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Hazard mitigation in coal mines

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Hazard mitigation in coal mines

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Abstract. Today's world witnesses increased number of mine accidents caused due to explosion and fire. When the methane gas concentration goes high, it causes fire leading to explosion. In this paper, an IoT based system is proposed to ensure safety to the mine workers in underground collieries. The proposed system consists of DHT-11 sensor to monitor the temperature and humidity of coal mines. When the gas sensor detects high methane gas level, blower is activated so that the atmospheric air can be pumped in from outside to dilute the gas concentration. The smoke sensor is also used to detect the fire. In case of any abnormality in any of these parameters the buzzer sounds. All these parameters are uploaded to the cloud directly so that the people at the control station can be well informed of the underground mines.

1. Introduction

In India, coal provides the primary resource of energy, which has led to the rapid industrial development of the country. About 70% of the power generation depends on coal. Thus coal mining has got major significance. But safety to the mine workers of primary concern in this industry. Large number of mine accidents occur due to explosion and fire and this threatens the life of miners. Most of the time this happens because of lack of timely communication between the underground mines and the control station[3].

Mining activities release lots of toxic gases and also leads to increase in temperature. Certain gases like methane are inflammable, Methane when it reacts with oxygen forms toxic gas which further increases the suffocation and also affects the health of miners in collieries. Therefore, ventilation systems are inevitable to supply sufficient oxygen, and to maintain non-explosive and non-toxic atmosphere. The methane gas can be diluted before it reaches the threshold value (5-15) % of its concentration by pumping atmospheric air. This in turn prevents the occurrence of fire.

2. Existing system

A monitoring system in coal mines plays a vital role in the protection of underground mine workers. The current system used in coal mines for protection of mine workers is based on wired communication which has certain limitations in monitoring. In case of trouble reconnection and abandoned laneway it is difficult to implement a wired communication[3]. People put forward the idea of Wireless Sensor Networks so as to overcome the limitation since it has a lack of bands for communicating and transferring data efficiently[1].



The system installed in Shyam Sundarpur Colliery located in Bankola area is based on signalling or telephonic system. At strategic points that is in 2 no. Pit and 3 no. Pit, telephones are placed. In this system, the wires are laid to the specific points and a direct two way communication is needed which is impossible[2]. This is the major shortcoming of the installed system. The best alternative to this scenario is an advanced wireless technology for communicating directly from surface to underground and also from underground to surface.

Wired Communication will not hold good in situations where connectivity is crucial i.e., battery failure, fire outbreak, explosions. Thus, wireless communication can eliminate the shortcomings and plays a major role in monitoring mine field.[1]

3. Proposed system

Coal mining has been a very dangerous activity and the list of coal mining disasters is never ending. The environment inside a coal mine should always be maintained. Various parameters in coal mines, certain gas such as methane, smoke, carbon dioxide, temperature, humidity etc. that needs to be monitored and kept under certain limit. These can cause hazardous situation if increased beyond the limit. These parameters thus have to be continuously measured and monitored to avoid any hazardous or life threatening situation in coal. We propose a system for the safety inside the coal mines by continuously monitoring these parameters and taking appropriate action if they exceed certain limit. Figure 1 shows block diagram of the system. Raspberry pi B 3 is the heart of the system. The system can be subdivided into two sections: a underground section that is kept inside the coal mine through which the parameters inside the mine is measured and actions are taken based on the parameter values; a remote PC that receives the parameters measured and through which these parameters are monitored from a remote location. The communication between the underground module and the remote PC happens through cloud. The underground module has Wi-Fi which sends the data to the cloud. These data can be accessed from the cloud in remote PC.

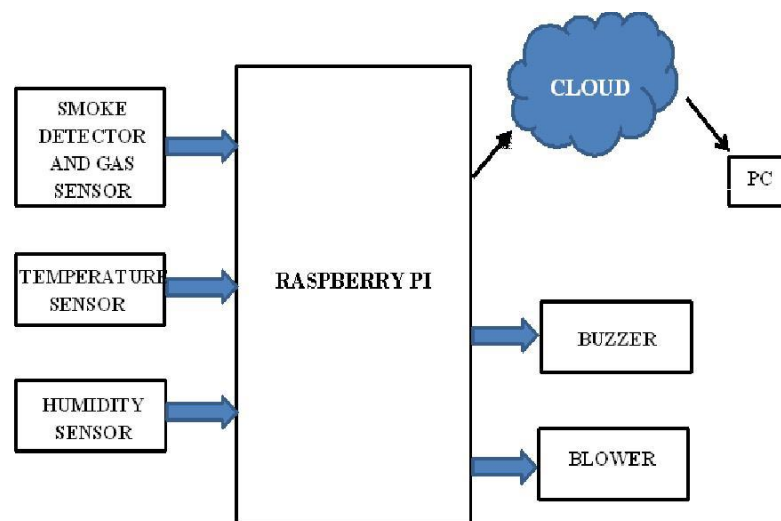


Figure 1. Proposed system

The system measures the toxic gas like methane, smoke, temperature and humidity inside the coal mines. The methane gas is continuously measured using MQ-4 sensor. The amount of methane gas that is almost tolerable inside a coal mine is 5% to 15%. We always try to maintain the concentration of methane upto 1% and if the methane concentration exceeds this level a blower is turned on that pushes the atmospheric air inside to dilute the concentration of methane gas inside the mine. The correct working of the blower is also ensured. The MQ-2 sensor is used to detect the presence of

smoke and carbon dioxide inside the mines. The temperature and humidity is also sensed using DHT11 sensor. The acceptable temperature of carbon dioxide inside the coal mines is 5% and relative humidity is 75%. According to the type of coal mine the acceptable temperature inside the mine ranges from 170 °C to 520 °C. When the presence of smoke, temperature or humidity exceeds a threshold level the buzzer turns on. All these measured parameters are sent to a remote PC through a cloud from where the parameters are monitored. The status of the blower is also sent to the PC.

4. Hardware description

The main hardware components used in this system are:

- Raspberry Pi 3 Model B
- MQ-4 gas sensor
- MQ-2 smoke sensor
- DHT11 temperature and humidity sensor
- Buzzer
- Blower

4.1 Raspberry Pi 3 Model B

Raspberry Pi 3 Model B is the third generation Pi with built-in Wi-Fi and Bluetooth module. It is a mini computer with 64 bit operating system

Technical Specifications:

- Broadcom 64bit ARMv7 Quad Core Processor running at 1.2GHz
- RAM : 1GB
- On board Wi-Fi : BCM43143
- On board BLE (Bluetooth Low Energy)
- 40 GPIO pins
- 4 x USB 2 ports
- Stereo output : 4 port
- Composite video port: 4 port
- Full size HDMI CSI camera port for connecting Pi camera
- DSI display port : connects touch screen display
- Micro SD port : loading OS and storing data
- Micro USB power source : supports 2.4 Amps



Figure 2. Raspberry Pi 3 Model

4.2 MQ-4 gas sensor

MQ-4 is used to sense harmful gas such as methane. They have fast response and a long life. The sensor has an exoskeleton inside which the sensing element is housed. When the sensing element comes in contact with any substance that contains methane, the methane gas gets ionized to its constituents. The ionized particles thus produce a potential that is then conveyed to the processing unit as current.



Figure 3. MQ-4 gas sensor

4.3 MQ-2 sensor

MQ-2 sensor is used to sense smoke, LPG, carbon dioxide, methane etc. SnO_2 is the main sensing element of the sensor that is housed inside a mesh. The output of the sensor is digital.



Figure 4. MQ-2 Sensor

4.4 DHT 11

DHT 11 is a low cost digital sensor which measures temperature and humidity. For measuring the surrounding air condition, it uses a thermistor and a capacitive humidity sensor and produces output on the data pin in digital format.

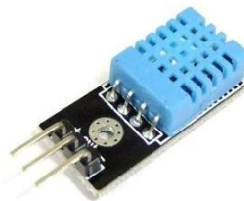


Figure 5. DHT 11

4.5 Buzzer

Buzzer is a device which signals audio and it can be mechanical, electromechanical or piezoelectric. It is used in timers, alarm clocks and also for confirmation of input given by the user i.e., in key press or mouse click. On connecting a battery to the buzzer's circuitry or when a button is pressed, a magnetic effect is created which causes current to flow through coils. The armature is attracted by the coil thus producing a sound.

4.6 Bower

Blowers are mechanical devices whose main function is to provide and accommodate a large flow of atmospheric air through the rotation of blades.

5. Results

The gas sensor(MQ-4), temperature and humidity sensor(DHT-11), smoke sensor(MQ-2) are connected to raspberry Pi as inputs .The blower, driver for blower and a buzzer are connected as outputs. The inbuilt Wi-Fi module is used to send data to the cloud using ThinkSpeak platform.

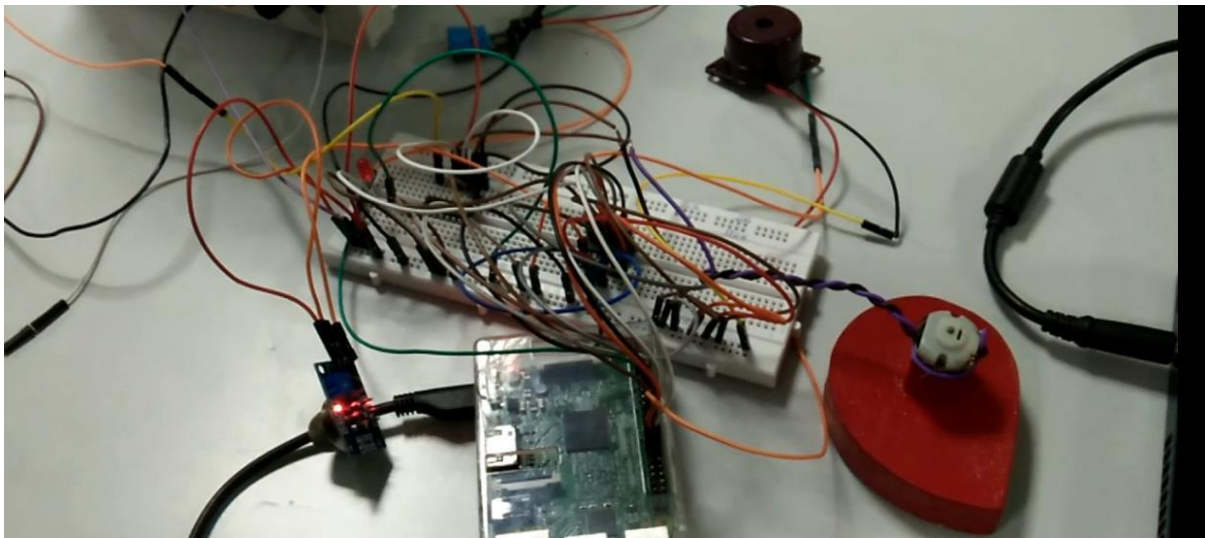


Figure 6. Hardware Snapshot

The IoT server at the underground mines regularly collects the sensor parameters and plots on graphs with reference of date at which they are measured in ThingSpeak IoT platform. The results obtained are shown below:

Channel Stats

Created: 13 days ago
 Updated: 9 days ago
 Last entry: 9 days ago
 Entries: 219

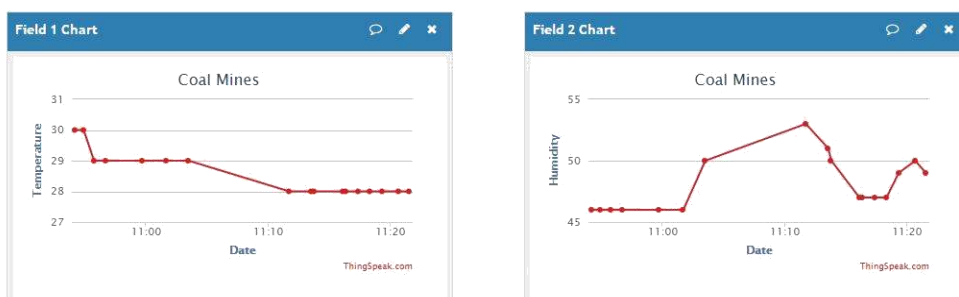


Figure 7. Temperature and humidity status of coal mines in ThinkSpeak platform

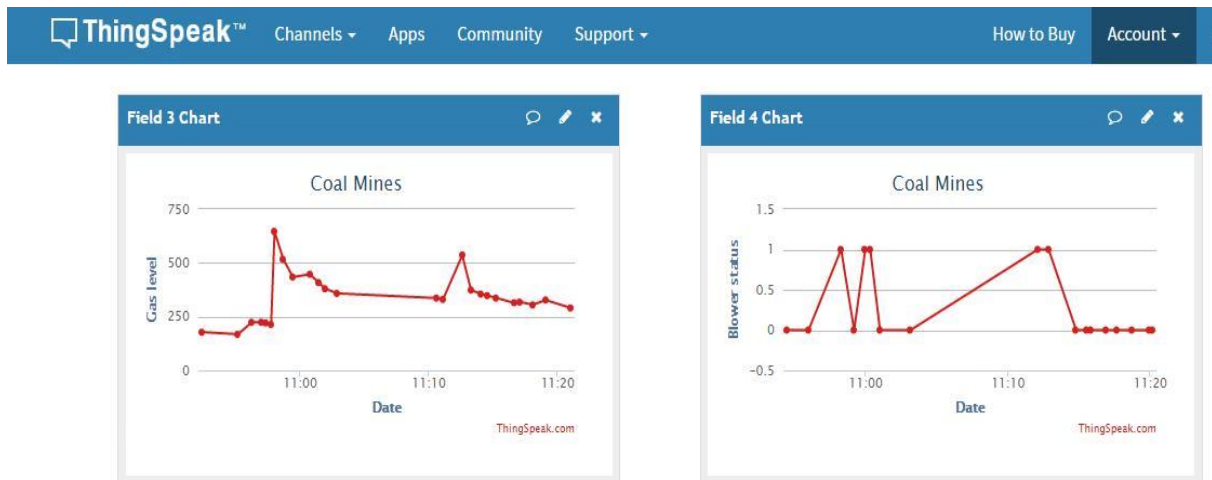


Figure 8. Gas (Methane) level and Blower status (1-ON, 0-OFF) of coal mines

6. Conclusion

The proposed system productively substitutes the present coal mine monitoring system by introducing an IoT based hazard mitigation technique. The server regularly updates the measuring parameters in the coal mine so that the mine can be monitored efficiently and necessary action can be taken immediately.

References

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