International Journal of Engineering & Technology, 7 (3) (2018) 1204-1207

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet.v7i3.12294
Research paper

Coal mine disaster management robot using IoT technology

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Abstract

One of the current trends in technology is an IoT. IoT stands for Internet of Things. It is interpreted as the communication between devices using IP address. Usage of IoT technology in coal mines reduces the number of untoward incidents. Rescue operation in coal mine deals with the risky mission. The work force inside the mine doesn't know some explosions taking place in the proximity of mines. The rescue team also cannot understand the conditions inside the mine. The environmental parameters include toxic gases, excessive temperature, Methane leakage as well as the Oxygen. Information from the deployed sensor is transmitted to the control room through Wi-Fi. In order to address the problems in real life conditions prevailing inside the coal mine, we propose a new method to extract the related information and process the same to alert the people who are working in the vicinity of the mine. For this purpose, a framework is designed using a robotic machine integrated with the raspberry pi3 version. A camera is used in the robot so that the live video is transmitted to the Control room. A cooling fan is deployed to reduce the temperature whenever the value exceeds the threshold level. The workers get an alarm through buzzer whenever any hazardous gas is detected. The robot is controlled by means of navigation buttons, which are in turn managed internally by web server.

Keywords:*Coal Mine; Robo; Wi-Fi; Raspberry Pi3.*

1. Introduction

Mining is the process of extraction of raw minerals from the earth. Coal is one of the mining products in that process. During the process of mining, the work force undergo varying conditions in the environment such as high temperature, toxic gases and lack of oxygen, which may lead to an injury or even the loss of lives. From the studies, it is understood that the loss of lives or injuries are mainly because of human errors.

Usually, two types of explosions take place in coal mines. One is methane explosion and the second one is coal dust explosion [1].In first case, methane gasoline enters the mine as a by-product of coal [2]. One ton of coal contains 100 to 600 cubic meters of methane. When methane comes into contact with heat and if there is insufficient air to dilute methane, explosion takes place. In the second case, methane explosion has the capacity to ignite more catastrophic coal dust. Coal mines inside the United States have taken safety measures to keep away the dust explosions by spreading limestone powder over the coal dust [3]. Lime stone powder makes it more difficult for shock waves to cause methane explosions. In olden days, they used to monitor these harsh conditions by deputing a person into the coal mine [4]. This method is dangerous and the person also gets affected by the same vital conditions. To overcome these difficulties, a Robot is sent inside the mine and programmed to send the atmospheric data using Wi-Fi [5]-[9].

2. Review of existing system

The monitored parameters are made available in the form of SMS and LCD [10]. The web server and the Robot were not able to alert the work force [11]. No special App was created to refine the information so as to acquire the data effectively [12]. It requires an improvement of a framework to minimize the human intervention during any operations in coal mines [13]. Sensors along with the Robot can also be effectively employed to meet the requirements [14].

3. Proposed system

Primary objective of the proposed work is to build a rescue robot that can be managed via a web page. A Wi-Fi communication is created between control room and raspberry pi. Commands are given thorough the web page for robot movement. If any critical state is detected in the mine, then the robot sends information about temperature, toxic gas levels. Subsequently, a buzzer is employed to initiate the precautionary actions to normalize the atmosphere by providing ventilation using a fan. Information related to location, temperature, toxic gas levels etc. are sent to controller room using Wi-Fi network. The DC motor is interfaced with the raspberry pi for the control and movement instructions from controller room. DC motors are used for controlling robotic wheels i.e. left, right, forward or backward.

4. Algorithm

Step 1: Specified power supply is given to the board.
Step 2: GPIO ports are initialized.
Step 3: Buzzer gives an indication whenever the threshold is exceeded.
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: Camera captures the present situation in coal mine.
Step 8: SMS and e-mail is sent to the control room.
Step 9: Sensor data is read by Raspberry Pi, so that the data is saved in a file and displayed on Webpage.
Step 10: Process is repeated until the user intervenes.

5. Methodology and Implementation

Hardware Architecture:
Main components used in the process of implementation are provided in figure.1a and 1.b

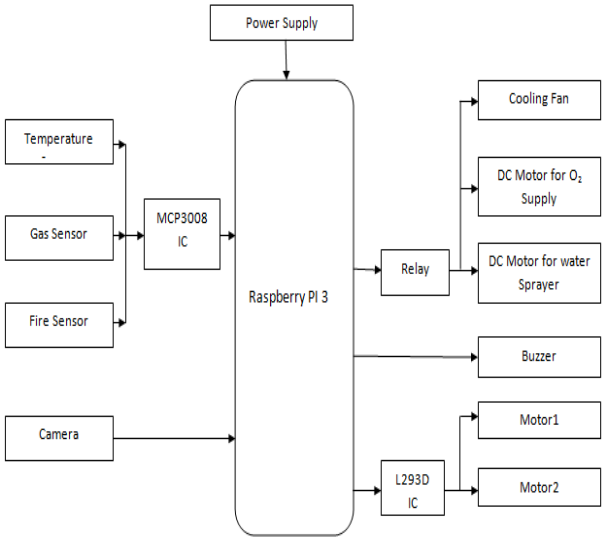

Fig. 1: a) Block Diagram of Transmitter.

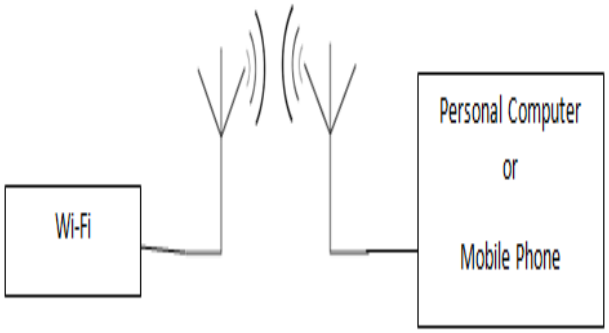

Fig. 1:b): Block Diagram of Receiver.

The proposed system consists of transmitter and receiver blocks. Transmitter block consists of a digital camera to take photographs of internal situations of coal mine. It is connected to USB port of raspberry pi3 which is powered by 5V, 2A electricity adapter. The display is connected to HDMI port.

Temperature (LM35) sensor is used to measure the temperature that is connected to one of the pins of raspberry pi module. Gas sensor is used to identify the presence of poisonous toxic gas levels (CH_4, CO, CO2).It is also linked to one of the GPIO pin of raspberry pi module. Fire place sensor is used to identify any hearth coincidence .All these sensors are analog in nature. Raspberry pi is not able to get the digital information and hence MCP3008 IC is used to transform analog data in to digital form. IC (MCP3008) is a 10-bit microcontroller .It has 8 channels to attach 8 sensors at a time, operated at 2.7 to 5V power supply.

To move the robot, servo motors are used. Cooling fan is used to reduce the temperature in mine. DC motors are used to deliver oxygen and water. All output devices are linked via relay. Relays are digital switches which are used as controllers at high power.

Receiver module consists of a PC which is used to display the data from the robot in the controller room. A web page is also used. The complete hardware setup is shown in the figure 2. The components & modules are attached to rpi3 board. In the first stage, the "rpi3" board is made ready to start. It works on OS (operating-system). Python is used to write the source code which is compiled and debugged onto the Raspberry-pi system.

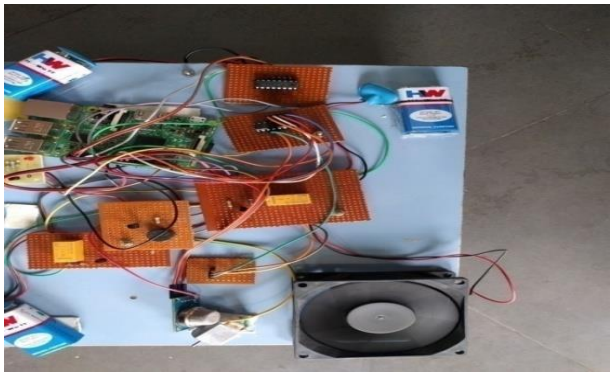

Fig.2: Hardware Setup of the Proposed Model.

Required equipment:

- Raspberry Pi
- Display/Monitor
- USB Web camera
- Gas sensor
- Temperature sensor
- Fire sensor
- DC motors
- Servo motors
- Power-supply

Results:
The results obtained after performing the experiments are shown below.
The GPIO-Port:
The complete project set-up is shown in figure 3.The status of 40 GPIO-pins on board is given in the figure 4 below. Among the 40 pins, only 26 pins are used as GPIO-pins and other pins are used for supply and grounding purposes. GPIO-pins are separated and arranged into two rows on the board. GPIO-port has 7 pins for generic use by default. They are pins 11, 12, 13, 15, 16, 18 and 22. In addition to this, Pin 7 can also be used as general purpose pin apart from its usage as clock pin. All these pins toggle between two states: high (+3.3V) and low (0 V), which is similar to 1 and 0 in binary logic.
Software requirements:

- Raspbian operating system
- Languages- python

Experimental Setup:

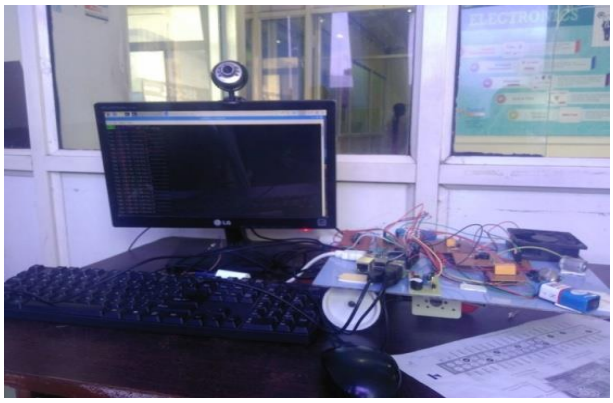

Fig.3: Project Setup.

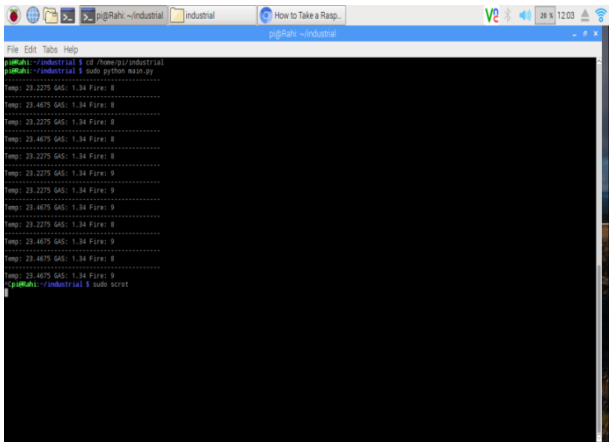

Fig.4: Pi Window when main code is running.

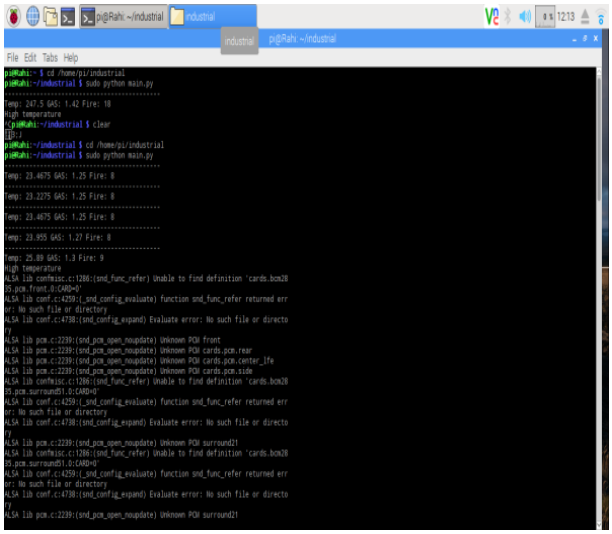

Fig.5: When a high temperature is detected.

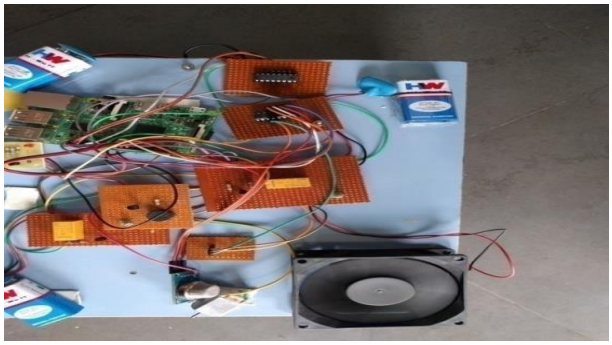

Fig.6: When the temperature is greater than 25 ° C, fan is ON.

Fig.7: Created Webpage Output.

Fig.8:SMS Output and Mail Output.

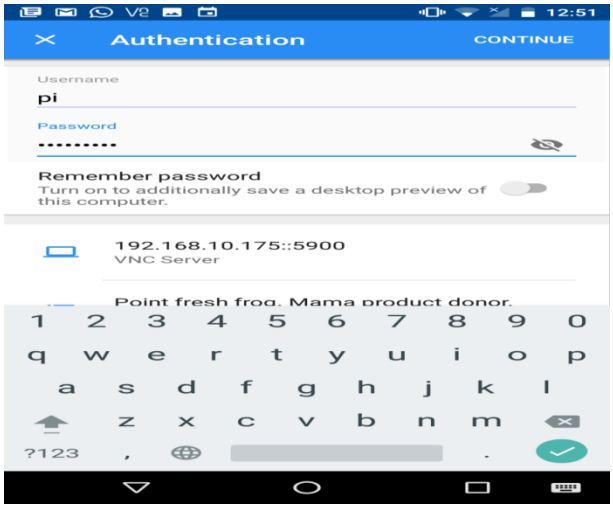

Fig.9: Authenticate Window Output.

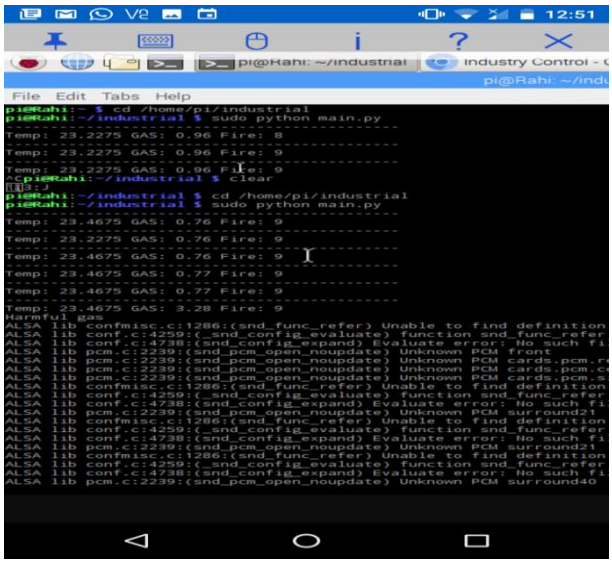

Fig.10: Raspberry Pi Window in the mobile through VNC Viewer.

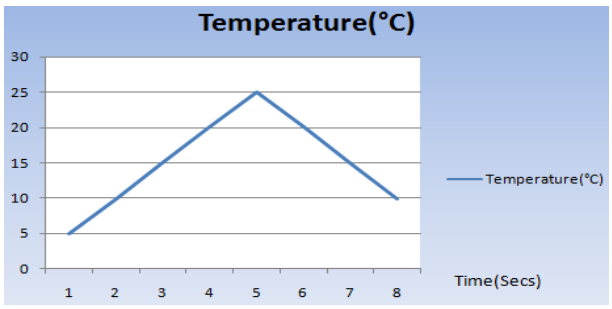

Fig.11: Temperature variation when it is exceeding threshold value.

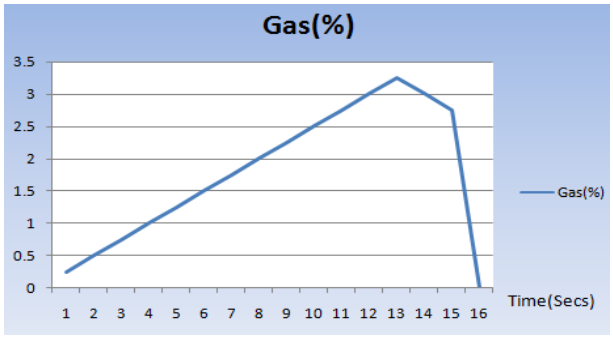

Fig.12: Variation of gas release according to threshold Value.

Fig.13: Fire control when it is exceeding a threshold Value.

6. Conclusion

The sensors are used to extract the data related to temperature, gas and fire. The gas sensor identifies other leakages such as hydrogen, smoke. From the control room, the workplace can be monitored. As the Wi-Fi is utilized, the information can be sent from one point to any point. The proposed application can be utilized for all regions. In clinics, shopping centers, this application can be utilized. The proposed work can be upgraded by putting a water sprayer. If there is any occurrence of fire, water must be splashed at the correct point. Additionally, few other sensors, for example, clean sensor, moisture sensor can be interfaced for the comfort of the labor.

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