Real Time Monitoring System for Coal Mine Safety and Control Automation

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Abstract- **Recently, the common coal mine security accidents havetriggered critical casualties and big monetary losses. It is urgent forthe worldwide mining industry to boom operational performance andenhance overall mining safety. Thisthe paper proposes a layout of a Wireless Sensor Network (WSN)with the assist of Raspberry Pi controller that is able to monitorthe temperature, humidity, fuel, and status of smoke in an underneathground mine. This machine additionally controls the air flow demand tomine workers relying upon present climate situations insidethe minefield. This machine makes use of the low power, cost-less Raspberry Pi a temperature sensor LM35, humidity sensor DTH11, smoke detector, gas sensor for sensing the mining climateparameters and Wi-Fi for faraway logging of statistics at valuablethe place to control the weather country with the assist of motor andfee manipulate circuitry**

Index Terms- **Raspberry pi, Gas Sensor, Humidity Sensor, LDR,Temperature Sensor, IoT**

I. INTRODUCTION

Underground mines are usually extensive labyrinths, of which the tunnels are generally long and narrow witha few kilometers in length and a few meters in width. Thousands of mining personnel are needed to work under extremeconditions according to the construction requirements, and hundreds of miners die from mining accidents every year [1]–[3].

It is now widely approved that the underground mining operations are of high risk. In view of this, a monitoring and controlsystem needs to be deployed as one important infrastructure inorder to ensure the mining safety and coordinate various tasks.However, underground coal mines mainly consist of randompassages and branch tunnels, and this disorganized structuremakes it very difficult to deploy any networking skeleton. Insuch a case, the utilization of a wireless sensor network (WSN)and other sensing devices may have special advantages for realizing the automation of underground monitoring and controldue to the rapid and flexible deployment. In addition, the multihop transmitting method can well adapt to the tunnel structureand thus provide enough scalability for the construction of amining system [4]–[7], and it is very suitable to the comprehensive monitoring and control in coal mines, which can effectivelycompensate the deficiencies of the exiting underground cablemonitoring system.

Recently, in the area of comprehensive application integration, some works have introduced the use of "mashup" concepts [8]–[14], also known as user-generated comprehensiveapplications. However, they mainly focus on mashing up information services and do not address the requirements thatcome with a physical devices integration. The mashup middleware for coal mine monitoring and control automation needs torapidly coordinate interaction between the business processesand distributed, multisource sensory devices. Also, the mashupmiddleware for coal mine monitoring and control automationshould change dynamically in a real-time way confronting withcontinuously and constantly changing for the underground coalmine physical world. With the help of visualization technology,the graphical user interface of different underground physicalsensor devices could be created, which allows the sensors tocombine with other resources easily.

II. LITERATURE SURVEY

In underground mining, ventilation systems are crucial to supply sufficient oxygen,maintaining non-explosive and non-toxic atmospheres and operating an efficient mine. Mineventilation system can help in eliminating high risk atmosphere. Primitive techniques tomonitor the mining atmosphere can be traced back to the use of canaries and other animals toalert miners, when the atmosphere becomes toxic. Integrating ventilation monitoring systemenables mine to intelligently make ventilation changes based on the extensive data, themonitoring systemprovides. Unexpected changes in the ventilation system are noticed by themonitoring arrangement, allowing prompt action to be considered. New and developingcommunication and tracking systems can be utilized to monitor mines more efficiently andrelay the data to the surface.

These are the previous research work on different systems using different technologies forthe safety of the environment.

Yu et al. (2005) proposed a real-time forest fire detection system based on wireless sensornetwork. The system collects the data and processes it in the WSN for detecting the forest fire.

They designed the monitoring and detecting sensor networks using neural network.

Joseph et al. (2007) focused on the problems and hazards of fire in libraries or archives anddescribed the necessary preventive steps to be adopted. They identified the diverse parts whichare applied for fire detection and alert system and also provided necessary strategies for theselection and installation of an ideal fire alarm system.

Fischer (2007) considered the simulation technique and applied this technique to design a firedetection system. This system detects the fire as well as differentiates fire and non-fire spot todecrease the false alarm rate in the non-fire event.

Cheng Bo et al. (2012) proposed a restful web services mashup improved coal minesafety monitoring and control automation using WSN network. This system can collect thevalues of methane, temperature, humidity and personal position information inside the mine.

Rajkumar Boddu et al. (2012) designed a coal mine monitoring system using Zigbee basedon GSM technology. The degree of monitoring safety can be improved using this scheme andreduce misfortune in the coal mine. They purposed a solution suitable for mine wirelesscommunication, and safety monitoring using this scheme.

Isaac O. Osunmakinde (2012) studied the different types of toxic fumes in dangerous regionsand their conditions and trends in the air for preventing miners from contracting diseases. Theydeveloped an autonomous remote monitoring system of WSNs which combines Ohm's lawand mobile sensing coupled with ambient intelligence governing decision-making for mineworkers. The system has been monitored the indoor scenarios which is successfully deployedin underground mines. The system provides pre warning for safety purpose.

Mohit Kumar et al. (2013) proposes a wireless control and monitoring system for an inductionmotor based on Zigbee communication protocol for safe and economic data communication inindustrial fields, where the wired communication is more expensive or impossible due tophysical conditions. This system monitors the parameters of induction machine and transmitthe data. A microcontroller based system is used for collecting and storing data and accordinglygenerating a control signal to stop or start the induction machine wireless through a computerinterface developed with Zigbee.

Mr. Kumarsagar et al. (2013) designed a wireless sensor network with the help of MSP430xxcontroller, which is monitor the smoke, gas, temperature and humidity in an underground mine.This system also controls the ventilation demand to miners depending using upon themonitoring data from the mine. This system utilizes a wireless Zigbee transceiver for remotelogging of data at a central location to control the environmental state with the assistance of amotor and valve control circuitry.

Berardo Naticchia et al. (2013) proposed the infrastructure less real-time monitoring systemto provide prompt support for inspecting the health and safety management on construction sites. They tested the specific applications of monitoring, interference between teams workingon large construction sites. The system is capable of alert in the occurrence of interference andto log any unexpected behavior.

Zhang Xiaodong et al. (2014) presented the problems and faultiness of current coal minemonitoring system. They examined the plan and implementation of a platform to remotelymonitor and control coal mine production processes over Industrial Ethernet based on theembedded engineering. Integrated with each lower computer terminal are

S3C2410microprocessors that can be utilized for linking up to the monitoring network effectively.

III. PROPOSED FRAMEWORK

This is the main block diagram used in the proposesystem. While using the four sensors that can be detected andgiven to raspberry pi, while motor, fan, blub are be usedcontrol under the mine which will be connected wired toraspberry pi and camera is connected to capture the image ofdetected sensor. The raspberry pi will be monitor through thesystem. The four sensor as the input to the raspberry pi.

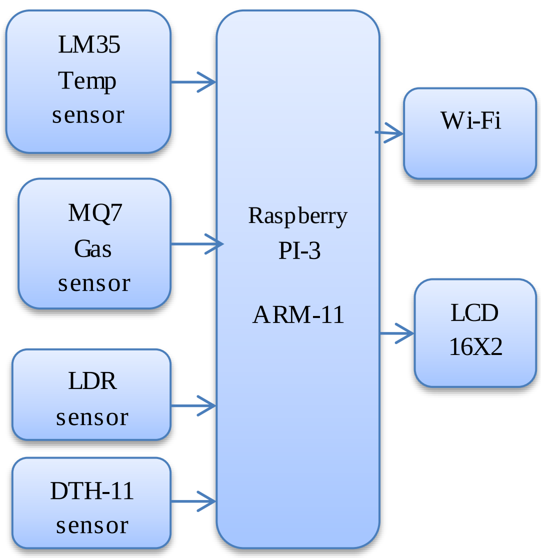

Fig.1. Coal mine safety system

A. Raspberry Pi 3: The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings you a more powerful processer, 10x faster than the first generation Raspberry Pi. Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.The main features of Raspberry pi 3 are[4]

Processor: Broadcom BCM2387 chipset.1.2GHz Quad-Core ARM Cortex-A53 802.11 b/g/n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)

GPU: Dual Core VideoCore IV® Multimedia CoProcessor. Provides Open GL ES 2.0, hardwareaccelerated OpenVG, and 1080p30 H.264 highprofile decode.

Operating System: Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT.

GPIO Connector: 40-pin 2.54 mm (100 mil) expansion header: 2x20 strip Providing 27 GPIO pins as well as +3.3 V, +5 V and GND supply lines.

Fig.2. Raspberry Pi 3 model

Temperature Sensor: LM35 IC which was manufactured by National Semiconductors is used to measure temperature. The temperature sensor has three terminals as shown in figure 1. The V_{cc} pin is given a supply voltage of 5V DC. The ground pin is grounded. The data pin is connected to the chanel-1 of the inbuilt ADC using port pin. The sensor gives electrical output proportional to the temperature (^{0}C). The general equation used to convert output voltage to temperature is

$T\,(^{o}C) = V_{out} * (100^{o}\ C/V_{cc})$

Light Sensor: LDR is Light Dependent Resistor which is used as light sensor. It gives output in terms of voltage which indicates the light intensity of the surroundings. The cell resistance falls with increasing light intensity. Its operating voltage is 320V AC or DC peak. LDR is having two terminals as shown in the figure 3. The data pin is interfaced with the trim pot which has variable resistance. The other pin of the LDR is grounded. The other pin of the trim pot is given to 3.3V power supply. The data pin is given to the inbuilt ADC of the microcontroller.

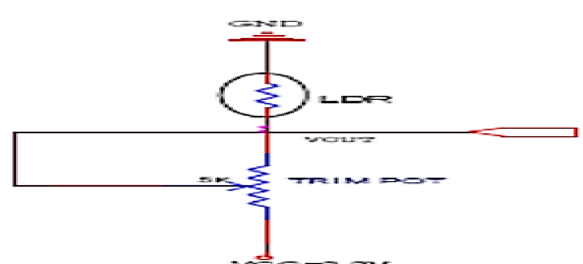

Fig.3. Light Sensor

DHT-11 Sensor:This DHT11 Sensor measures the temperature and humidity. The sensor has greater reliabilityand very good stability. A resistive-type humidity measuring component with negativetemperature coefficient is used. It connects to a microcontroller and shows excellent quality,anti-interference and fast response ability.

Fig.4DHT11Sensor and Module

Carbon Monoxide Sensor (MQ7):Various types of sensors are available in the market in which semiconductor sensors areconsidered to have fast response. MQ7 semiconductor sensor is mainly used for detectingcarbon monoxide (CO).MQ-7 gas sensor composed of micro Al2O3 ceramic tube and Tin Dioxide (SnO_2). Electrodeand heater are fixed into a crust. The heater provides required work conditions for the work ofsensitive components.

Fig.5 MQ-7 sensor, MQ7 Module

LDR:The on-chip ambient sensor has the power to measurethe exact visible light from 0.03 lux to 65,000 lux andcommunicate through an I2C digital communication bus. TheIC has patented sensors, filters, and circuitry to mimic thehuman eye response.With on-chip calibration registers, itperforms the same in different light conditions (i.e.,fluorescent, incandescent).The interrupt pin minimizes theneed of constant polling of the device,freeing upmicrocontroller resources for efficient communication andthus reducing overall power consumption.

Webcam:In this system we use a USB 2.0 Webcam of 25MP(interpolated). It provides a frame rate of up to 30 fps.

Fig.6. Web Cemera

IV. RESULTS AND DISCUSSION

Above designed system is used to test in the laboratory under artificial mining environment.At first when we connect only two sensors carbon monoxide and temperature sensor. Usingthese sensors in the laboratory following value is shown, which shows in the Figure.7.

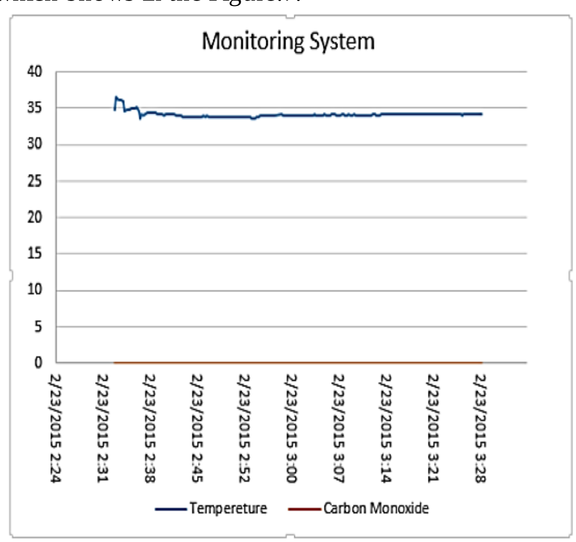

Fig. 7 Graphical representation of Temperature and Carbon monoxide sensors value.

Blue colour curve shows the temperature values and orange colour curve shows the carbonmonoxide values in ppm.

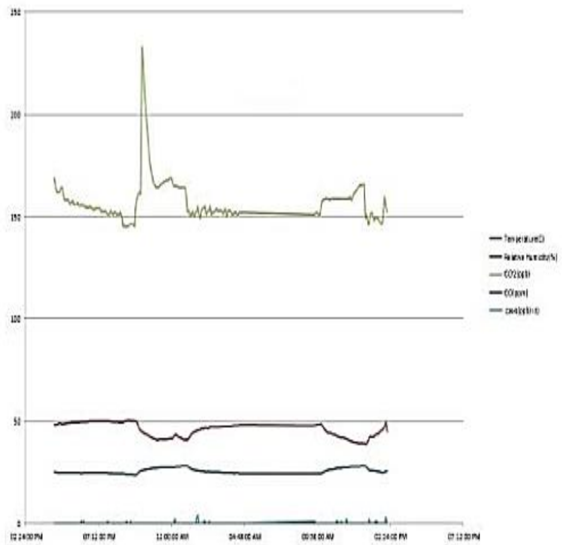

Fig. 8 Graphical representation of different sensor value (approx 8 hrs.).

Blue colour curve shows the temperature values, brown colour curve shows the relative humidity, light green colour curve shows the carbon dioxide values, violet colour curve shows the carbon monoxide values and sky blue colour curve shows the methane value.

V. CONCLUSION

This paper builds a lightweight mashup middleware for coalmine safety remote monitoring and control visualization. However all four sensors are be connected to the raspberry piwhen their will be alteration in the mine of any gases aretemperature. The sensor will be detected then camera willcapture the image the message will be sent tomobile by theIoT process used in the raspberry pi. The sensor detecting alsobe monitor. Photo which are capture will be sent it our emailaddress for our requirements. This coal mine will be alsocontrol through the mobile to change the temperature and alsoto reduce the undesirable gas in the mine by the concept of IoTin raspberry pi system.

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