SAFETY MONITORING SYSTEM IN MINING ENVIRONMENT USING IOT

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Abstract. The average mine worker is exposed to the harsh underground environment which can sometimes cause an injury or loss of life. The older methods of mine condition monitoring involved using a person to go down and report back. This method is however dangerous as the person who is monitoring a specific hazard could be harmed by that hazard. This standard can be reinforced through the implementation of modern technology which is central to the non-invasive mine safety system with wireless sensor networks to obtain the best possible result.

1. Introduction

Underground mining industry comes to the category, where each and every parameter such as methane gas, high temperature, fire accidents and so on has to be monitored regularly. Monitoring becomes even more powerful when external data sources such as weather forecasts are also utilized and related to day-to-day operations. This can help when scheduling works to ensure that the most appropriate activities are carried out at the best possible time. Effectively monitoring a mine site can be greatly improved by the installation of a network of sensors. Using a sensor network to gather data and feed it in real-time back to a centralised information platform allows a clear whole of facility picture to be understood reducing risk and extending traditional operation monitoring capabilities.

2. Existing System

The existing system of a mine safety system prototype uses a wireless sensor network with the objective of building a safety system to monitor the ambient characteristics of the mining environment. A review of the current literature relating to the health and safety of mine workers and mine safety systems is done. The hardware consisted of electronic circuitry where a microcontroller is the principal processing unit. A graphical user interface is also implemented. The characteristics measurements of the existing system include: (i) temperature, (ii) air-flow, (iii) humidity, (iv) noise, (v) dust and (vi) gas concentration. The device should be placed on the mining area for monitoring.

3. Proposed System

In IOT based technology, a device which is attached to the safety jacket of miners is used for the employees safety purpose who is working in the construction and mining site. A research is carried out on mining site and construction site industries the report says that the cause of the accident is always due to hazard according to the statistics. The underground workers could face collapse and flood due to the consequence of dust or gas explosion. Similarly, a toxic contaminants release could be due to the fire. The harmful disease to the miners is caused by the hazardous gases present in the mining area like carbon dioxide, carbon monoxide, methane, ethane, Propane, etc. All the above issues can be avoided if we take proper preventive measure. The design and implementation of a continuous...
monitoring device to measure the physiological variables of miners at high altitudes with wireless communication, safety monitoring. Extreme environment conditions are detrimental for human health. The various environmental parameters of mine safety monitoring and controlling system, such as Heartbeat, Relative humidity, gas detection and Ambient Temperature are used in the T-Shirt or safety jacket of miners when an sensor detects the gas it will alert through the buzzer, and the information is transmit to the base station by using Xbee technology.

![Figure 1. BLOCK DIAGRAM](image)

The setup consists of a microcontroller along with a gas and humidity sensor which used to monitor the current working environment for the coal mine workers. During the process of mine development, it is very important to measure the gas concentration in mines. Gas disaster is the most harmful for the safety of coal mine production. For the present of situation of gas concentration monitoring system for monitor the harmful gases like CO2 using sensors.

Heartbeat through Heartbeat Sensor and temperature level is monitored using LM35. After detecting the level of these gases then take the corresponding control process by micro controller. Relative humidity is measured with the help of humidity sensor. All the levels will be transmitted using Xbee and the level is monitored in PC. If the level is increased above the normal level buzzer alert is provided for the coal mine workers for their safety. The smoke sensor is used to suppress the fire.

**XBEE MODULE**

According to new market research Digi XBeeDigiMesh 3 delivers end-point device connectivity with a globally deployable 2.4 GHz transceiver. These modules use the DigiMesh networking protocol.

The XBee module is capable of extending the operational life of battery dependent networks. Digi XBee modules are ideal for low-power, low-cost applications. Digi XBee-PRO modules are power-amplified versions of Digi XBee modules for extended-range applications. These modules are easy-to-use, share a common hardware footprint, and are fully interoperable with other products utilizing
the same technology. Module users have the ability to substitute one Digi XBee for another with minimal development time and risk.

![XBee module](image)

Figure 2: XBee module.

Wireless Xbee system opens up new markets for us and makes the system easier to install and maintain. These devices enable you to connect your device to the cloud, a common concept for the Internet of Things (IoT). The XBe module supports multiple wireless protocols and RF frequencies, enabling a wide array of use cases.

The XBee module ranges up to +40 miles for each hop which is more efficient than a zigbee module. The security of XBee module is both 128 and 256-bit AES encryption. It supports the frequencies & RF data rates at the rate of 900MHz (Upto 250Kbps), 868MHz, 2.4GHz. The interface tolerance is 900MHz Frequency-Hopping Spread Spectrum (FHSS), 2.4GHz: Direct Sequence Spread Spectrum (DSSS). It uses MAC address (64bit) only. Simpler addressing can help in diagnosing problems and setting up a network. Frame payload & throughput up to 256 bytes, depending on product. Improves throughput for applications that send larger blocks of data. Single: One Homogenous node type, with more flexibility to expand the network. DigiMesh simplifies network setup and reliability in environments where routers may come & go due to interference or damage.

Digi XBee is more than a module. It's a complete ecosystem of wireless modules, gateways, adapters, and software, all engineered to accelerate wireless development for global deployments. One socket allows you to connect to IoT networks around the globe. With the authentic Digi XBee footprint, you can future-proof your design and know that Digi has you covered for new technologies as they emerge.

SAFETY MEASURES

The main objective is to provide safety for miners working at high altitude must handle extreme climatic and physiological hazards without specialized medical supervision. The design and implementation of a continuous monitoring device to measure the physiological variables of miners at high altitudes with wireless communication, safety monitoring. The device is attached with the worker’s safety jacket. It automatically indicates the dangerous situations, doesn’t need any manual work for monitoring. It will provide the each person’s information to the monitoring unit. If any abnormal occurred in coal mining area it will also indicate as well as buzzer will be triggered.
Ignited methane gas is a common source of explosions in coal mines, which in turn can initiate more extensive coal dust explosions. For this reason, rock dusts such as limestone dust are spread throughout coal mines to diminish the chances of coal dust explosions as well as to limit the extent of potential explosions, in a process known as rock dusting. Coal dust explosions can also begin independently of methane gas explosions. Frictional heat and sparks generated by mining equipment can ignite both methane gas and coal dust.

Safety has long been a concern in the mining business, especially in underground mining. High temperatures and humidity may result in heat-related illnesses, including heat stroke, which can be fatal. The presence of heavy equipment in confined spaces also poses a risk to miners. For this purpose we are using various sensors for the alarm triggering like temperature sensor, dust sensor, heartbeat sensor, humidity sensor, smoke sensor etc.

**MONITORING UNIT**

The design and implementation of a continuous monitoring device to measure the physiological variables of miners at high altitudes with wireless communication such as Xbee, safety monitoring. Extreme environment conditions are detrimental for human health. The various environmental parameters of mine safety monitoring and controlling system, such as Heartbeat, Relative humidity, gas detection, ambient Temperature, fire are used in the safety jacket, when a sensor detects the gas or any other parameters it will alert through the buzzer, and the information is transmit to the base station by using Xbee technology which is a wireless medium that transmits the data at a very fast rate.

The alarm is triggered automatically if any dangerous situation occurs, the information is passed through the Xbee module to the monitor through UART to the control unit. UARTs transmit data asynchronously, which means there is no clock signal to synchronize the output of bits from the transmitting UART to the sampling of bits by the receiving UART. Instead of a clock signal, the transmitting UART adds start and stop bits to the data packet being transferred. These bits define the beginning and end of the data packet so the receiving UART knows when to start reading the bits. When the receiving UART detects a start bit, it starts to read the incoming bits at a specific frequency known as the baud rate. Baud rate is a measure of the speed of data transfer, expressed in bits per second (bps). Both UARTs must operate at about the same baud rate.
The baud rate between the transmitting and receiving UARTs can only differ by about 10% before the timing of bits gets too far off.

**SENSOR MODULE**

Sensors are sophisticated devices that are frequently used to detect and respond to electrical or optical signals. A Sensor converts the physical parameter (for example: temperature, dust, heartbeat, smoke, humidity, sound, etc.) into a signal which can be measured electrically.

A sensor node is a node in a sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.

![Sensor node](image)

**Figure 5 : Sensor node**

**a. Temperature sensor**

Temperature is a qualitative measure for classifying how matter appears to be hot or cold. More specifically, matter is made up of moving particles (molecules), each molecule has its own motion speed, the kinetic energy. Temperature is a physical parameter that describes the average kinetic energy of molecules, it is not a measure of energy itself, but it is proportional to the average kinetic energy. Thus, there are several different techniques to measure temperature. The most commonly used temperature sensors in oceanography are the Resistance Temperature Detectors (RTDs) and the Thermistors.

**b. Gas sensor**

Methane gas explosion is one of the hazards related to coal mining. Methane, a so called 'fire damp gas', can accumulate in pockets in the mine and trigger catastrophic explosions at concentrations of around 10%. SenseAir AB, a world leading producer of CO2 gas sensors, have launched a multimillion-SEK development of a new type of methane gas sensor, targeting the coal mining market, where the sensors will be used to increase safety for the workers. SenseAir's technology, based on proprietary IR spectroscopy, is superior to competing products in terms of less calibration requirements, higher accuracy, and better quality. Acreo participates in the development with resources and expertise in spectroscopy, microscopy, modeling and statistical analysis.

**c. Dust sensor**

Monitor and protect your personnel from hazardous dust particles and fine dust emitted into the atmosphere, through our highly advanced, real-time and incredibly accurate dust detection sensors. The first of their kind, our new dust detection sensors are built to operate flawlessly in harsh and hazardous industrial and mining operations, and to form part of an advanced dust control strategy. Our dust detection sensors ensure that your people are properly protected and that permitted exposure levels are never exceeded, protecting both your personnel and your business in an increasingly
d. Smoke sensor

A smoke detector is a device that senses smoke, typically as an indicator of fire. Commercial security devices issue a signal to a fire alarm control panel as part of a fire alarm system, while household smoke detectors, also known as smoke alarms, generally issue a local audible or visual alarm from the detector itself.

Smoke detectors are housed in plastic enclosures, typically shaped like a disk about 150 millimetres (6 in) in diameter and 25 millimetres (1 in) thick, but shape and size vary. Smoke can be detected either optically (photoelectric) or by physical process (ionization); detectors may use either, or both, methods. Sensitive alarms can be used to detect, and thus deter, smoking in areas where it is banned. Smoke detectors in large commercial, industrial, and residential buildings are usually powered by a central fire alarm system, which is powered by the building power with a battery backup. Domestic smoke detectors range from individual battery-powered units, to several interlinked mains-powered units with battery backup; with these interlinked units, if any unit detects smoke, all trigger even if household power has gone out.

e. Humidity sensor

Humidity sensors work by detecting changes that alter electrical currents or temperature in the air. There are three basic types of humidity sensors: capacitive, resistive and thermal. All three types of sensors monitor minute changes in the atmosphere in order to calculate the humidity in the air.

CONCLUSION

With the continuous development of the network technology the safety measures of the workers is provided using internet of things (IoT) technology. This system uses the remote monitoring system for monitoring the mining environment and pass the information to the central monitoring unit using Xbee module which is very simple, low power consumption, portable device, stable performance, etc. Since, the device is attached with the worker’s safety jacket, the alarm can be generated quickly without having to be monitored and controlled manually. Therefore a complete mine system was constructed using hardware and specific software. Thus the health and safety of mine workers and mine safety system is achieved.

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