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Chatura Suraksha Kavacha – The Smart Safety Helmet for Mine Workers

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ABSTRACT

The underground mines all over the world are adversely affected by various hazards including gaseous explosions, landslides, fire hazards, etc. This leads to the significance of safety for the mineworkers. The proposed work talks about safety helmet which is used to avoid the accidents, which will cause in the workspace with a low-cost sensor. The smart helmet has been produced to assist miners operating in the mining industry. Many risky incidents commonly occur in the mining sector, many of which result in life-threatening injuries or death. A miner's helmet is one of the most regularly used safety equipment for mineworkers hence it must be loaded with some more advanced features. With the use of different sensors, the smart helmet will be able to identify catastrophic situations such as harmful gases like Carbon-Monoxide (CO), methane (CH4), liquified petroleum gas (LPG), and natural gases. The existence of the helmet on the worker's head is detected by an infrared sensor. Each sensor has a threshold value that, if exceeded, causes the buzzer to activate and the LEDs to illuminate, signalling the miners and supervisors. The ESP32 cam module fitted in the miner's helmet allows the mining officials to monitor the worker continuously. Furthermore, an Emergency Button has been implemented, which, when pressed, sends an emergency signal to the higher authorities outside the mines. A mobile application has also been created to display all of the data supplied wirelessly from the sensors. As a result, the proposed smart helmet protects miners from upcoming accidents.

Keywords: Internet of things, Blynk, ESP-8266, ESP32 CAM module, GPS module, DHT11, MQ6, helmet

I. INTRODUCTION

In the 21st century, the mining industry has become one of the most dominant sectors of the economy because of the increasing need for metals and other

geological materials. Among all the minerals available, coal is used extensively in electricity production due to its high availability [1]. It can be mined both by surface mining and underground mining. Thus, the safety of underground miners becomes paramount for the concerned authorities [2]. Coal mines involve dangers liken falling objects and the presence of dangerous gases like CH4, LPG, which could cause serious cardiovascular complications. Removal of helmets while operating in mines is additionally dangerous [3]. If any bulky object falls on a mineworker's head even after putting on a helmet, the individual may become injured and could die if immediate treatment isn't provided. So, this smart helmet is built in such a way that it will notice all types of dangerous events with the assistance of devices that are mounted on it [4]. Multiple sensors are mounted on the smart helmet that will help to detect any change in environmental parameters [5] and is also capable of tracking the miners' location incessantly. A watch will also be provided to the miner which informs the miner about the environmental parameter changes and also notify regarding helmet removal [6]. In the proposed safety helmet, there are three salient factors. First is detecting the presence of dangerous gases, the second is helmet removal by the miners, and the third one is the panic button pressed in any adverse situation [7,8]. Networks within the mines are a serious downside for the communication of miners. Communication within the mines is often carried out in the form of cables which might get disrupted during rockfalls. Additionally, since the cost of fitting and maintaining the cabling is high, the data has to be transferred wirelessly to the observance station through a wireless communication system.

II. METHODS AND MATERIAL

In our proposed work, we have used different sensors, which perform different tasks. DHT11 is a sensor, which measures the temperature and humidity of the working place. MQ6 sensor is a gas sensor, which is used to detect the hazardous gases. The temperature, humidity and gas sensor's data are collected by the Node-MCU microprocessor.

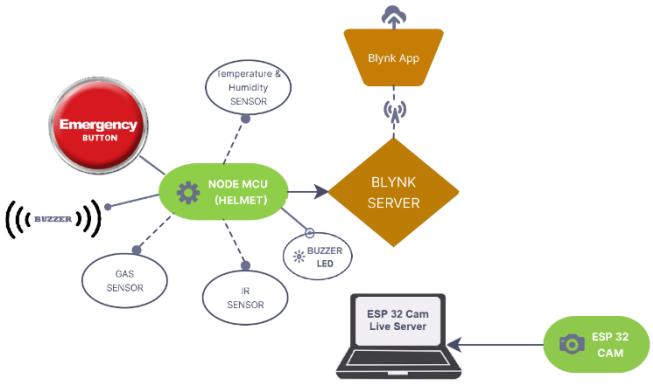

Figure 1: Block Diagram of working flow of Smart Safety Helmet

Infrared (IR) sensor notifies the existence of the helmet on the worker's head. Using ESP32 CAM the current working condition of the worker can be known. All the data is finally sent to the Blynk server and displayed in the Blynk app. Then the temperature, humidity and gas level will be displayed on the Blynk app.

In case of emergency, a distress signal can be sent to the mining authorities using the emergency button. As the miner presses, the emergency button a mail is sent to the authorities within short spam of seconds, which helps the authorities to reach the miner as fast as possible thereby, saves the mines life. To avoid the possibility of mail ignorance the mail is continuously sent until the authorities give a suitable response.

To continuously monitor the working condition of the worker a live streaming esp32 cam is embedded on top of the helmet. 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, it also helps to know whether the worker is properly working in the assigned area or not, through live streaming if any adverse situation in their surrounding area happens then it can be identified and further it can be intimated to the worker in that particular area and can also use this feed for research and future reference.

Micro Controller (ESP8266 (Node-MCU)):

Figure 2: Node MCU

Node MCU is an open source IOT platform. It includes firmware, which runs on the ESP8266 Wi-Fi SOC from Express if Systems, and hardware, which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the Lau scripting language. It is based on the Lau project, and built on the Espressif Non-OS SDK for ESP8266.

IR SENSOR:

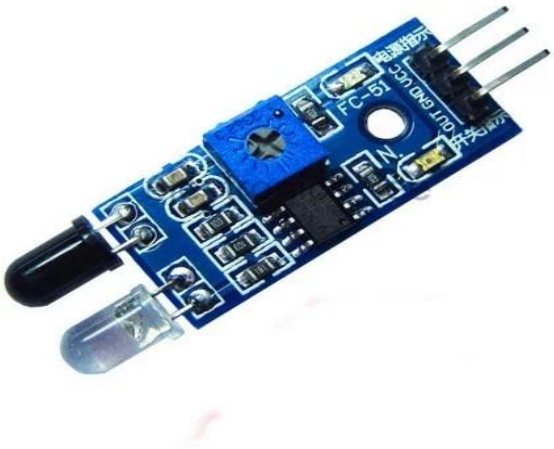

Figure 3: Infrared Sensor

An infrared sensor is an electronic device that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measure only infrared radiation, rather than emitting it that is called a passive IR sensor. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation.

DHT 11 SENSOR:

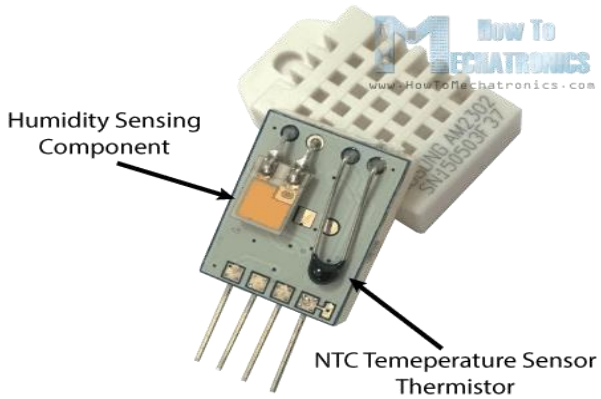

Figure 4: DHT 11/DHT 22 Working Component

For measuring humidity, they use the humidity-sensing component, which has two electrodes with moisture holding substrate between them. So as the humidity changes, the conductivity of the substrate changes or the resistance between these electrodes' changes. This change in resistance is measured and processed by the IC, which makes it ready to be read by a microcontroller.

MQ-6 GAS SENSOR:

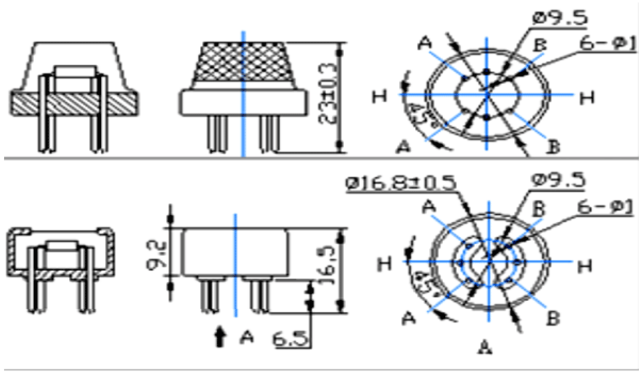

Figure 5: 2D Model of MQ-6 Gas Sensor

The MQ-6 Gas sensor can detect or measure gases like LPG and butane. The MQ-6 sensor module comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. When it comes to measuring the gas in ppm the analog

pin has to be used, the analog pin also TTL driven and works on 5V and hence can be used with most common microcontrollers.

ESP 32 CAM MODULE

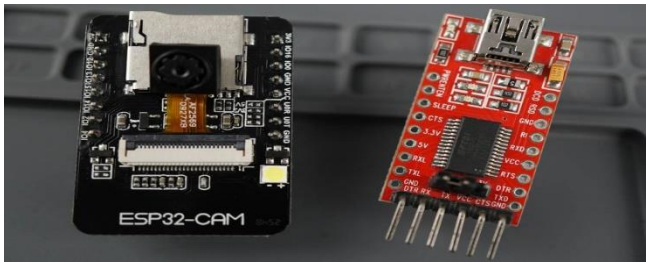

Figure 6: ESP-Cam AI-Thinker

The ESP32-CAM AI-Thinker development board can be programmed using Arduino IDE. This guide shows how to program and upload code to the ESP32-CAM (AI-Thinker) development board using Arduino IDE. The ESP32-CAM AI-Thinker module is an ESP32 development board with an OV2640 camera, microSD card support, on-board flash lamp and several GPIOs to connect peripherals. However, it doesn't have a built-in programmer. You need an FTDI programmer to connect it to your computer and upload code.

III. RESULTS AND DISCUSSION

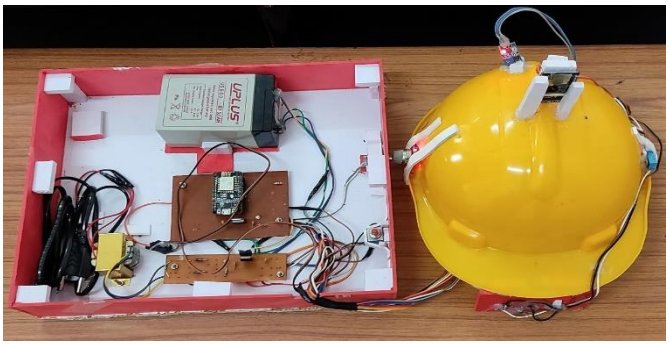

Figure 7: Working Model

In this project, there are four main objectives. First objective is to detect the presence of Hazardous gases like Carbon-Monoxide, Methane, LPG, and other natural gases, the second objective is about helmet removal by the miners, the third objective is the emergency button pressed in any adverse situation and the last objective is to monitor the miners continuously using esp32 cam. Therefore, it is crucial to have a monitoring and surveillance system to acquire the evaluated data, transmit it to the control centre, and make the most appropriate decision at the earliest possible moment.

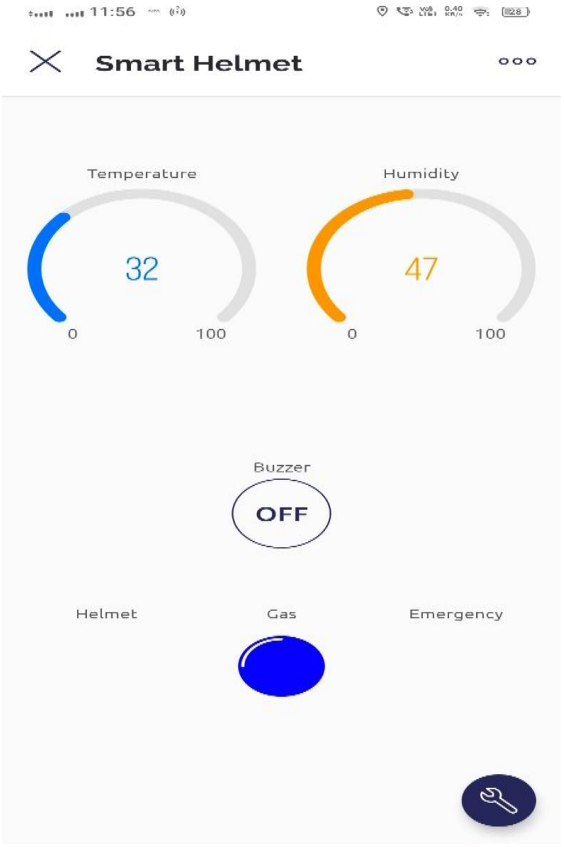

Figure 8: Gas Alert in Blynk App

Detecting the presence of Hazardous gases like Carbon Monoxide, Methane, LPG, and other natural gases is the first objective of our project. Air quality test is done using MQ-6 gas sensor. As shown in Fig 3, as soon the presence of CH4, LPG and natural gases above 55% is detected by the MQ-6 sensor a signal is sent to the higher authorities in the control room. Concurrently, the buzzer and the LED is switched ON to notify the mine worker. The MQ-6 sensor collects data after every 0.2 second interval for better accuracy.

Second objective of our project is to detect the existence of the helmet on the worker's head. An IR sensor is used to perform smart helmet removal test, when a miner removes their helmet, it gets detected by the sensor. As soon as the worker removes the helmet

it is detected in the blynk server as shown in Fig 4. Red LED along with a buzzer sound prompting to wear the helmet back is activated. The IR sensor checks the condition after every 0.2 second for more accuracy.

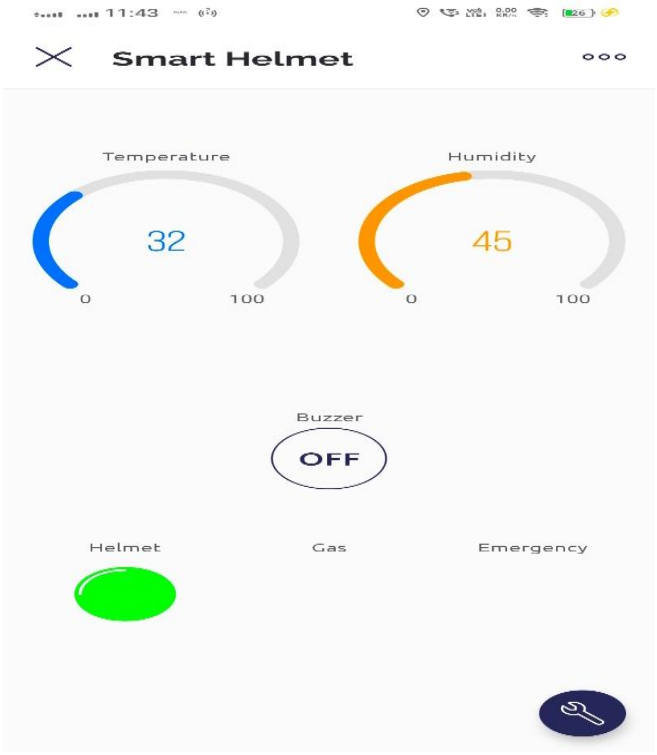

Figure 9: Alert about helmet removal

Third objective of our project is to press the emergency button in any adverse situation. In case of emergency a signal can be sent to the mining authorities using the emergency button. As the miner presses the emergency button a mail is sent to the higher authorities within 5 seconds which helps the authorities to reach the miner as fast as possible thereby save the miners life. As shown in Fig 5 to avoid the possibility of mail ignorance the mail is continuously sent until the authorities give a suitable response.

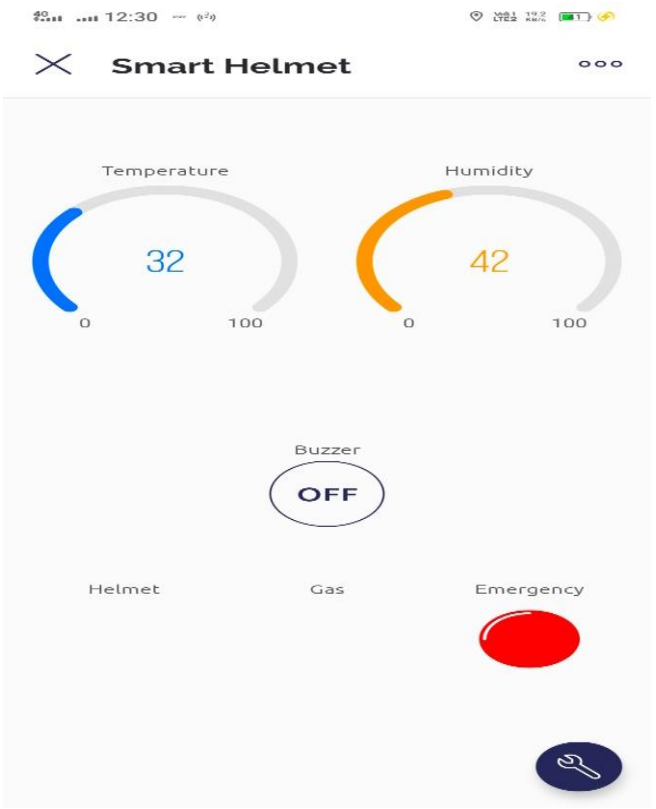

Figure 10: Emergency signal in blynk app

The last objective of our project is to monitor the mineworker's location continuously using esp32 camera. As shown in above Figure 6, the esp-32 camera 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.

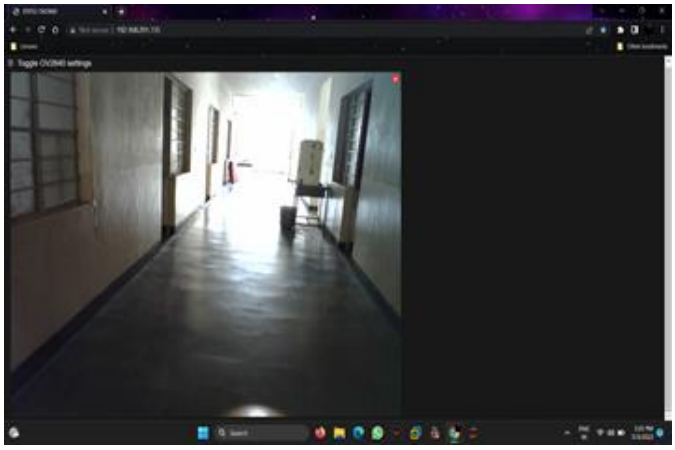

Figure 11: Live video streaming of Mineworker

IV. CONCLUSION

The mining industry all over the world is adversely affected by various hazards including gaseous explosions, landslides, fire hazards, etc. Many risky incidents commonly occur in the mining sector, many of which result in life-threatening injuries or death. This leads to the significance of safety for the mineworkers. A miner's helmet is one of the most regularly used safety equipment for mineworkers hence it must be loaded with some more advanced features. A Wi-Fi 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 inside the mine. This smart helmet is also capable of sending real time temperature and humidity levels to the servers thereby keeping the concerned authorities always updated about the mine conditions. The presence of an emergency button in the smart helmet helps the miners to send signals easily just with a press of a single button that indicates the rescue team that the worker needs to be rescued. The helmet removal notifier feature helps the authorities to get informed if any miner tries to remove the helmet. We have provided an esp32 camera to monitor the mineworker's location continuously. 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.

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