2 sensor for the detection of poisonous gases and LDR for the detection of absence of light. The emergency lighting system consists of LEDs controlled by a transistor(2N3904). The alarming system includes a buzzer and an LED. The helmet is also equipped with a push button to call for help. Arduino UNO is the microcontroller used. NodeMCU ESP8266 module is used to send the sensor data to the server. The server was set up using WAMP.

3.2 BLOCK DIAGRAM:

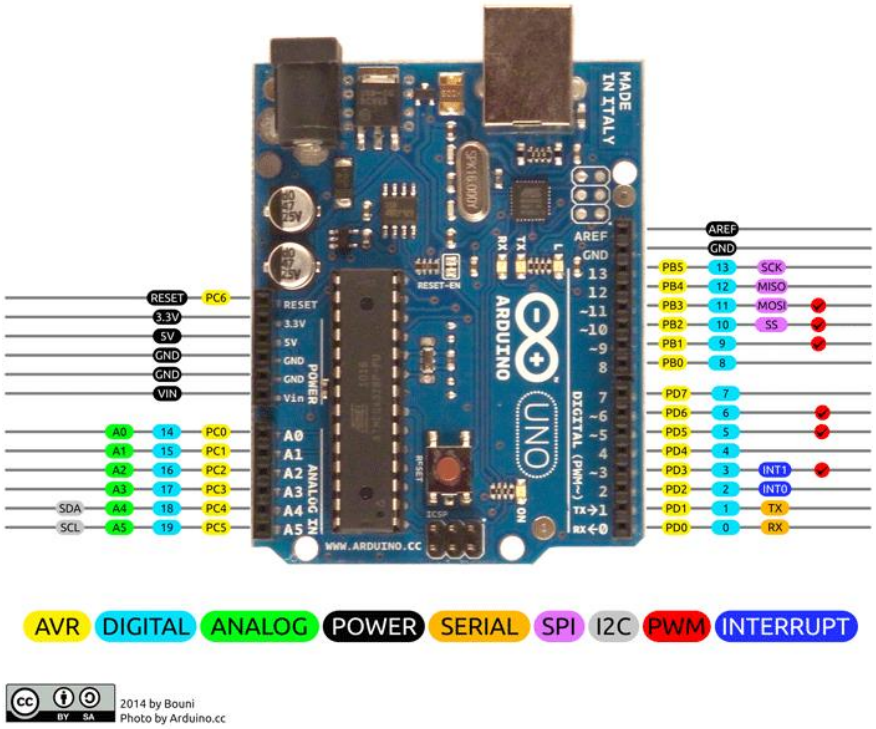


Various components used are as follows:

HARDWARE

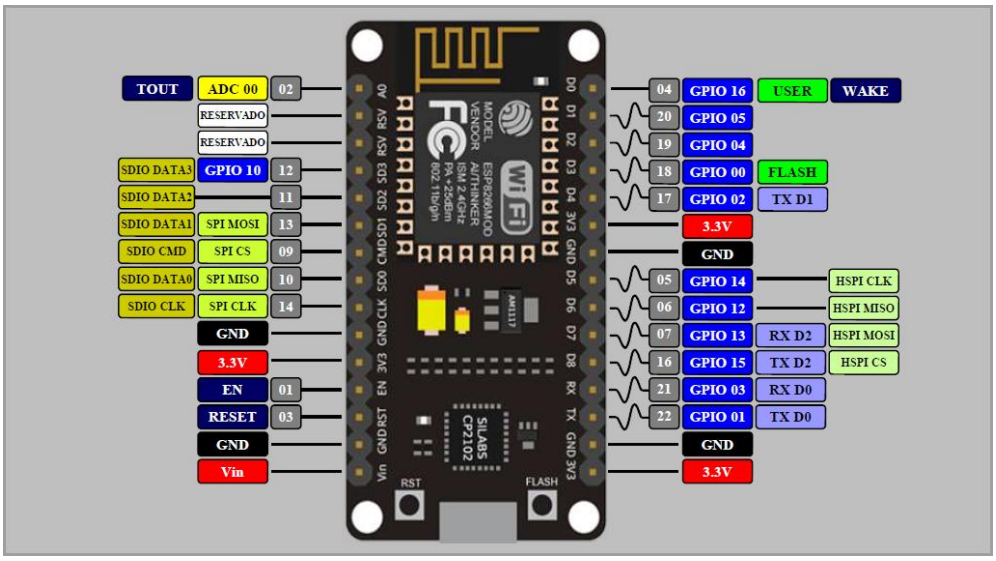
1. Arduino UNO: The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc.

Microcontroller	Microchip ATmega328P
Operating Voltage	5 Volts
Input Voltage	7 to 20 Volts
Digital I/O Pins	14 (of which 6 can provide PWM output)
Analog Input Pins	6 pins
Clock Speed	16 MHz



2. NodeMCU ESP8266: NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

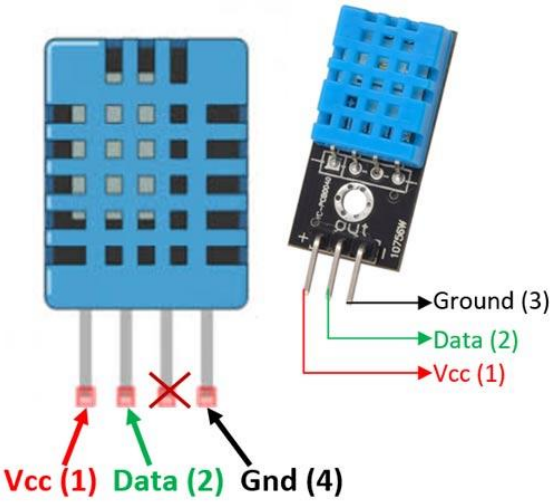
Microcontroller	Tensilica 32-bit RISC CPU
Operating Voltage	3.3 V
Input Voltage	7-12 V
Digital I/O Pins	16
Analog Input Pins	1



3. DHT11: DHT11 electronic brick of digital temperature & humidity sensor features a digital temperature & humidity sensor complex with a calibrated digital signal output. Its single-bus operation, extremely small size and low consumption enable it to be used in HVAC, automotive, weather stations and other applications.

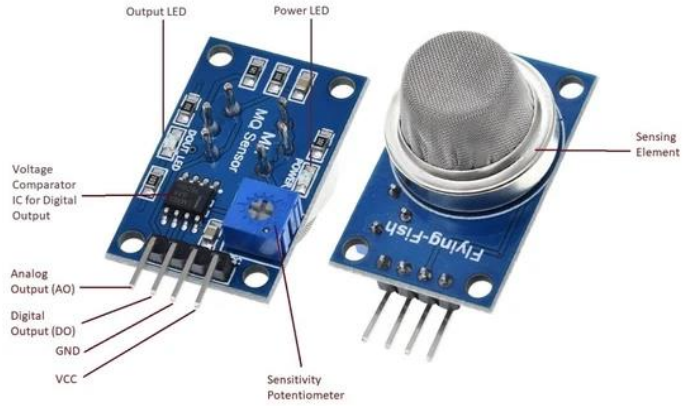
PCB size	22.0mm X 20.5mm X 1.6mm
Working voltage	3.3 or 5V DC
Operating voltage	3.3 or 5V DC
Measurement range	20-95%RH ; 0-50°C

Resolution	8bit(temperature),8bit (humidity）
Compatible interfaces	2.54 3-pin interface and 4-pin Grove interface



4. MQ2: It is a Metal Oxide Semiconductor (MOS) type Gas Sensor also known as Chemiresistors as the detection is based upon change of resistance of the sensing material when the Gas comes in contact with the material.

Operating voltage	5 V
Load resistance	20 KΩ
Heater resistance	33Ω ± 5%
Heating consumption	<800mw

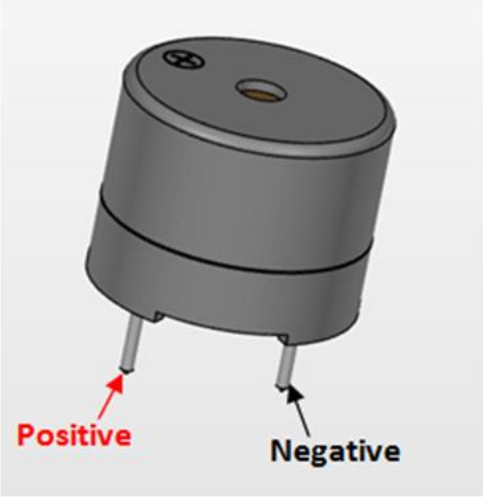


5. LDR: Light dependent resistors, LDRs or photoresistors are often used in electronic circuit designs where it is necessary to detect the presence or the level of light.

Maximum power dissipation	200mW
Maximum voltage	200 V
Peak wavelength	600 nm
Resistance Range	1.8kΩ to 4.5kΩ

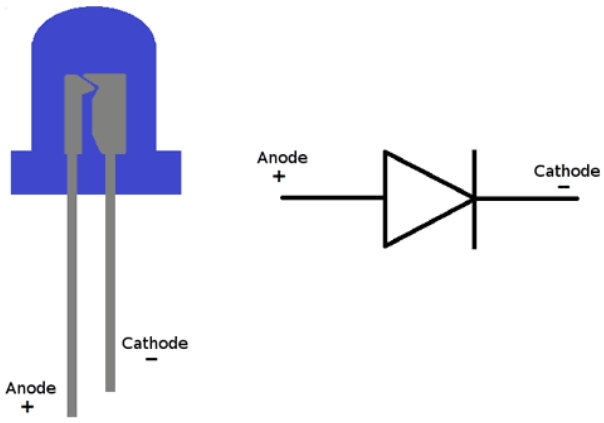
6. Buzzer: A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric.

Rated Voltage	6 V
Operating Voltage	4-8 V DC
Rated current	<30 mA
Sound Type	Continuous Beep



7. LED: An LED is a two-lead semiconductor light source, which emits lights when activated.

Forward Current (IF)	30 mA
Forward Voltage (VF)	1.8 V to 2.4 V
Reverse Voltage	5 V
Operating Temperature	-30℃ to +85℃



8. Resistor: A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.

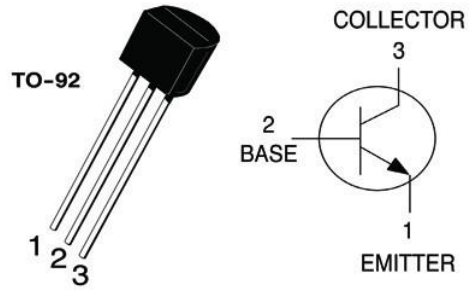
9. Push Button: A push-button (also spelled pushbutton) or simply button is a simple switch mechanism to control some aspect of a machine or a process.

Mode of Operation	Tactile Feedback
Power rating	MAX 50mA 24V DC
Insulation Resistance	100Mohm at 100v

Operating Force	2.55±0.69 N

10. **Transistor 2N3904:** The 2N3904 is a common NPN bipolar junction transistor used for general-purpose low-power amplifying or switching applications. It is designed for low current and power, medium voltage, and can operate at moderately high speeds.

Transistor Polarity	NPN
Collector Emitter Voltage V(br)Ceo	40 V
DC Collector Current	200 mA
Power Dissipation Pd	625 mW



2N3904 Pinout

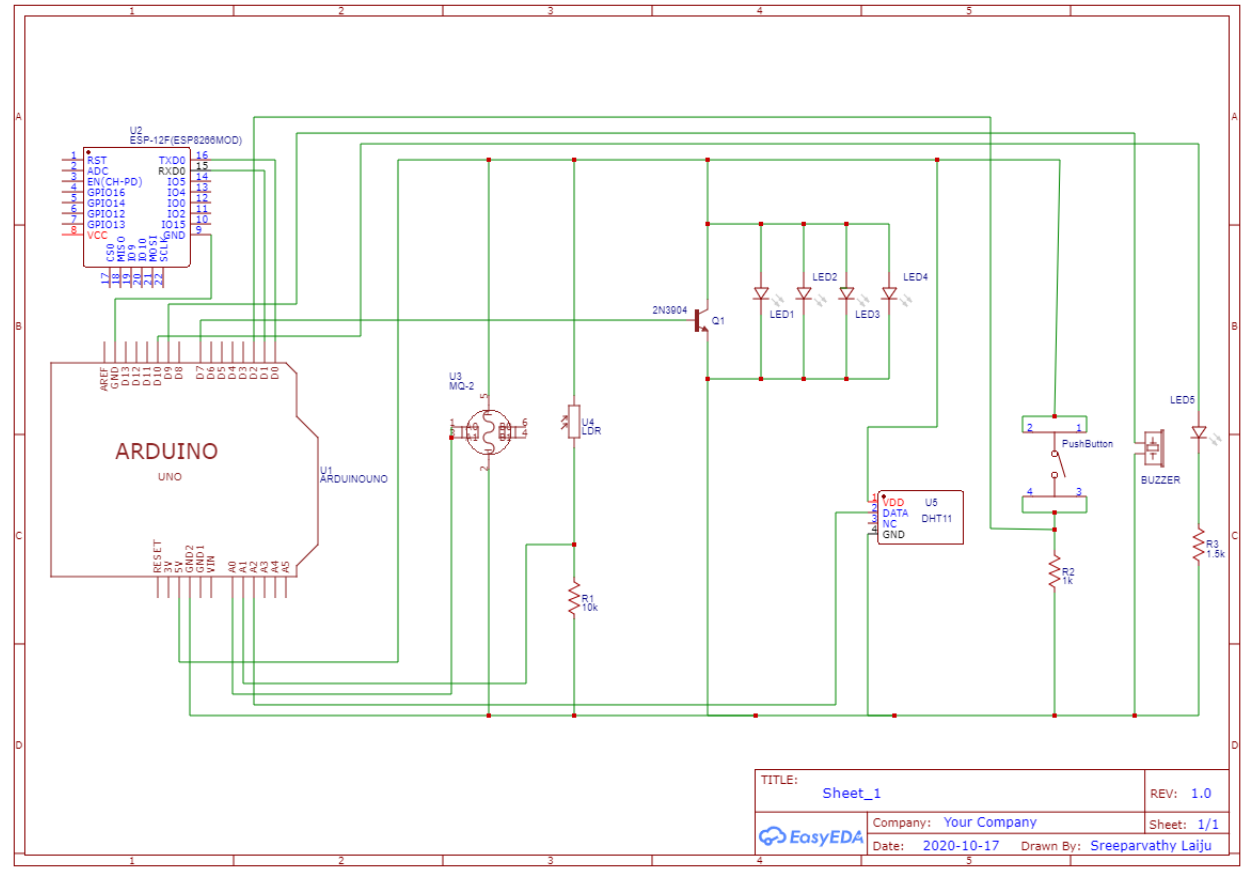
SOFTWARE

1. Arduino IDE : The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards.

2. Notepad++: It is a text and source code editor for use with Microsoft Windows. It supports tabbed editing, which allows working with multiple open files in a single window. The project's name comes from the C increment operator. Notepad++ is distributed as free software.

3. WAMP: WampServer refers to a solution stack for the Microsoft Windows operating system, created by Romain Bourdon and consisting of the Apache web server, OpenSSL for SSL support, MySQL database and PHP programming language.

3.3 CIRCUIT DIAGRAM:



4. IMPLEMENTATION

4.1 INTRODUCTION:

The smart helmet consists of a network of sensors including the temperature sensor, humidity sensor, gas sensor and light sensor, an emergency lighting system that consist of LEDs controlled by a transistor and an alarming system which includes a buzzer and an LED. The helmet is also equipped with a push button to call for help. The sensor values are sent to the server setup using WAMP and also stored in our database simultaneously. Thus, real-time monitoring of data is made possible.

4.2 METHOD OF IMPLEMENTATION

1. Measurement of temperature, humidity, gas and light intensity.

The temperature and humidity are measured by DHT11 sensor. The MQ2 sensor measures the concentration of gases like CO, Methane, LPG etc. in Parts Per Million. The LDR used detects the presence of light. We have set threshold values for temperature, concentration of gas and LDR output.

Threshold for temperature = 40 °C

Threshold for gas concentration = 500 PPM

Threshold for LDR output = 20

2. Function of the emergency lighting system and alarm system

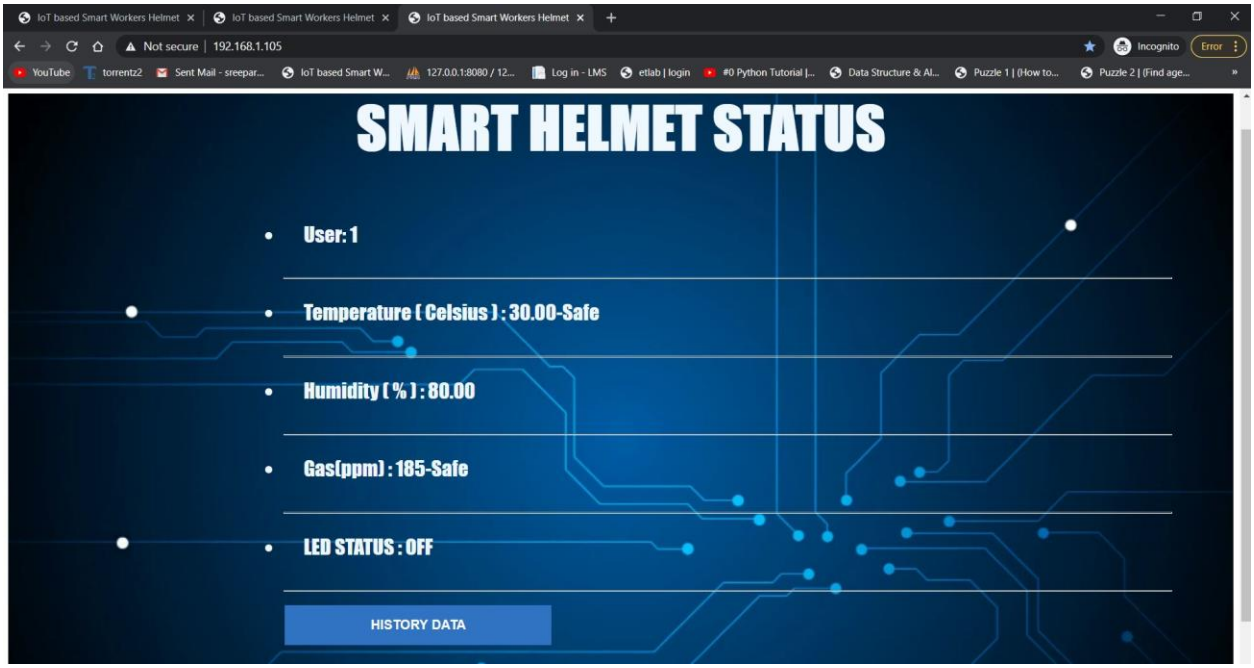
Emergency lighting system: When the LDR output goes below the threshold we have set; the microcontroller applies a voltage at the base of the transistor which turns on the LEDs. The transistor acts as a switch here.

Alarm system: When the temperature and gas value go beyond the threshold values, the buzzer beeps. The red LED also turns on simultaneously.

3. Smart Helmet Status- Website

The microcontroller sends the data to the NodeMCU which in turn sends the data to the server. The sensor data is displayed on the website in response to the HTTP post request. The sensor data is simultaneously stored in our database.

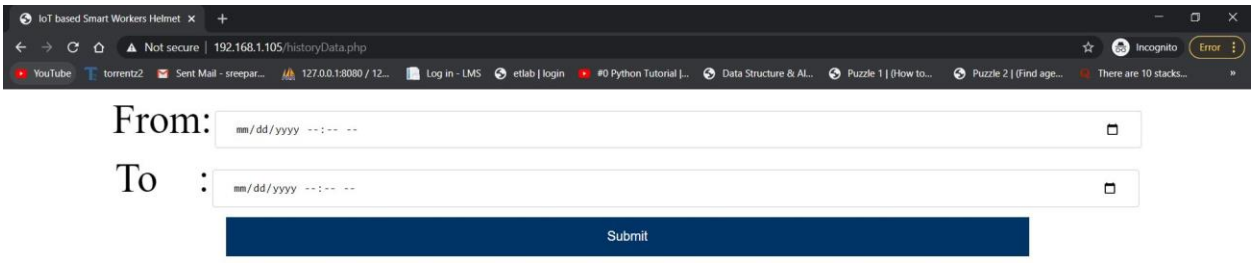
When the temperature and humidity is above the threshold value, the website displays ‘danger’ and when it is below the threshold value, the website displays ‘safe’. The website also displays the status of LEDs of the emergency lighting system.



The “HISTORY DATA” button on the website helps to retrieve the data.

1.Click on the “HISTORY DATA” button.

2.Set the time interval for which we want to retrieve data.

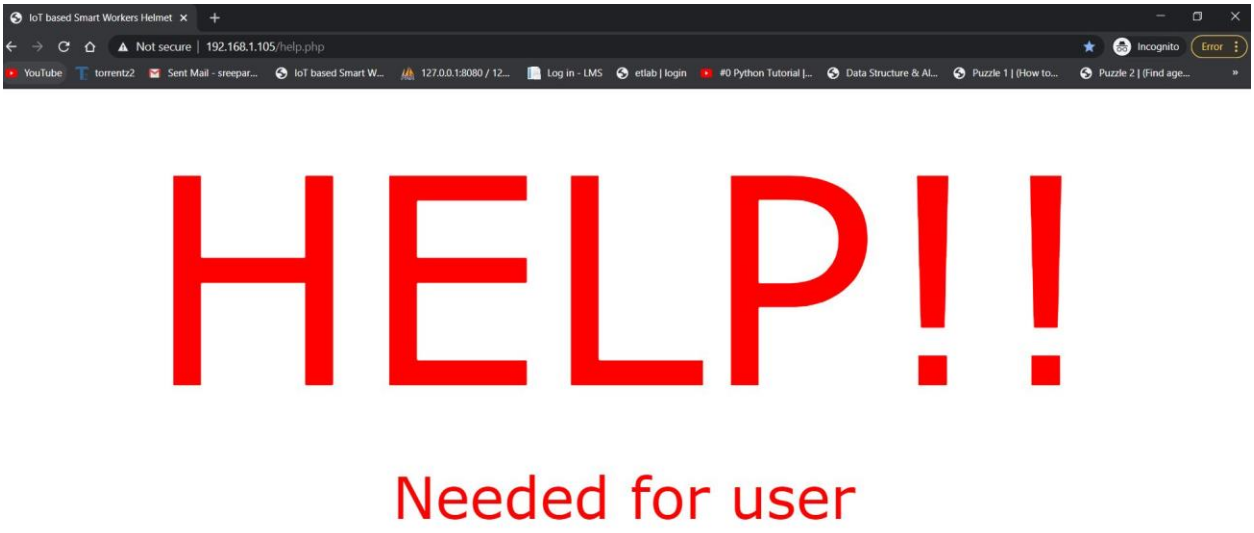


3.Click on submit.

DateTime	Temprature	Humidity	Gas	Light
2021-01-16 12:40:00	29.000	75.000	289.000	ON
2021-01-16 12:40:01	29.000	75.000	285.000	ON
2021-01-16 12:40:02	29.000	75.000	286.000	OFF
2021-01-16 12:40:03	29.000	75.000	258.000	OFF
2021-01-16 12:40:04	29.000	75.000	280.000	OFF
2021-01-16 12:40:05	29.000	74.000	263.000	ON
2021-01-16 12:40:06	29.000	74.000	279.000	ON
2021-01-16 12:40:07	29.000	74.000	277.000	ON
2021-01-16 12:40:08	29.000	74.000	277.000	ON
2021-01-16 12:40:09	29.000	75.000	276.000	ON
2021-01-16 12:40:10	29.000	75.000	277.000	ON
2021-01-16 12:40:11	29.000	75.000	277.000	ON
2021-01-16 12:40:12	29.000	75.000	297.000	ON
2021-01-16 12:40:13	29.000	74.000	287.000	ON
2021-01-16 12:40:14	29.000	74.000	291.000	ON
2021-01-16 12:40:15	29.000	74.000	285.000	ON
2021-01-16 12:40:16	29.000	74.000	289.000	ON
2021-01-16 12:40:17	29.000	74.000	289.000	ON
2021-01-16 12:40:18	29.000	74.000	288.000	ON

Sampling rate = 1 Second

We have a push button on the helmet which is used to call for help. On pressing it, the website displays the help request as shown below.



4.3 RESULT:

The smart helmet helps in real-time monitoring of the working environment of the workers ensuring their safety and protection. The data stored in the website can be retrieved using the "HISTORY DATA" button.

5. CONCLUSION AND FUTURE SCOPE

Safety of workers is very important in many industries and especially in the coal mine industry. Monitoring and reduction of the number of casualties and providing immediate help to the miners in distress are the main goals of this project. The helmet is also suitable for workers in similar working conditions.

There are effective scopes of improvement in the project. Utilising Li-Fi for high-speed data transmission in future increases its efficiency. Facility to send messages to nearby hospitals automatically can be done. Call alerts to the authorised person can also be done. Helmets can be equipped with sensors like heart beat sensor, pressure sensor, etc. to monitor the health condition of individual workers. Provision to check whether the worker is wearing the helmet or not can also be done.

Technological evolutions are speeding up. This project can be updated with the latest technologies in the course of time.

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