

Coal Mine Monitoring System Using Raspberry Pi and IOT for Efficient Miner Rescue Operations

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ABSTRACT- Now a day's rescuing the miners who work under coal mine environment has become a tedious task. Labours inside the mine may not be aware when any explosion happens. They may enter into the mine without knowing the environmental condition inside. The environmental parameters such as toxic gases, high temperature, methane leakage, oxygen are sensed and the data is transmitted to the control room via Wi-Fi. Thus this paper aims in designing a monitoring and rescue system using raspberry pi3 model. The rescue system has a camera that captures image send to the control room. Cooling fan is turned ON automatically when the temperature exceeds a threshold value and workers are alerted by a buzzer when any leakage of gas is sensed. The parameter are controlled using buttons in the webpage and it consists of sensor data, image and buzzer alert. Hence this design minimizes the loss caused by coal mine disaster resulting in efficient rescue operation.

KEYWORDS- Coalmine, Raspberry Pi3, camera, Wi-Fi.

I. INTRODUCTION

Human safety is considered as an important concern in hazardous working environment. Due to explosions and leakage of toxic gases, human lives in coal mines became unpredictable and miners are majorly injured. Even Fire accidents may occur. Moreover the absence of particular

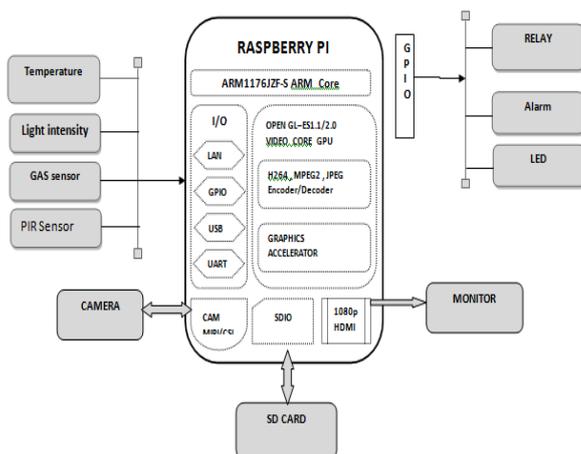


Fig.1: Transmitter Section

person at the place of monitoring may lead to serious hazards. Accidents are still happening though various systems are implemented for industrial purposes. In case of any serious situation a live image of the environment is received from the rescue system to mobile phone of the user who is controlling the parameter through Wi-Fi technology. The new design consists of temperature and gas sensors to detect toxic gases and ambient temperature. The information should be received to the receiver without any fail, even if any disaster occurs. Hence the design must be protected with flame-proof equipment. The developed setup should work under high temperature conditions as well. A camera is also interfaced to provide a means of alert to the nearby workers.

Wireless communication is quite challenging task in the industrial area. It is unworthy to use wired technologies as the cables may ruin within a certain period of time or damage due to some environmental conditions. Hence wireless communication is preferred. By properly designing the coal mine environmental monitoring protocol, the end to end data delivery will be effective. This improves the reliability. That is there should neither be any loss of data nor any delay in data that must be transmitted which has been collected from the sensors. Some of the techniques such as Zigbee, Bluetooth provide a small range and the data rate is low when compared to Wi-Fi. Hence the usage of Wi-Fi provides wide range of data transmission with a high data rate of 54Mbps.

II. BLOCK DIAGRAM

The Transmitter section of coal mine monitoring system is shown in the Figure-1. The Pi3 board is interfaced with LDR, PIR, temperature and gas sensors. Among the four USB ports from the board, one is connected to the camera. The miners are alerted with a buzzer which is interfaced to a GPIO pin. A cooling fan is used to minimize the ambient temperature when the temperature exceeds a threshold. The rescue system has a camera that captures image, send to the control room.

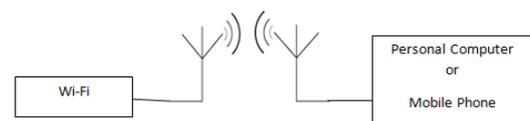


Fig.2: Receiver Section

The receiver section of coal mine monitoring system is shown in Figure-2. Either smart phone or computer can be used in this setup. The rescue system is tethered with network of mobile phone. The created webpage can be browsed and used in it.

III. HARDWARE IMPLEMENTATION

The Raspberry pi3 is used as it is compact in size and it has low power consumption. The in-built Broadcom chip BCM2837 SoC consists memory of 1GB LPDDR2 RAM with 1.2GHZ frequency. When compared to earlier versions of Raspberry Pi, Pi3 is fast. And also as it contains quad core processor, many peripherals or sensors can be interfaced with it simultaneously. Pi3 contains 26 GPIO pins, two 3.3V pins, two 5v pins and 8 GND pins. And also contains four USB ports which allows to connect camera, Wi-Fi module etc. Hence this processor has the capability to interface with many modules at a time.

LM35 is used as the temperature sensor which is an analog sensor. This sensor is used in coal mine to sense the ambient temperature. LM35 is connected to one of the GPIO pins. Based on this sensed data cooling fan is being worked. The operating range of LM35 is about -55°C to 150°C . The temperature inside the industrial will be around 45°C . So this sensor can be used as it falls in this range.

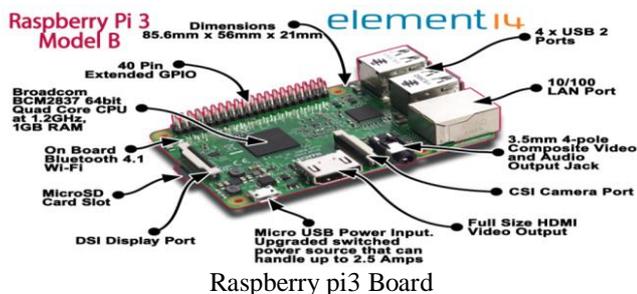
MQ6 gas sensor is used in the coal mine areas to sense the leakage of gases. It is used to detect the combustible, flammable and the toxic gases. This sensor mainly senses the methane gas which is most emitted in coal mining areas. It is connected to one of the GPIO pin which provides the required 5V voltage. The gas is detected by allowing the H-pins in the gas sensor to heat for a while. An alert is provided to the workers when the gas is sensed.

The Fire sensor which is used for protection against fire is a compact and simple device. A comparator and an IR sensor are used by this module. This allows to sense fire over a range of 1-2 m based on its density.

Raspberry pi3 have only digital pins. All the sensors are analog sensors, so we have to convert analog values to digital values using MCP3008 IC.

A USB camera which has 150ft area of coverage is connected to the Raspberry pi3 board. It sends the captured live image to the receiver. As the data transmission rate is about 54Mbps, the live image can be transmitted without any delay.

The relay which acts as a switch here is used to make the cooling fan and the buzzer to work.



IV. SOFTWARE IMPLEMENTATION

The Raspberry pi board operates with Raspbian OS. This OS is available for free. Raspbian is customized from Debian to make it run on Pi board. Pi comprises of around 35,000 packages and pre-compiled software. This helps in smooth installation on Raspberry Pi. The sensors are programmed and monitored by python code. It is chosen as Python is pseudo-code in nature and simple. Moreover it is an open source software. Many platforms like Linux, VxWorks, and PocketPC etc can also use this language. Python supports both procedural programming and Objective Oriented programming. The web page is designed in HTML. To access web page through Wi-Fi, the static IP address of the Raspberry pi should be configured. This allows establishing Wi-Fi connection with mobile phone and transmitting the live frame. Inorder to interface with USB camera the Raspberry pi3 board must be initially installed with the camera packages using Linux commands.

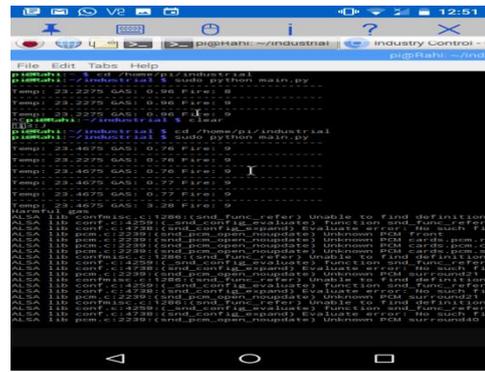
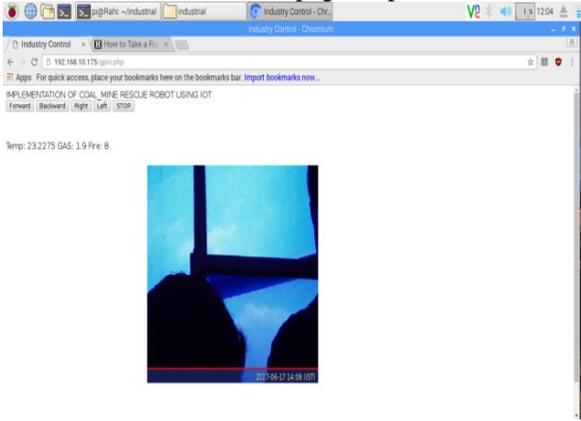
V. PROPOSED WORK

A coal mine rescue system is designed using the raspberry pi board. 5V power supply is given to raspberry pi board. The sensors connected to the board are powered by GPIO pins. An USB camera is fixed to raspberry pi. It will capture the environmental parameters and will transmit the image to mobile phone and display in the designed web page. Enter the static IP address of raspberry pi in the address bar of the web browser. This opens the designed web page automatically after successful authentication. The cooling fan connected to the GPIO pin is operated when the temperature sensed is above 35°C . The buzzer is turned ON when the respective GPIO pin connected to gas sensor is set LOW. The high amount of carbon dioxide emission inside the mining area results in more suffocation. When this CO2 is sensed, the GPIO pin of that particular relay is set to LOW and the oxygen supply cylinder will be opened. An ALERT button is pressed in case of any emergency situation and thus the sound will be produced. The sensed data is displayed accordingly in the web page.

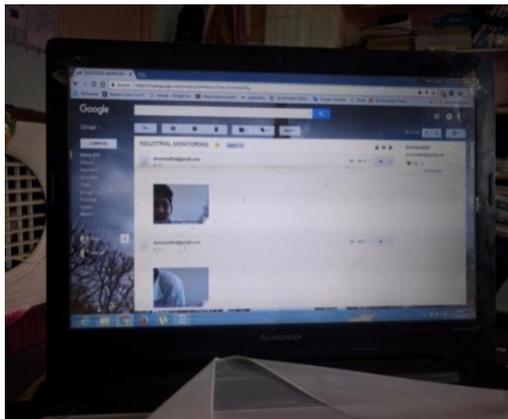
VI. PROJECT ALGORITHM

- Step 1** : Raspberry PI Board is supplied with Power
- Step I. 2** : GPIO Ports are initialized for Raspberry PI, Sensors and Hardware
- Step 3** : An alert is given through buzzer when any sensor value exceeds the threshold value
- Step 4** : If temperature exceeds threshold value cooling fan will be ON
- Step 5** :If gas value exceeds threshold value oxygen cylinder will be opened
- Step 6** :If fire value exceeds threshold value water sprinkler will be ON
- Step 7** :Then Camera Capture the Present Situation in coalmine
- Step 8** :SMS and Mail send to the control room
- Step 9** :The sensed data read by Raspberry PI is saved in a file and displayed on Webpage

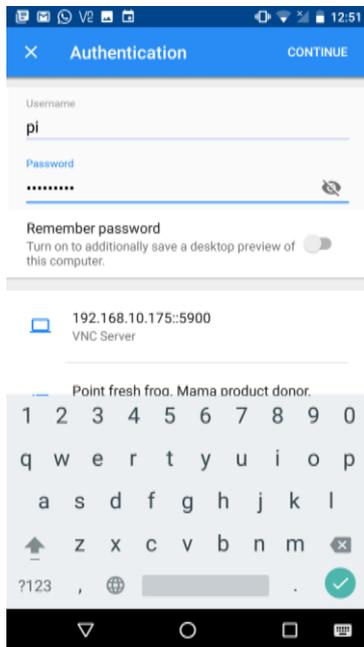
Created webpage output



Raspberry pi window in the mobile through VNC viewer



Mail output



Authenticate Window output

VIII. CONCLUSION AND FUTUREWORK

The designed rescue system can be used in any working environment and reliable. Sensitivity of the sensors used is high. Other gases such as hydrogen, smoke etc can also be detected by gas sensor. This model is also suitable for many other purposes. The coal mine workplace can be observed from the control room as well. As Wi-Fi is used, the transmission of data can be done from any place. This system helps in avoiding the suffocation of workers inside the mine. Preventive measures can be taken for the accidents being caused by ambient conditions. The application when used in the industrial area avoids the human intervention for security. Hospitals, shopping malls can also make use of this design. The enhancement of this project can be done by introducing a water sprayer in case of any fire accidents. Moreover, few sensors like humidity sensor, dust sensor can also be used for enhancing the convenience of workers.

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