International Journal of Research in Engineering, Science and Management
Volume-1, Issue-9, September-2018
www.ijresm.com
ISSN (Online): 2581-5782

IoT Based Smart Helmet for Underground Mines

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***Abstract*: The security of the underground mines must be increase because disasters in underground mines are very serious issues now a days. The difficulties faced by miners working underground are gas explosion, deficiency of light, etc. If any disaster occurs in mine and if miner gets injured, all the blame directly goes on supervisor. So there must be communication between miners, supervisor and control station. Therefore the purpose of the proposed system is to modify an existing mining safety. Helmet is one of the safety accessories miner should wear while mining. The aim is to make the helmet even safer by adding network. This added network is used to sense the environmental conditions around the miner working underground and all the real time values are wirelessly updated on the internet by using IoT so the control station get to know about the environmental conditions in which miner working and if any abnormal condition occur they are able to provide the rescue as early as possible. The system also includes the LCD and buzzer to let co-workers know if any unwanted event occurs with miner. The proposed system uses different sensors like Gas Sensor, Humidity and Temperature Sensor, LDR and IR Sensor. Here the IR sensor is used as helmet removing sensor.**

Keywords: IoT (Internet of Things) module, Raspberry Pi

I. Introduction

The world is having an extensive and diverse mineral resources and large mining industry. The proper supervision and proper communication is very important requirement of mining industry. Supervisors are held responsible for all injuries sustained under their supervision, and should therefore be aware of potentially risky situations [1]. The problem addressed is the improvement of a mining helmet in order to ensure more safety awareness between miners. When working with noisy equipment, being aware of one's surroundings can sometimes be challenging [7]. In the mining industry miners tend to remove some of their safety gear because the gear is too heavy, warm or uncomfortable to work with. However, miners generally do not remove their helmets. Presently mining safety helmets only have the purpose of protecting the miner's head against potential hazardous bumps. The safety helmets do not have any technology added to it to let miners know when a fellow miner has encountered a hazardous event. Therefore the purpose of the project is to modify an existing mining safety helmet to make the helmet even safer by adding a wireless sensor node network. The task was extended to designing the system small enough to fit into the safety helmet and last long enough while running on battery power.

A further challenge was to modify the helmet without changing its physical structure. The added weight had to be kept to a minimum. A mining helmet needs to be modified to improve miner safety by adding intelligence to the helmet. When a miner removes his helmet he needs to be warned. If an object falls on a miner even when wearing his helmet he can become unconscious or immobile. The system must determine whether or not a miner has sustained a life-threatening injury. These two events are defined as hazardous events. Thirdly, dangerous gases need to be detected and announced.

II. Literature Survey

Yongping Wu and Guo Feng proposed a coal mine monitoring using the Bluetooth wireless transmission system. As a standard of unified global short-range wireless communication, Bluetooth technology is to be establishing a common low-power, low cost wireless opening system. The system uses CAN bus technology maturely, has realized the combination of wired and wireless data transmission system [1]. The main difficulty of this system is that the Bluetooth is short distance wireless technology and use of cabling is difficult. Jingiiang Song, Yingli Zhu implemented automatic monitoring system for coal mine safety with wireless sensor network. The sensor groups of the system temperature, humidity and other parameters in the underground mine, parameters measured are sent to wireless communication module by the micro-controller [2]. The collected data is sent to long-distance monitoring center by the cable. Pranjal Hzarika proposed implementation of the safety helmet for a coal mine workers. This helmet is equipped with methane and carbon monoxide gas sensors. This sensor sense the gas and the data is transmitted to the control room wirelessly, through a wireless module called Zigbee connected with the helmet [10]. This system does not detecting fall down of the person and weather the worker is wearing the helmet or not.

III. Proposed System

In mining industry worker safety is very important issue. Every year, thousands of miners die in accidents and many more get injured, especially in the processes of the coal mining and hard rock mining. The main reason of accidents are gas or dust explosions, gas intoxications, improper use of explosives, electrical burn, fires, collapsing of mine structures, rock falls from roofs, flooding, workers stumbling/falling/slipping, or errors from malfunctioning or improperly used mining equipment [11]. In coal mine use of personal protective equipment like helmet, shoes etc. are not proper and proper arrangements were not there to check if the person is wearing personal protective equipment or not. The proper supervision for worker wear the protective element is very important factor for consideration. Underground mines are very dark so any miners are fall unconscious because of suffocation or falling of

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structure, supervisor don't know about his health condition and proper treatment is not provided him in time. The main reason for miner death is harmful gases explosions. In coal mines carbon monoxide, methane, LPG gases existing and they are very harmful for human body.

The proper supervision and proper communication is very important requirement of mining industries. The smart helmet provides a real time monitoring of harmful gases, proper light intensity for work, humidity and miner is wearing the helmet or not. The harmful gases like carbon monoxide, LPG, Methane and also temperature are monitor using this system [11]. The wired communication network is not so effective because when natural calamity or a roof fall occurred, wired network is damages, so it is very difficult and costly to reinstall the entire system. The effective solution for communication from base station to underground mine is IOT based wireless network.

The smart helmet for mining industry consists of various sensors which are fixed on the helmet. The sensors used are Gas Sensor, Temperature Sensor, Humidity Sensor, LDR for light intensity, and IR sensor to detect weather the miner wearing helmet or not. By using IOT module the mine information like environmental parameters in mine or wearing helmet or not can be seen anywhere anytime by using internet. So the proper action can take within time to rescue the miner.

IV. Block Diagram

A. Block diagram description

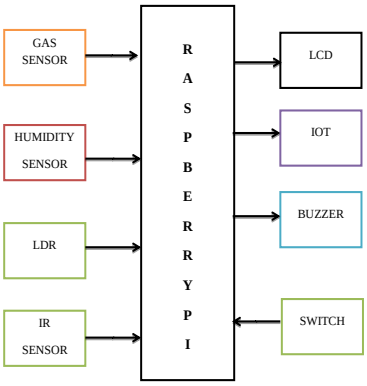

Fig. 1. Block diagram of proposed system

The MQ6 is used to monitor the level of Methane, LPG, Hydrogen, Carbon monoxide, Alcohol, and Smoke. The LM35 is used for monitoring temperature. The DHT11 is used to monitor the humidity. The LDR is used to detect the light intensity of the environment in which miners are working. To detect weather the miner is wearing helmet or not the IR sensor is used. These are semiconductor type sensor. The sensor senses the various environmental parameters like temperature, humidity, light, level of gases and transmitted real time data to the controller, the controller receive the data processing on it and transmitted to the base station using IOT module. At the same time if gases level is increases above threshold, alert signal will be send to the base station.

The alerting device, buzzer is used for alerting to the supervisor or the person at the base station if any of the sensor data exceed than rated or threshold values. LCD displays the massage according to sensor values, like if LPG level increases then LCD will display "LPG detected". If helmet is removed by miner then, "Helmet Removed" will be displayed on LED.

All the data is received from helmet and transferred to the base station through IOT and display on PC. By using IOT module we will able to get mine's update anywhere anytime through internet.

V. Hardware Description

A. Raspberry Pi

Raspberry Pi proved that it is a great tool for Learning Programming, Computers & Concepts of Embedded Linux, etc. Support for all Age Groups (School Children, College Undergraduates, Professional Developers, and Programmers). Consumes less than 5W of power, supports Full HD Video Output (1080p), Multiple USB Ports, Ethernet, WiFi, Camera module etc. Following figure shows The Raspberry Pi 3 Model B.

In the proposed system, Raspberry pi is a heart of the system. The operation of the system is based on this smart controller which collects all the real time sensor data automatically, and performs operations to give required output. When we code it properly we are able to display real time sensor values to the LCD, computer at base station as well as we can upload it on web so anyone can see values anytime anywhere by using internet.

B. Gas Sensor MQ-2

MQ2 gas sensor can be used to detect the presence of LPG, Propane and Hydrogen, also could be used to detect Methane and other combustible steam. Sensor is sensitive to flammable gas and smoke. Smoke sensor is given 5 volt to power it. Smoke sensor indicates smoke by the voltage that it outputs .More smoke more output. A potentiometer is provided to adjust the sensitivity. Sn02 is the sensor used which is of low conductivity when the air is clean. But when smoke exist sensor provides an analog resistive output based on concentration of smoke. The circuit has a heater. Power is given to heater by VCC and GND from power supply. The circuit has a variable resistor. The resistance across the pin depends on the smoke in air in the sensor. The resistance will be lowered if the content is more. And voltage is increased between the sensor and load resistor.

C. Humidity Sensor DHT11

They consist of a humidity sensing component, a NTC temperature sensor (or thermistor) and an IC on the back side of the sensor. They are very cheap but still providing great performance. The sampling rate for the DHT11 is 1Hz or one reading every second. The operating voltage of sensor is from

International Journal of Research in Engineering, Science and Management
Volume-1, Issue-9, September-2018
www.ijresm.com
ISSN (Online): 2581-5782

3 to 5 volts, while the max current used when measuring is 2.5mA.

D. LDR

An LDR or light dependent resistor is also known as photo resistor, photocell, and photoconductor. It is a one type of resistor whose resistance varies depending on the amount of light falling on its surface. When light falls on the resistor, resistance of the resistor changes. This resistor works on the principle of photo conductivity.

E. IR Sensor

In the proposed system the IR sensor is used as a helmet removing sensor. The IR sensor consist of a transmitter infrared LED and infrared receiver. Infrared Transmitter is a light emitting diode which emits infrared radiations. Hence, they are called IR LED's. Even though an IR LED looks like a normal LED, the radiation emitted by it is invisible to the human eye. Infrared receivers are also called as infrared sensors as they detect the radiation from an IR transmitter. IR receivers come in the form of photodiodes and phototransistors. Infrared Photodiodes are different from normal photo diodes as they detect only infrared radiation.

F. LCD

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

G. Buzzer

Piezoelectric buzzers are sometimes also called as piezo buzzer. Piezo buzzer is the sound generator, used as audio indicator in electronic circuits. It is widely used as alarm generator in electronic devices. A Piezo buzzer has an oscillator and a Piezo disc inside. Around 2-4 kHz frequency is generated by oscillator and to produce the sound the Piezo element vibrates accordingly. The Piezo buzzer works between 3 – 12 volts DC [4].

VI. IoT

Internet of Things (IoT) has been considered as one of the charming technologies. It allows people and things to be connected anywhere, anytime, with anyone and anything, using any link and any service. It offers a platform for sensors and devices to be connected seamlessly within a smart environment in order to provide advanced and intelligent services for human-beings. The key technologies are present in IoT where sensors and devices sense and collect all kinds of data about the target and then, the data can be further processed and analyzed to extract useful information to enable intelligent services. In the proposed system we used Thingspeak as a IoT platform. According to its developers, ThingSpeak is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates". ThingSpeak has integrated support from the numerical computing software MATLAB from MathWorks.

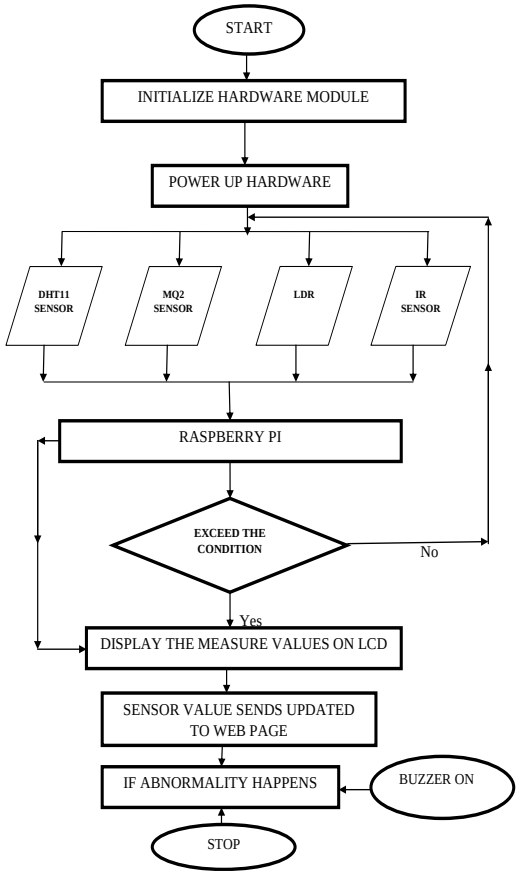

Fig. 2. Flowchart of proposed system

VII. Experimental Results and Discussion

This section discusses the results of the proposed system. The sensors sense the environmental conditions around the miner working in underground mining. All the real time data is display on LED, and also updated on the web by using IoT with the help of Thing speak. If any of the environmental parameters exceeds its standard value the miner, co-miners, supervisor and the control station get notify by buzzer. If any hazardous event occurred in the mine in such case the control station will be able to provide the rescue team as early as possible.

A. Experimental setup

The following Fig. 3, shows the experimental setup of the proposed system. Here the Gas sensor (MQ-2), Humidity and

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www.ijresm.com
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temperature sensor (DHT11), LDR, IR sensors and switch are connected as an input to the raspberry pi and LCD and buzzer as output.

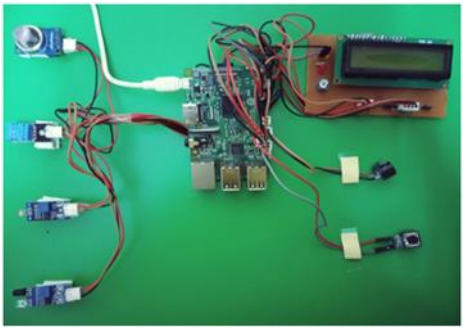

Fig. 3. Experimental setup

B. *Web page showing temperature around miner*

The following Fig. 4, will show the temperature around the miner working underground in mine. The threshold value of the temperature is set at 50 degree Celsius. In the following chart the X-axis represent the time temperature in degree Celsius and Y-axis represents the temperature in degree Celsius.

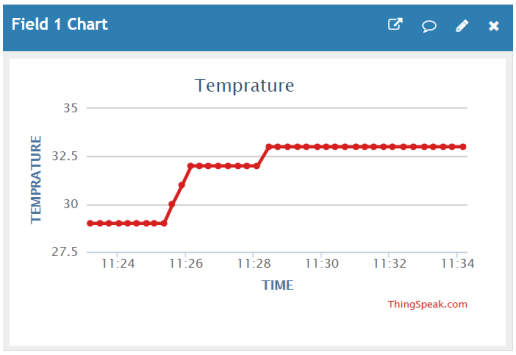

Fig. 4. Web Page showing temperature around miner

C. *Web page showing humidity around miner*

The following Fig. 5 will show the relative humidity around the miner working in underground mine. The threshold value of the humidity is set at is set at 90% RH. The X-axis represents the time and Y-axis represents the related humidity in percentage.

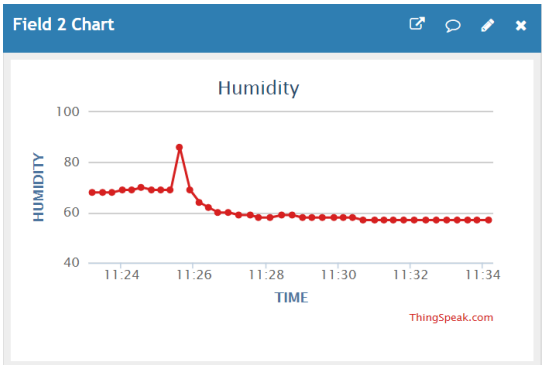

Fig. 5. Web page showing humidity around miner

D. *Web page showing gas leakages around miner*

The gas sensor i.e. MQ-2 sensor gives the digital output. In the following figure 6 when no gas detected then output will be 1. When gas detected then it will give the output 0. That is for normal condition the output of the sensor must be 1. In the following chart X-axis represent the time and Y-axis represent the gas value.

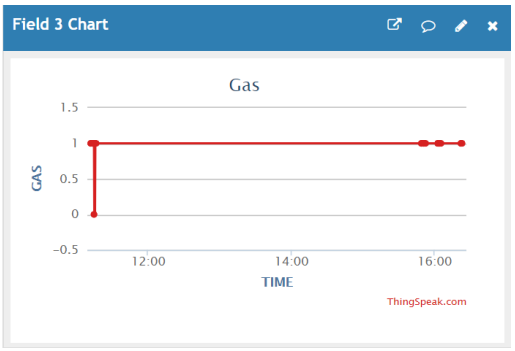

Fig. 6. Web Page showing gas concentration around miner

E. *Web page showing gas leakages around miner*

The LDR sensor is used to detect is there sufficient light to work under mines. The light intensity is shown by 0 or 1. The graph in following Fig. 7, will show output 0 if the sufficient light is present. And if there is no sufficient light then it will show output 1. In the following chart x- axis represent the time and Y- axis represent the light condition.

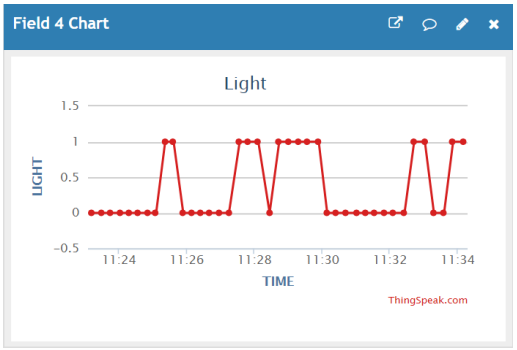

Fig. 7. Web page showing light intensity around miner

VIII. Conclusion

A mining helmet is developed that is able to detect different types of hazardous events such as, humidity condition of mines, then temperature and existence of combustible gases, the helmet removing by miner, and light intensity inside the mines.

Heart of the system is Raspberry pi 3 who control and monitor the all these events using IOT. This system is displaying the parameters on the base station PC and alerting miner, from base station higher authority can monitor every thigh, which can provides rescue operation for the miner. The first is the presence of the hazardous gases such as CO, SO2, NO2, and particulate matter exceed its limit raspberry pi sends

information through IoT to the base station and alert the miner through buzzer.

The second is the measurement of environmental humidity and temperature around miner, which is done by sensors used. In the third case if the miner removes his helmet off their head. Then to determine successfully when the helmet is on the miner's head an off-the-shelf IR sensor is used. The fourth is the measurement of light intensity inside the mines if the light intensity becomes low raspberry pi informs the miner by buzzer. So this project is useful for the persons who are working in the underground, or in mines.

The system can be further improved. To allow the transmissions to the control station or supervisor node hopping can be implemented. The system can also be improved by adding the sensors to detect collision inside the mines, and we can also add the devices to check the miner's heart rate and blood pressure.

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