Telemetry of Coal Miners Using Smart Jacket

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Abstract: Subsurface atmosphere in mines may be contaminated with poisonous gases that displace necessary oxygen for inflammable gases leading to explosion. Damp gasses lead to spontaneous combustion and result in collapse of mines. The hazardous gases, if present in an influential quantity say carbon monoxide (White damp) can even be lethal. From recent incidents in the mining sector, we can infer that hazardous conditions lead to life loss in mines. To reduce the risk of miners at greater cost, an innovative jacket which can incorporate a variety of gas sensors is designed. This proposed system with an efficient sensing and transmitting approach enables us to predict and prevent misfortune in the mining sector. For processing and transmitting data ESP32 is used. On variations in threshold values of various sensors, alerting the miners is done individually (Buzzer) as well as the monitoring authority. Effective supervision of mining is of great significance to enhance the safety of coal miners. Thus, our innovative smart jacket integrated with various sensors, alerting mechanism, communication network and monitoring system is developed to accentuate the risk reduction and safety of the miners.

Keywords: Smart Jacket, wireless network, miner's safety monitoring

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1. Introduction

Challenges at mines are increasing each day due to frequent accidents. The exposure to natural gases at mines is very frequent. Due to the conventional safety systems miners get hurt or even die when accidents occur. The risk could be reduced to certain extent by modern sensing technology. The accurate monitoring network provides improved surveillance of the gases at mines. The urge for modernization of mines is prevalent in the current mining industry.

Fig 1 General Block Diagram

Fig1 Represents the general block diagram. The development of improved safety monitoring and rescue systems is being prioritized more strongly as major mining nations including [2] South Africa, Australia, Canada, the United States, and India work to achieve zero fatality goals. Sensor based technology could be a progressive step in achieving zero-fatality in mining. The suggested system tracks the above-mentioned dangerous

parameters in real time using appropriate sensor modules for damp gases and provides the microcontroller with the resulting data. Following this analysis and comparison with a predetermined range, the microcontroller activates the buzzer if any of the parameters are outside of the acceptable range. For ground control, this technology is useful since it allows for both authority and real-time monitoring of the miners. Early detection of accidents is the key to saving miners' lives. It is precisely in this domain that sensor networks outclass other detection systems. A combination of multiple sensors is used for accident detection, various sensing technologies used to detect different accident indicators.

2. Proposed Method

The most typical attire required of all miners when working in coal mines is a jacket and a helmet. A smart jacket for coal miners is a piece of equipment that is worn by miners as clothing and has sensors built right in. These sensors are further connected to external devices via wireless connection. The Gas sensors used in the prototype are used to sense the environmental conditions of the coal miners and can detect the presence of harmful gases and once the threshold level of the gas is reached the esp32 module sends an alarm to the Managing authority. Then the miners can be easily evacuated from the mining location.

We have created a system that not only offers precise position, depth, and GPS finder but also monitors the miner's heart rate to deliver prompt medical aid with the highest priority as needed. In this paper, a quick comparison of several methods for keeping an eye on a potential event and rescuing the affected coal miners underground has been made. In order to be in contact with all miners and learn about their present health state, such as the availability of dangerous gas, oxygen level, pulse rate, etc., the suggested jacket can serve the needs of coal miners.

The system is used to track and regulate a number of characteristics in coal mines, including the detection of gases temperature, and humidity levels, and heart rate. The threshold value of different gases and gas sensors are measured, and the values are set to the microcontroller as trigger. The threshold values are mentioned in the table below.

S.NO	SENSORS	RANGE	ABNORMAL VALUE	THRESHOLD VALUE
1	METHANE	300-1000 ppm	>1000ppm	800 ppm
2	CARBON MONOXIDE	10-500 ppm	>150ppm	50 ppm
3	NH3, BENZENE	10-1000 ppm	>500ppm	400 ppm
4	SMOKE	300-400 ppm	>400 ppm	350 ppm
5	TEMPERATURE	45-60 C	>60 C	50 C
6	HEARTBEAT	60<bpm<200	>200 bpm	750-150 bpm

Threshold Of Various Gases

The Coal miners' jackets have all these sensors, which are regarded as a single unit. For analysis, all sensor values are continually tracked. Here, all the sensors and their values are regularly checked, and if there are any ambiguities concerning the amount of gas, the miners and the authorities are notified instantaneously.

3. Working

The microcontroller ESP 32 has a built-in Wi-Fi module, and the entire controller is compact. Hence it can be placed within the safety jacket. Once the gas sensors sense ambiguities in gas concentration the buzzer notifies the miner by sound and the concentration of gas in the place is sent to the authority simultaneously. The resistance of Gas sensitive FETs (Gas FETs) change dramatically due to the presence of gases. The following figure represents the workflow.

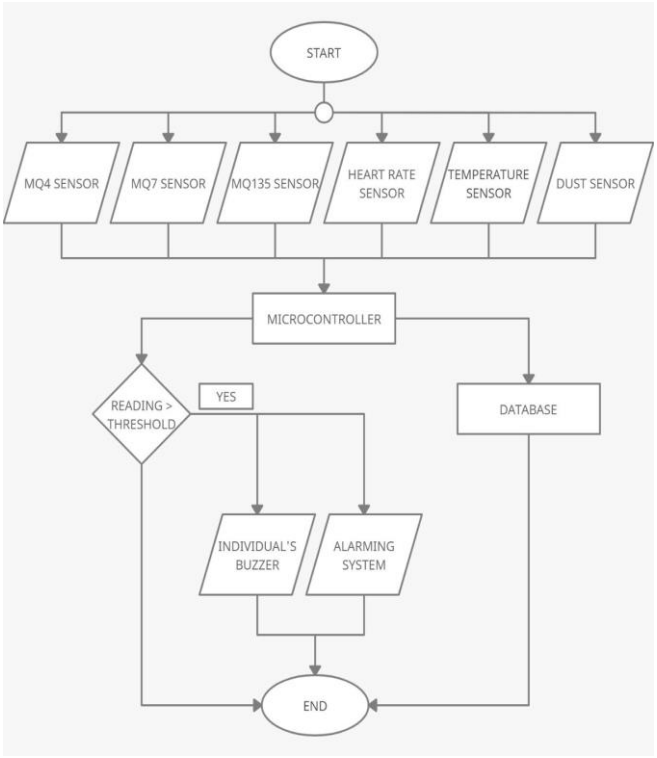

Fig 2 Flow Chart

Data from each sensor is stored in a database. which can be used for retrieval of the data and can be used for future references.

METHANE	CARBON MONOXIDE	NH3	TEMPERATURE	PULSE	DUST
180	5	68	28	86	10.34
195	5	68	28	86	10.91
145	3	67	30	93	10.91
120	6	62	31	94	10.91
170	4	0	29	94	10.91
139	6	0	31	93	10.91
159	3	0	28	92	10.91
110	3	0	28	88	10.91
165	6	0	31	94	10.91
194	6	0	30	93	10.91
106	5	0	28	89	10.91

Fig 3 Database Image

The above image represents the data recording from various sensors. The values of gases and other environmental parameters are sensed in real time and are sent to the cloud for storing from the microcontroller. Once the trigger values are reached the microcontroller automatically alerts the miners using the buzzer proving that it does not rely on the cloud for alerting the miners in case of emergency. All the sensor readings are stored in the cloud for data analysis and future reference.

4. Components Used

4.1 ESP32

The ESP32 is a microcontroller module with a dual-core 32-bit processor, integrated Bluetooth and Wi-Fi connection, and a range of input/output ports. ESP32 is used for processing the data and transferring it to the cloud using (802.11 b/g/n). We are using a 30-pin configuration here as it is more than enough for the prototype. It contains several analog and digital pins. ADC2 pins are used for strapping during wifi connectivity so only the ADC1((32-39) pins can be used.

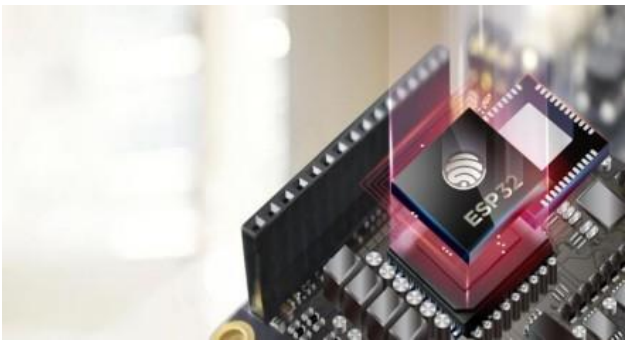

Fig 4 ESP 32

4.2 Gas Sensors

MQ 4, MQ 7 and MQ 136 are the Gas sensors used in the prototype. All Gas sensors work on 5V. Node MCU is enough to provide power supply to it. It is used to detect Smoke, LPG, Alcohol, Hydrogen, Methane, Propane, and Carbon Monoxide concentrations anywhere from 250 to 9900 ppm

Fig 5 Proposed Sensors

1. MQ136 Sensor
2. MQ 7 Sensor
3. Heart Rate Sensor
4. GPS Sensor
5. Dust Sensor

All these sensors sense and record the data in the database. There are various other sensor modules used in the design of the safety jacket for increased accuracy for securing the life of coal miners. Further to power all sensors are powered up by the lithium-ion batteries.

5. Result and Discussion

Experimental Setup:

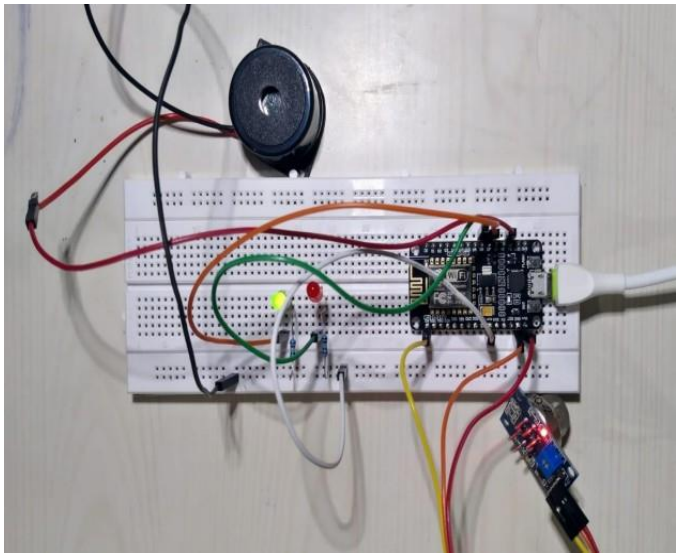

Fig 6 Prototype Image

Firstly, this whole prototype was designed in a simple bread board for testing and later fixed in a jacket as shown in following figure. The following figure represents the readings from the gas sensor.

Fig 7 Gas Sensor Measurement

To test the working of the prototype we have used isobutane gas. The gas commonly present in a gas lighter is isobutane, which can be detected using MQ2 Sensor. The result of the prototype was satisfying. This represents the final and working prototype. The above shown wearable is compact in size and hence it can be easily carried in the mines. The Sensors in the prototype can do the intended work and showed good accuracy.

Fig 8 Final Prototype

To ensure that the system meets the criteria, it was thoroughly examined. Future work on this experiment may use more advanced sensors to monitor the dangers of underground mines. The System is accurate and able to detect the gases and the GPS sensors can send the exact latitude and longitude of the jacket. This system can provide all the details of the mining environment. Thus, the miners can be rescued even if something went wrong. The system can be used in coal mines to ensure the safety of coal miners.

6. Conclusion

The suggested system has been tested satisfactorily and has demonstrated a prompt response to changes in dangerous parameters. We may draw the conclusion that this approach will significantly contribute to cutting down on future deaths brought on by abrupt changes in these parameters and contribute to making the work safer. The system may be implemented practically, thanks to the small and effective design. For a defined range, the system was tested. It may be altered to meet the needs, though, depending on the environment of the various coal mines. The implementation of the solution might achieve nearly zero fatality mining because of its capacity to identify accidents early and quickly.

7. Future Scope

The system was checked extensively to assure whether or not the system works to the requirements. Future work on this experiment may involve further refining the system by applying more advanced sensors to monitor the dangers of underground mines. More advanced communication and data transfer techniques can also be added for high efficiency of mine safety systems.

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