IOT BASED COAL MINE SAFETY MONITORING AND ALERTING SYSTEM

ABSTRACT-Many coal miners are concerned about their safety in the workplace. In coal mines, poor ventilation exposes workers to toxic gases, heat, and smoke, which can lead to sickness, injury, and death. IoT based Coal mine safety monitoring and alerting system based on sensor network can timely and accurately reflect situation of staff in the underground regions to computer system. The air pollution from coal mines is mainly due to emissions of hazardous gases include sulphur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO) etc. To monitor the concentration level of harmful gases, gas sensors are used. To check the temperature in the coal mine Temperature sensor is used. A smoke detector is a device that senses smoke, typically as an indicator of fire. And the Fire sensor is used. This system also provides an early warning, which will be helpful to all miners present inside the mine to save their life before any accidents occurs. To address the issues, IoT based coal mine safety monitoring and alerting system based on a sensor network and the Internet of Things, which can increase the monitoring level is created.

I. Introduction

An overview of internet of things

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network. Increasingly, organizations in a variety of industries are using IoT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business.

"Things" in the IoT sense, is the mixture of hardware, software, data, and services. "Things" can refer to a wide variety of devices such as DNA analysis devices for environmental monitoring, electric clamps in coastal waters, Arduino chips in home automation and many other. These devices gather useful data with the help of various existing technologies and share that data between other devices. Examples include Home Automation System which uses Wi-Fi or Bluetooth for exchange data between various devices of home.

Working of iot

An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

Just like Internet has changed the way we work & communicate with each other, by connecting us through the World Wide Web (internet), IoT also aims to take this connectivity to another level by connecting multiple devices at a time to the internet thereby facilitating man to machine and machine to machine interactions. People who came up with this idea, have also realized that this IoT ecosystem is not limited to a particular field but has business applications in areas of home automation, vehicle automation, factory line automation, medical, retail, healthcare and more.

Importance of iot

The internet of things helps people live and work smarter, as well as gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a real time look into how their systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations. IoT enables companies to automate processes and reduce labour costs. It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods, as well as offering transparency into customer transactions.

As such, IoT is one of the most important technologies of everyday life, and it will continue to pick up steam as more businesses realize the potential of connected devices to keep them competitive.

Components of iot system

IoT devices include wireless sensors, software, actuators, and computer devices. They are attached to a particular object that operates through the internet, enabling the transfer of data among objects or people automatically without human intervention.

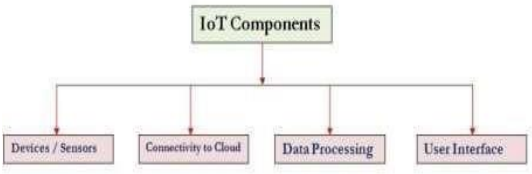

Figure 1.1 Components of IoT

Sensors/devices

First, sensors or devices help in collecting very minute data from the surrounding environment. All of this collected data can have various degrees of complexities ranging from a simple temperature monitoring sensor or a complex full video feed.

A device can have multiple sensors that can bundle together to do more than just sense things. For example, our phone is a device that has multiple sensors such as GPS, accelerometer, camera but our phone does not simply sense things. The most rudimentary step will always remain to pick and collect data from the surrounding environment be it a standalone sensor or multiple devices.

Connectivity

Next, that collected data is sent to a cloud infrastructure but it needs a medium for transport. The sensors can be connected to the cloud through various mediums of communication and transports such as cellular networks, satellite networks, Wi-Fi, Bluetooth, wide-area networks (WAN), low power wide area network and many more. Every option we choose has some specifications and trade-offs between power consumption, range, and bandwidth. So, choosing the best connectivity option in the IOT system is important.

Data processing

Once the data is collected and it gets to the cloud, the software performs processing on the acquired data. This can range from something very simple, such as checking that the temperature reading on devices such as AC or heaters is within an acceptable range. It can sometimes also be very complex, such as identifying objects (such as intruders in your house) using computer vision on video. But there might be a situation when a user interaction is required, example- what if when the temperature is too high or if there is an intruder in your house?

That's where the user comes into the picture.

User interface

Next, the information made available to the end-user in some way. This can achieve by triggering alarms on their phones or notifying through texts or emails. Also, a user sometimes might also have an interface through which they can actively check in on their IOT system. For example, a user has a camera installed in his house, he might want to check the video recordings and all the feeds through a web server.

However, it's not always this easy and a one-way street. Depending on the IoT application and complexity of the system, the user may also be able to perform an action that may backfire and affect the system. For

example, if a user detects some changes in the refrigerator, the user can remotely adjust the temperature via their phone. There are also cases where some actions perform automatically.

By establishing and implementing some predefined rules, the entire IOT system can adjust the settings automatically and no human has to be physically present. Also in case if any intruders are sensed, the system can generate an alert not only to the owner of the house but to the concerned authorities.

Coal mine

coal mining, extraction of coal deposits from the surface of Earth and from underground. Coal is the most abundant fossil fuel on Earth. Its predominant use has always been for producing heat energy. It was the basic energy source that fuel the Industrial Revolution of the 18th and 19th centuries, and the industrial growth of that era in turn supported the large-scale exploitation of coal deposits. Since the mid-20th century, coal has yielded its place to petroleum and natural gas as the principal energy supplier of the world. The mining of coal from surface and underground deposits today is a highly productive, mechanized operation.

Mining accidents

A mining accident is an accident that occurs during the process of mining minerals or metals. Thousands of miners die from mining accidents each year, especially from underground coal mining, although accidents also occur in hard rock mining. Coal mining is considered much more hazardous than hard rock mining due to flat-lying rock strata, generally incompetent rock, the presence of methane gas, and coal dust. Most of the deaths these days occur in developing countries, and rural parts of developed countries where safety measures are not practiced as fully.

Iot in coal mines

While IoT solutions have been successfully implemented in metal/nonmetal mines, the application of such technology in coal mines has been limited. Some barriers to IoT integration in coal mines may be attributed to intrinsic safety requirements enforced in underground coal mines, the complexity of integrating full coverage into a mine infrastructure, and the initial overhead costs associated with integrating sensor networks and automation. Despite these barriers, some manufacturers and mine operators have taken initial steps to explore IoT in underground coal mines.

IoT has the potential to boost the safety and productivity of the mining industry to new levels by enhancing the collaborative operation between people, equipment, transportation tools and the mining process.

Besides mining companies, the proposed IoT systems have the potential to influence mining equipment manufacturers, health and safety professionals, and worldwide researchers by creating new network-based applications enabled by IoT systems.

Problem statement

Coal is one of the most important commodities and raw materials for a number of industries. It is used for power generation as well as the extraction of many by-product chemicals and materials. The extraction of coal from the coal mine is, however, a complex and dangerous process. These led to numerous life losses and immeasurable resource loss. There is no proper early detection of the uncertainity in the coal mines. Coal mining has been a very dangerous activity. The dangers and hazards can be reduced significantly by making use of the latest smart technologies.

Objective

Mining environment often has hidden dangers within such as toxic gases, high temperature and causes fire which may present severe health exposures to the people

working within mining. These environmental conditions need to be detected at times and informed the dangerous situation in right time for the safety of miners. Wired network monitoring systems have assisted the mine safety significantly, but it is not idea for all types of mining environment.

A real- time monitoring systems may assist in monitoring and control over the mining environment. IoT technology offers its most of the advantages ideal for the real-time monitoring system. Thus, the primary objective of this project is decided to design an efficient real-time monitoring system so that various surrounding conditions could be identified at times and preventive measures could be devised accordingly.

When we turn the system on, it gets connected to the website using WIFI, System monitor shows four signs namely gas, temperature, fire, smoke. While monitoring these environmental factors the value gets updated over IOT and LCD display. And in case of abnormal situation it will send an alarm sound and also message will be sent.

II. Procedure for Paper Submission

Describtion and frabrication of components

Power supply unit

All electronic circuits work only in low DC voltage, so we need a power supply unit to provide the appropriate voltage supply for their proper functioning. This unit consists of a transformer, rectifier, filter & regulator. AC voltage of typically 220v RMS is connected to a transformer voltage down to the level of the desired ac voltage. A diode rectifier that provides the full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit can use this dc input to provide a dc voltage that not only has much less ripple voltage but also remains the same dc value even the dc voltage varies somewhat, or the load connected to the output dc voltages changes.

Arduino nano

Figure 2 Arduino Nano

The **Arduino Nano** is a small Arduino board based on **ATmega228P** or ATmega628 Microcontroller. The connectivity is the same as the Arduino UNO board. The Nano board is defined as a sustainable, small, consistent, and flexible microcontroller board. It is small in size compared to the UNO board. The Arduino Nano is organized using the Arduino (IDE), which can run on various platforms. Here, IDE stands for Integrated Development Environment. The devices required to start our projects using the Arduino Nano board are Arduino IDE and mini USB. The Arduino IDE software must be installed on our respected laptop or desktop. The mini USB transfers the code from the computer to the Arduino Nano board.

Wiring

Wiring is an open-source programming framework for microcontrollers. Wiring allows writing cross-platform software to control devices attached to a wide range of microcontroller boards to create all kinds of creative coding, interactive objects, spaces, or physical experiences. The framework is thoughtfully created with designers and artists in mind to encourage a community where beginners through experts from around the world share ideas, knowledge, and their collective experience. There are thousands of students, artists, designers, researchers, and hobbyists who use

Wiring for learning, prototyping and finished professional work production.

Temperature sensor

A temperature sensor is a device, typically, a thermocouple or resistance temperature detector, that provides temperature measurement in a readable form through an electrical signal. A thermometer is the most basic form of a temperature meter that is used to measure the degree of hotness and coolness. Temperature meters are used in the geotechnical field to monitor concrete, structures, soil, water, bridges etc. for structural changes in them due to seasonal variations.

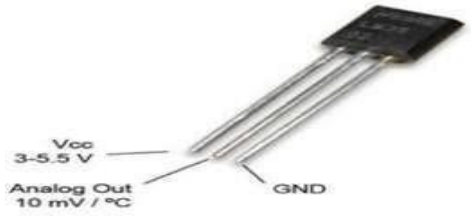

Figure 2.5 Temperature sensor

Fire sensor

A sensor which is most sensitive to a normal light is known as a flame sensor. That's why this sensor module is used in flame alarms. This sensor detects flame otherwise wavelength within the range of 760 nm – 1100 nm from the light source. This sensor can be easily damaged to high temperature. So this sensor can be placed at a certain distance from the flame. The flame detection can be done from a 100cm distance and the detection angle will be 600. The output of this sensor is an analog signal or digital signal. These sensors are used in firefighting robots like as a flame alarm.

A fire sensor is one kind of detector which is mainly designed for detecting as well as responding to the occurrence of a fire or flame. The flame detection response can depend on its fitting. It includes an alarm system, a natural gas line, propane & a fire suppression system. This sensor is used in industrial boilers. The main function of this is to give authentication whether the boiler is properly working or not. The response of these sensors is faster as well as more accurate compare with a heat/smoke detector because of its mechanism while detecting the flame.

Figure 2.6 Fire sensor

Gas sensor

MQ7 is a gas sensing module, sensing module, which is used to measure methane gas in the atmosphere. It contains Gas sensing layer, which is made up of SnO2. SnO2 is sensitive to gases like LPG, CH4, H2, CO, Alcohol, and smoke. As the decaying food emits methane gas (CH4), the MQ7 sensor can measure this gas to monitor food quality. You can also check this MQ125 sensor interfacing project where we used a similar gas sensor to monitor air quality by measuring PPM.

Along with SnO2, the sensor consists of an Al2O2 ceramic tube, measuring electrode, and heating element. The heating element provides the necessary working conditions for the sensor to operate. The MQ7 sensor is available in two formats in the market, in module format or only sensor format. The sensor module has four pins in which we are going to use only three pins in our project. We leave the D0 pin, as it is not helpful in the calculation of the ppm. The working of the MQ7 sensor is similar to that of LDR (light-dependent resistor). When the concentration of the methane gas is high, the module's resistance decreases.

Figure 2.7 Gas Sensor

Smoke sensor

The smoke sensor detects whether or not there is smoke in the environment, as well as the concentration of smoke, such as sensing intense smoke during a fire. When the smoke probe comes into contact with smoke or another gas, its internal resistance changes, and an analog value is created to regulate it. To provide the corresponding analog signal of the smoke concentration to the host, the smoke sensor exploits the idea that the concentration of smoke (primarily combustible particles) affects the resistance value of the smoke-sensitive element.

Figure 2.8 Smoke sensor

Liquid crystal display

Advances in the features, miniaturization, and cost of LCD (Liquid Crystal Display) controller chips have made LCDs usable not only in commercial products but also in hobbyist projects. By themselves, Liquid Crystal Displays can be difficult to drive because they require multiplexing, AC drive waveforms, and special voltages. LCD modules make this driving simple. by attaching hardware to the raw glass LCD to assist in some or all of these rudimentary driving tasks. LCD modules can be split into two groups: those that have built-in controller and driver chips, and those that have only driver chips. LCDs that do not have controllers are typically used with powerful hardware, such as a laptop computer, where a video controller is available to generate the complex drive signals necessary to run the display. Most colour and large (greater than 220 x 240) monochrome displays are of this type. Other common sizes are 16x1, 20x1, 20x2, 20x4, 40x1, and 40x2 (characters x lines). Fortunately, all HD44780-based displays (of any size) use the same standard 14-wire interface.

Therefore, code and hardware made for one size/type display can be painlessly adapted to work for any HD44780 compatible. Information about these displays can be easily obtained on the web by including "HD44780" in our search keywords. Because of their widespread use, these displays can be purchased surplus with typical prices of $2 for small displays to $20 for large ones.

Figure 2.9 16/2 LCD

Software requirements

The Arduino Integrated Development Environment (Arduino IDE) is the free software required to interact with the Arduino controller board, without the Arduino IDE, can't able to program the Arduino microcontroller to do cool stuff like control a cool robot car. Almost all Arduino modules are compatible with this software that is open source and is readily available to install and start

compiling the code on the go. Choose a device to install the Arduino IDE software on; in the example below installing the software on a Desktop PC running Windows 7.

III Helpful Hints

Experimental setup

The system is implemented using a combination of hardware components.All the hardware components are assembled in the implementation phase. The experimental setup diagram of the developed system is demonstrated.

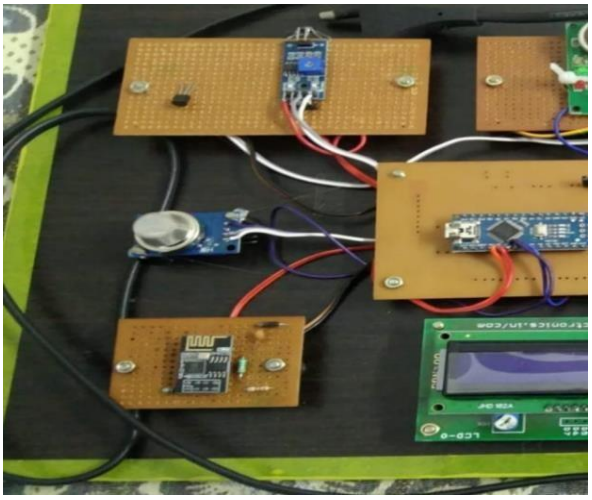

Figure 3.1 Experimental Setup

The circuit has a power supply unit which include DC power supply filters, and regulators to provide the required power supply for the circuit to work. The transformer receives a power supply of 220V the transformer step down the voltage to 12v which is further processed to 5v supply which is required by the Arduino and other components to function. The LED is placed inside the woodenshaft in which the test tube should be placed; smoke sensor, fire sensors, Temperature sensor and gas sensor are connected.

Lcd display output

The input for each sensors such as temperature sensor, gas sensor, fire sensor and smoke sensor are given. And these sensor works according to the command given in the Arduino Nano and the value for these sensors are fixed within the specified range.

Figure 3.2 LCD display output

These sensors monitor each parameter like temperature, fire, gas and smoke. And the values detected by each sensor are displayed in LCD. And if the value exceeds the specified range a buzzer will alarm us and an alert message will be seen.

Think speak output

The values showed in the LCD display are stored in the IoT platform "Thinkspeak".

Figure 3.3 Thinkspeak output

The above figure shows the value of each sensor in the thinkspeak with respect to time.

IV Conclusion

The aim of our proposed system is to build safest environment so that the working environment information is conveyed quickly to the person who is monitoring the coalmine. The designed model leads to the better and effective monitoring of coalmine and the collected data is networked worldwide with the help of internet and communication which provide a quick response. The study on real time monitoring of toxic gases and other parameters present in underground mine has analysed using wireless sensor network. A real time monitoring system is developed to provide clearer and more point to point perspective of the underground mine. This system is displaying the parameters on the LCD at the underground section where sensor unit is installed as well as on the monitoring unit; it will be helpful to all miners present inside the mine to save their life before any casualty occurs. And the message sent to the mobile phones. This system also stores all the data in the computer for future inspection.

V Reference

1 Ashish "Coalmine safety monitoring using Wireless sensor Networks",International Journal of Scientific Engineering and Technology (IJSET) Volume 2,Issue 10,October 2013.

2 Aarthi "Coal Mine safety Monitoring system using ARM 9",International Journal of Science and Research (IJSR), Volume-3,Issue-11,November 2014.

3 Boddu, R., Balanagu, P., & Babu, N. S. (2012). Zigbee based mine safety monitoring system with GSM. International Journal of Computer & Communication Technology, 3(5), 63-67

4 Chaamwe, N, Liu, W, Jiang, H, "Seismic Monitoring in Underground Mines: A case of Mufulira Mine in Zambia Using wireless Sensor Networks for Seismic Monitoring", Proc. IEEE international Conference on Electronics and Information Engineering, vol. 1(V1), pp 310-14, 2010.

5 Dohare, Y. S., Maity, T., Paul, P. S., & Das, P. S. (2014, July). Design of surveillance and safety system for underground coal mines based on low power WSN. In 2014 International Conference on Signal Propagation and Computer Technology (ICSPCT 2014) (pp. 116-119). IEEE.

6 Feng, X., Qian, J., Sun, Z., & Wang, X. (2010, September). Wireless mobile monitoring system for tram rail transport in underground coal mine based on wmn. In 2010 International Conference on Computational Aspects of Social Networks (pp. 452-455). IEEE.

7 Henriques, V., & Malekian, R. (2016). Mine safety system using wireless sensor network. IEEE Access, 4, 3511-3521.

8 Jin-ling, S., Heng-wei, & G.,Yu-jun,S. , "Research on Transceiver System of WSN Based on V-MIMO Underground Coal Mines", Proc. International Conference.

9 Jingjiang Song ,Yingli Zhu and Fuzhou DongK, Dzautomatic monitoring system for coal mine safety based on wireless sensor networkdz, IEEE Radio Science and Wireless Technology Conference, pp.933-936, 2011.

10 D. Koenig, M. S. Chiaramonte, A. Balbinot, "Wireless Network for Measurement of Whole-Body Vibration", J. Sensors, vol. 8, pp. 3067-81, 2008.

11 Kumarsagar "Design of Monitoring system for Coal mine safety based on MSP430", International Journal of Engineering Science Invention(IJESI) Volume2,Issue 7, July 2013.

12 Kumar "Design and Implementation of Portable health monitoring system using PSOC mixed signal Array chip". International Journal of Recent Technology and Engineering (IJRTE), ISSN, 2277-3878,2012.

13 LiHui "Design of Monitoring system for Coal mine safety based on Wireless sensor Networks" 2008 International Conference on Mechatronic and Embedded systems and Applications (ASME).

14 Liu, T., Wei, Y., Song, G., Li, Y., Wang, J., Ning, Y., & Lu, Y. (2013, December). Advances of optical fiber sensors for coal mine safety monitoring applications. In 2013 International Conference on Microwave and Photonics (ICMAP) (pp. 1-5). IEEE.

15 Madhu Coalmine safety monitoring system", International journal of Mechanical Engineering and Technology (IJMET) Volume 8,Issue 12 ,December 2017

16 Marjani, M., Nasaruddin, F., Gani, A., Karim, A., Hashem, I. A. T., Siddiqa, A., & Yaqoob, I.(2017). Big IoT data analytics: architecture, opportunities, and open research challenges. Ieee access, 5, 5247-5261.

17 Maity, T., Das, P. S., & Mukherjee, M. (2012, March). A wireless surveillance and safety system for mine workers based on Zigbee. In 2012 1st International Conference on Recent Advances in Information Technology (RAIT) (pp. 148-151).IEEE.

18 X. Ma, Y. Miao, Z. Zhao, H. Zhang, J. Zhang, "A novel approach to Coal and Gas Outburst Prediction Based on Multi-sensor Information Fusion", Proc. IEEE international conference on automation and logistics, pp 1613-18, China 2008.

19 Nakirekanti, M., Prasad, R. M., Mahammad, E., Narsimha, R. K., & Khalandar, B. D. (2017). Coal mining safety monitoring system. International Journal of Mechanical Engineering and Technology, 8(12), 542-550.

20 R. S. Nutter and M. D. Aldridge, "Status of mine monitoring and communications," IEEE Trans. on Industry Applications, vol. 24, no. 5, pp. 820-826, Sep./Oct. 1998.

Authors:

Siva Sankari S, CSE Student at National Engineering College, Kovilpatti

Merlin Rani A, CSE Student at National Engineering College, Kovilpatti

Varshini S, CSE Student at National Engineering College, Kovilpatti

Dr.V.KalaivaniM.E,Ph.D Professor at National Engineering College,Kovilpatti.