# SMART HELMET FOR COAL MINERS

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*Abstract* - To aid miners working in the mining business, a classic edition of the smart helmet has been developed. Many risky incidents commonly occur in the mining sector, many of which can result in life-threatening injuries or death. A miner's helmet is one of the most regularly used safety equipment for mine workers. Helmets, on the other hand, do not improve the safety of miners today, other than providing illumination. With the use of different sensors, our smart helmet will be able to identify catastrophic situations, such as hazardous gases like CO, $CH_4$, LPG, and natural gases. Whether the miner is wearing his helmet or not is detected by an infrared sensor. Each sensor has a critical value that, if exceeded, causes the buzzer to activate and the LEDs to illuminate, signaling the miners and supervisors. The GPS module fitted in the miners' helmets allows to readily track them and their location. Furthermore, a Panic Button has been implemented, which, when pressed, sends an emergency signal via the mail to higher authorities outside of the mines. A mobile application has also been created to display all of the data supplied wirelessly from the sensors. As a result, our smart helmet protects miners from any upcoming accidents.

***Keywords*** – Internet of things, Blynk, Node-MCU, ESP32 cam module, GPS module, DHT11, MQ6

## I. INTRODUCTION

In today's world, the mining industry plays a dominant role due to the need for metals and other geological materials. Coal is used extensively in the production of electricity. It is extracted from the earth through surface mining and underground mining. In underground mining, miners' safety is of utmost concern. In coal mines, safety equipment like helmets is not in proper condition. Sometimes miners remove their helmets just because they are not comfortable working with them. In coal mines, dangerous events like heavy objects might fall and the presence of dangerous gases like CO, CH4, LPG might cause severe cardiovascular diseases. Removal of helmets while working in mines is also dangerous. If any heavy object falls on a miner's head even while wearing a helmet, a person may become unconscious and may die if proper treatment is not provided on time. A smart helmet is designed in such a way that it can detect all these dangerous events with the help of sensors that are mounted in it. A sensor circuit is mounted with the helmet of each miner that will observe and analyze the environmental changes. A watch will also be provided which receives notifications regarding helmet removal instantly. Networks inside the mines are a major drawback for the communication of miners. During the development of safety helmets, we consider mainly 3 factors. First is the presence of dangerous gases, second is helmet removal by the miners and the third one is the panic situation faced. A wired communication system in the form of cabling and pipeline can be used but in the mining industry in case of gas explosion and rockfall, the system may become damaged. Also, the installation and maintenance cost of the cabling is high so a wireless communication system is used to transfer data wirelessly to the monitoring station.

## II. PROPOSED SYSTEM

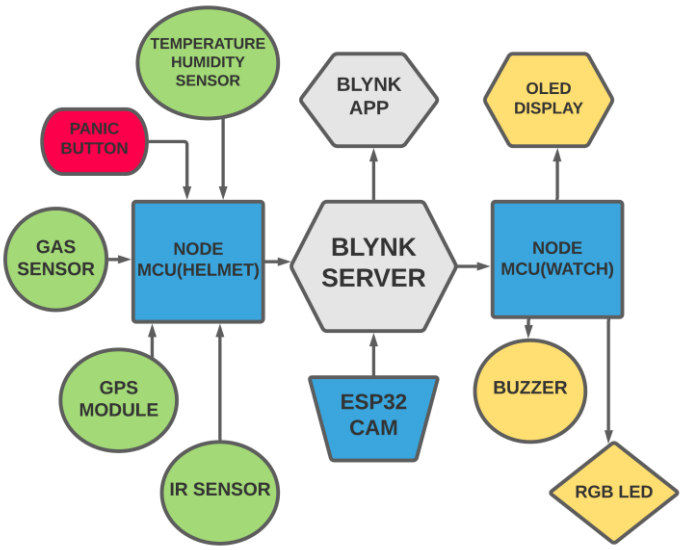


**Fig1:Block Diagram of Proposed System**

All the data from various integrated sensors is being sent to the Node-MCU of the helmet. This Node-MCU sends the data to the Blynk server. An esp32 camera module is also installed which will send a live video stream to the Blynk server. Now all the data from the Blynk server is shown in the Blynk app. The Node-MCU in the miner's watch uses the Blynk server to collect all the relevant data display it in the OLED display and warn the miner by sounding the buzzer in case of any emergency.

## III. EXPERIMENTAL SETUP

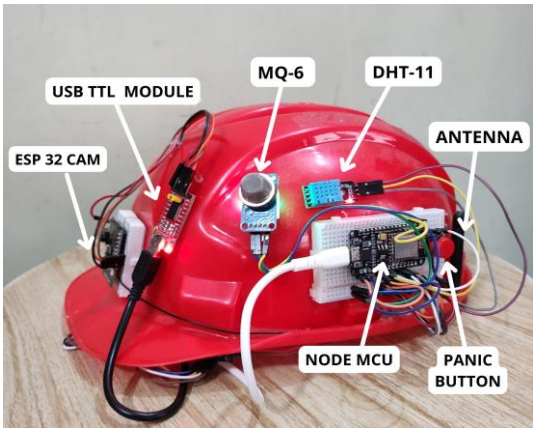


**Fig2: Smart Helmet side-view**

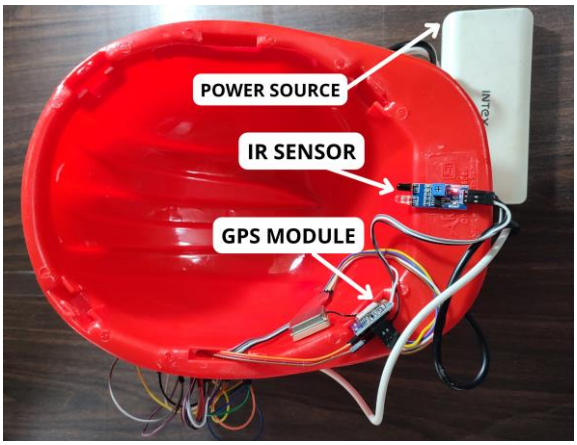


**Fig 3:Inside view**

- The Node-MCU collects the temperature and humidity data from the DHT11 sensor and the gas level data from the MQ6 sensor.
- The GPS module sends the location data to the Blynk server which is shown on a map in the Blynk app.
- IR sensor notifies if the helmet is removed or not.
- The ESP32 cam is used to record the live video stream.
- All the data is finally sent to the Blynk server and displayed in the Blynk app.

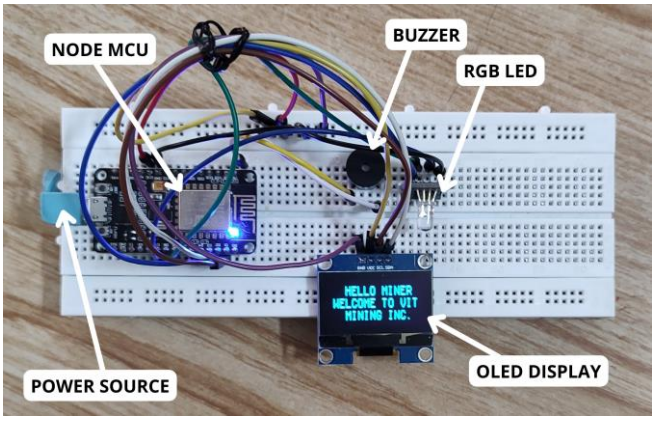


**Fig 4: Watch**

- The watch is used to display all the parameters after fetching from the Blynk server.
- The watch also issues a warning if any parameter exceeds or falls below the permissible level.
- The RGB led is used to show the current status.

## IV. HARDWARE USED

- *ESP8266 (Node-MCU):*

A 32-bit LX106 RISC microprocessor powers the Node-MCU ESP8266 development board. It has a configurable clock frequency of 80MHz to 160MHz and supports RTOS. To store data and programmes, the Node-MCU contains 128 KB of RAM and 4MB of Flash memory. A Micro USB jack and a VIN pin can be used to power it (External Supply Pin). It has interfaces for UART, SPI, and I2C.

- *DHT-11:*

- The DHT11 is a basic digital temperature and humidity sensor. It measures the ambient air with a capacitive humidity sensor and a thermistor and outputs a digital signal on the data pin (no analog input pins needed). It's simple to use, but data collection necessitates careful timing. The only major disadvantage of this sensor is that you can only collect new data from it once every 2 seconds, therefore sensor values can be up to two seconds outdated when implemented.

- *MQ-6 Gas sensor:*

Gases such as LPG and Butane can be detected or measured with the MQ-6 Gas sensor. The MQ-6 sensor module has a Digital Pin that allows it to work without a microcontroller, which is useful when you simply want to detect these gases. The analogue pin is used to measure the gas in ppm; the analogue pin is also TTL driven and works on 5V, thus it may be used with most popular microcontrollers.

- *IR Sensor:*

The IR sensor, also known as an infrared sensor, is an electronic component that emits or detects IR radiation to detect specific properties in its surroundings. This sensor is analogous to the visionary senses used by humans to detect barriers. PIR, or passive infrared, is a sensor that just measures IR radiation rather than emitting it. In general, all target radiation and some types of thermal radiation with range from 0.7μm 5 to 1000μm in the IR spectrum are not visible to the naked eye but can be detected by this sensors.

- *GPS module(Tracker):*

The Global Positioning System (GPS) is a satellite-based navigation system that gives users information about location and time. The system is freely accessible to anyone with a GPS receiver and unobstructed line of sight to at least four of GPS satellites. The position of a GPS receiver is calculated by accurately timing the signals sent by GPS satellites. The GTPA010 module is simple to operate, with both an RS232 and a USB interface. It operates on a 3.2 to 5V supply range, allowing it to interface with both 3.3V and 5V microcontrollers.

- *OLED Display:*

OLED (Organic Light-Emitting Diodes) is a flat light-emitting technology in which a sequence of organic thin sheets are sandwiched between two conductors. A brilliant light is emitted when an electrical current is applied. OLEDs are emissive displays that do not require a backlight, making them smaller and more energy efficient than LCDs (which do require a white backlight).

- *ESP 32 CAM:*

The ESP32-CAM is a compact, low-power camera module based on the ESP32 microcontroller. It comes with an OV2640 camera and a TF card slot onboard. Wireless video surveillance, Wi-Fi image upload, QR identification, and other intelligent IoT applications can be performed from the ESP32-CAM.

## V. RESULTS AND DISCUSSION

*Welcome message on system startup:*

The OLED display is turned on as soon as 5V power source is provided, and it displays a welcome greeting to the miner, as well as the time, date, and day. Then the temperature, humidity, and gas level will be displayed on the screen.

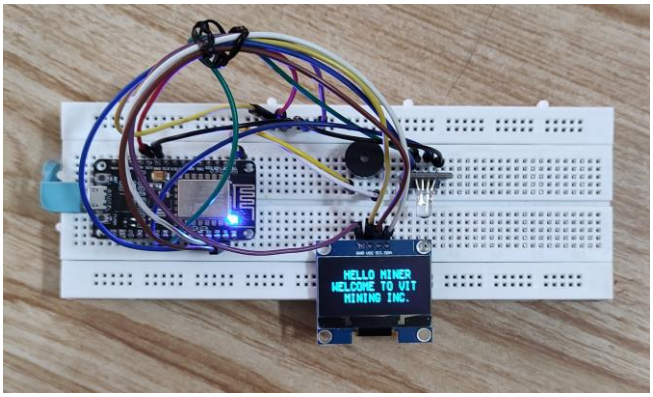


**Fig 5:Welcome message in Watch**

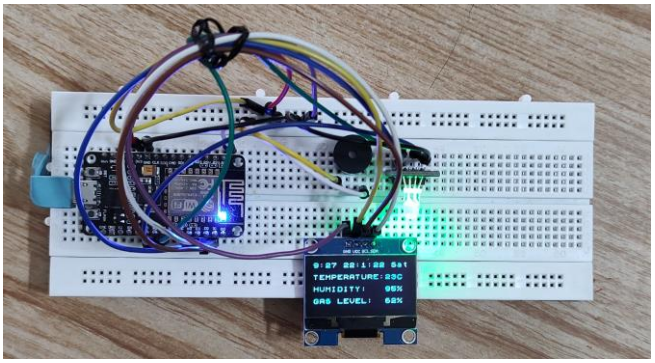


**Fig 6:Temperature , Humidity and Gas level in Watch**

*Air quality test:*

Air quality test is done by MQ-6 sensor. When MQ-6 sensor detects presence of $CH_4$, LPG and natural gases above the 55% then an alert message will be sent from the transmitter section as “GAS DETECTED” to the monitoring section on the OLED screen. At the same time, the buzzer of the watch automatically switched ON. The MQ-6 sensor collects data after every 0.2 second interval for better precision .

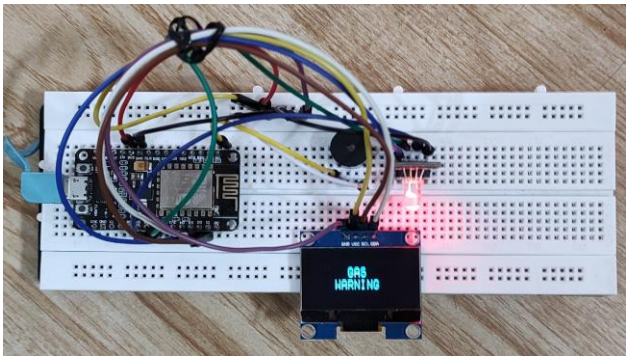


**Fig 7:Gas Alert in Watch**

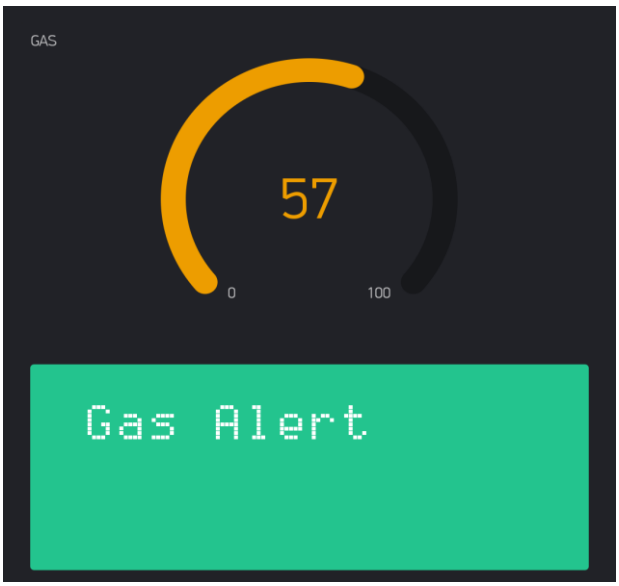


**Fig 8:Gas Alert in BLYNK app**

*Helmet removal test:*

Smart helmet removal test is done by infra-red sensor. When a miner removes his helmet from the head, it gets detected by the transmitter section which sends a “HELMET REMOVED” message to the authorities. . Then, a message will also be displayed on the watch along with a buzzer sound to wear the helmet back. The IR sensor checks the condition after every 0.2 second for more precision


**Fig 9:Helmet removal alert in BLYNK app**

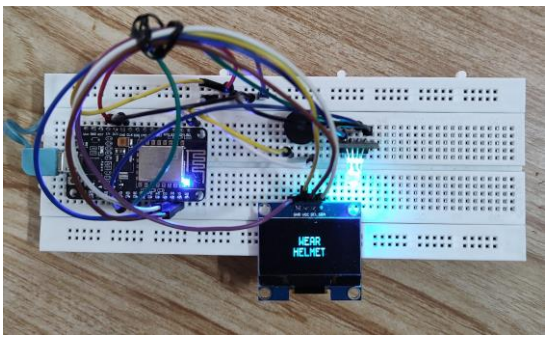


**Fig 10:Helmet removal prompt in watch**

*Temperature and Humidity Test:*

The DHT11 sensor is able to measure temperatures from 0 to + 50 °C with an accuracy of +/-2 °C and relative humidity

levels of 20 to 95% with an accuracy of +/-5%. A measurement was done every 2 seconds to increase the efficiency of the output.

In our project if the temperature rises above 35°C “HIGH TEMPERATURE” and if the humidity of the environment exceeds over 86% “HIGH HUMIDITY” message is displayed on both watch and Blynk App.


**Fig 13:Temperature and Humidity Blynk Dashboard**

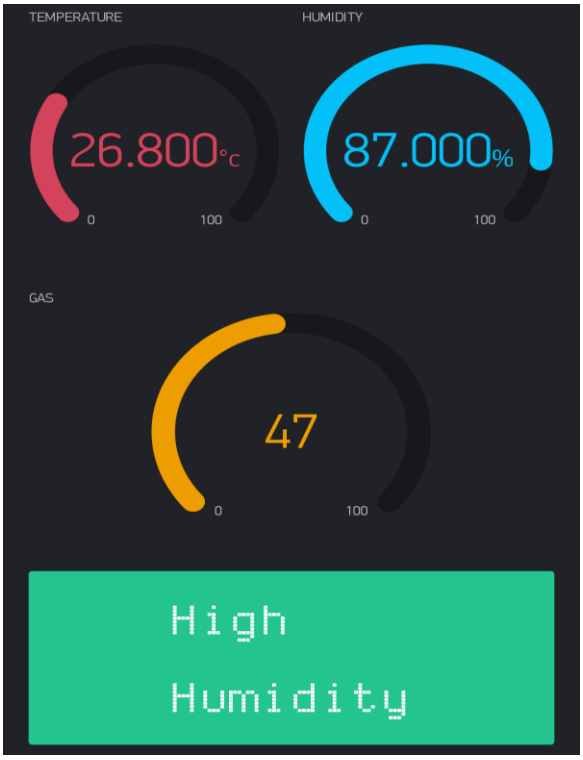


**Fig 14:High Humidity alert in Blynk**

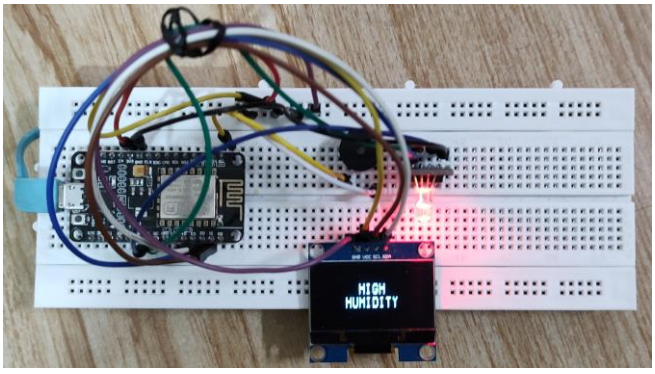


**Fig 12:High Humidity alert in watch**

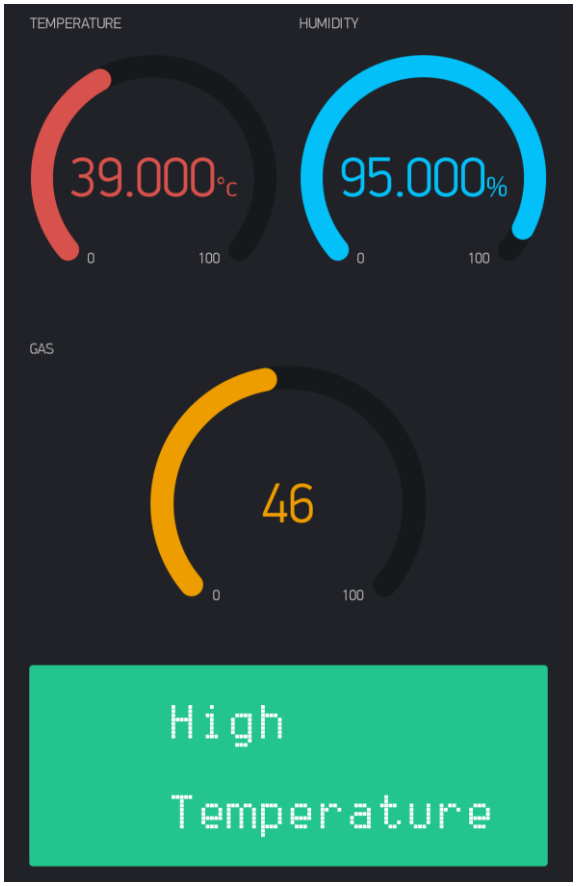


**Fig 15:High Temperature alert in Blynk**

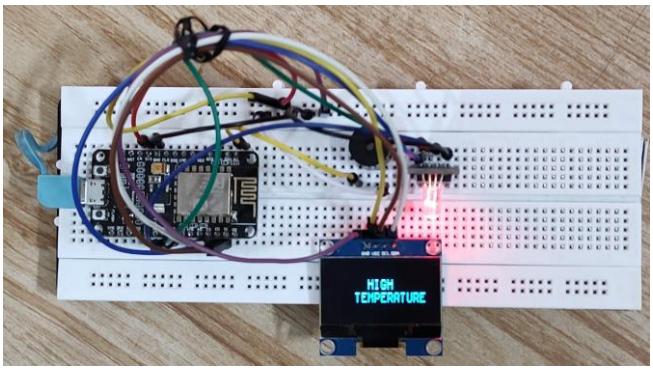


**Fig 11: High Temperature Alert in watch**

*Location Test:*

GPS module integrated with our helmet is tested with the location sent by the user living in that area and the precision is observed with the actual location. The module renews its values at interval of 5 seconds. In our helmet the GPS module helps the authorities to get constantly notified about the miners’ location using a map.

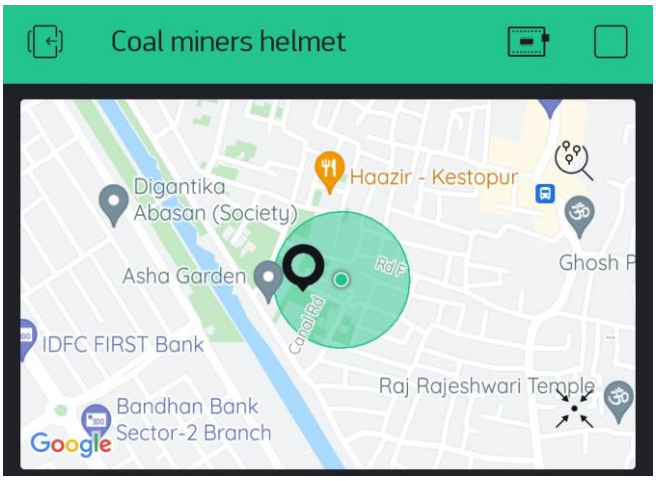


**Fig 12:Location of miner shown in BLYNK app**

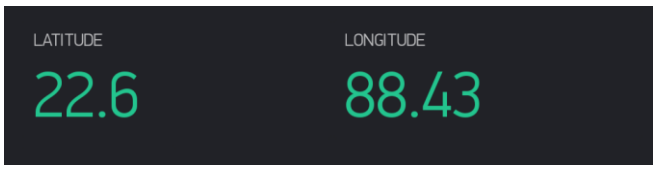


**Fig 12: Latitude and Longitude of the miner**

*Panic button feature :*

In case of emergency a distress signal can be sent to the mining authorities using the panic button. As the miner presses the panic button a mail is sent to the authorities within 5 seconds which helps them to reach the miner as fast as possible thereby save the miners life.

To avoid the possibility of mail ignorance the mail is continued to be sent until the authorities give a suitable response.

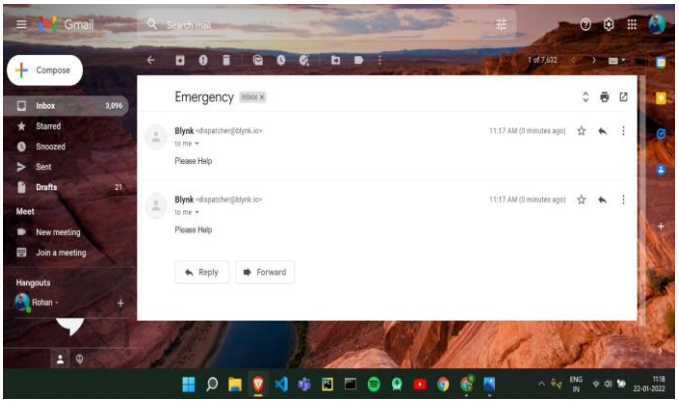


**Fig 12:Mail sent when panic button is pressed**

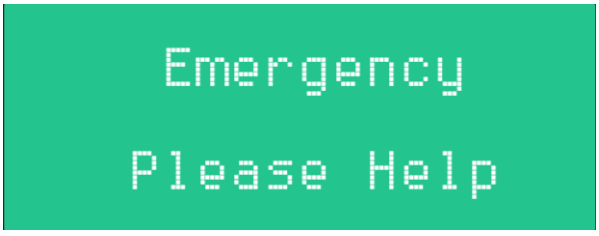


**Fig 12:Emergency notification shown in the BLYNK app**

*Surveillance Test :*

The ESP-32 CAM module attached to helmet, will stream live video to the authorities for monitoring. The streaming is done at 160 MHz clock speed with a pixel count of 2MP. This live video stream will help the mining officials to get a constant update of the situation under the mines and can also use this feed for research and future reference.

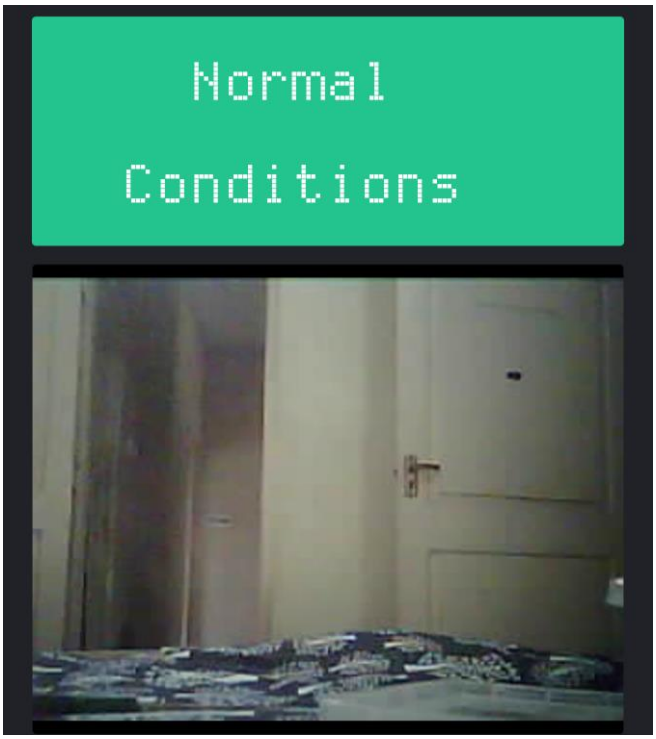


**Fig 12:Mail sent when panic button is pressed**

## VI. COMPARITIVE STUDY OF THE PROPOSED MODEL WITH EXISTING LITERATURE

Cheng Qiang [1] has proposed a cost effective wireless mine supervision system which uses ZigBee protocol for communication providing a lesser stable frequency range compared to our Wi-Fi communication system providing a highly stable frequency range of operation.

C.J. Behr [2] had produced a similar method of operation for hazardous event detection inside mines and where Air Quality Index(AQI) was monitored using Gas sensors. Apart from using Gas sensors, in this system we have also provided Humidity and Temperature sensor for analyzing the surrounding environments.

Sawant[4] concern is based on using Arduino UNO as the development board for making the desired smart helmet .In our project we used Node MCU which has a much powerful processor and can also be used for transfer of real time data wirelessly to a web server.

A.Katara[9] has used an LCD to display all the parameters received from the sensors. On the contrary we have used a web server to establish a communication between the

sensors and the control rooms thereby making it easier to observe the mine parameters.

## VII. CONCLUSION

A WIFI based smart helmet has been designed for coal miners which is capable of detecting threatening events like the increase in the level of harmful gases.

This smart helmet is also capable of sending real time temperature and gas levels to the servers thereby keeping the concerned authorities always updated about the mine conditions. The presence of a panic button in the smart helmet helps the miners to send distress signals easily just with a press of a single button and the GPS module helps the rescue party to find the exact location of the miner quickly thereby saving the lives on miners.

In addition to the helmet the miners are also provided with a watch which always keeps the miners notified about parameters like temperature, humidity and gas levels .

The helmet removal notifier feature helps the authorities to get informed if any miner tries to remove the helmet.

This low-cost, reliable and efficient prototype has been designed and tested with software and hardware debugging. Placement of each module and sensors has also been done carefully thus resulting in the best working of the product.

The proposed model can be upgraded by using a LORA module in addition to the WIFI thereby making the communication process less network dependent.

Further an oximeter can also be included to constantly monitor miners oxygen level and heart rate.

Also a collision sensor can be installed which can detect any collision or accidents.

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