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Autonomous Rescue Robot

Mahendra P. Dongare*, Vinayak B Shinde, Ravindra B. Sathe
Amrutvahini COE, Sangamner
India

Abstract—

Using robots to assist rescue personnel in mine rescue missions is an active area of research. We are going to develop a robot to send it into the mine to gather information about the environment inside a mine and to search for victims. Coal mine is a dangerous place in which many fatal factors are dangerous for human life, especially when blasts occur. Rescue persons usually don't know the actual situation of the mine tunnel under such circumstances. Therefore it can be very dangerous for rescuers to go into mine tunnels to search survivors without detecting environmental information beforehand. To solve this problem, the coal mine detect and rescue robot can be developed for assisting people to do the rescue work. The coal mine detect and rescue robot is used for detecting the explosion environment of coal mine and rescuing miners who are trapped in the underground coal mine after gas explosion. We will develop prototype of a fully autonomous robot which can be used to indicate presence of harmful gases inside a mine for mine rescue operations in case of emergencies caused by natural calamities such as explosion. Coal mine rescue robot is a kind of mobile robot. It can go into explosion environment and detect gas content. This paper designs a coal mine detect and rescue robot. It has many characters suitable to mine tunnel. It is composed of mechanical, electrical, computer, control, communication, sensor, etc. There are three major parts in constructing the robot and they are mechanical, electronic and software design. In this paper, the implementation of embedded control system based on the microprocessor is presented. The embedded control system can achieve many tasks of the robot, such as motion control, environmental information acquisition communication with the remote control system and executing complex control algorithms.

Keywords— rescue robot, coal mine, embedded, mobile robot etc.

I. INTRODUCTION

Coal mine is a special mine. It is a tunnel system underground. If there is any fault, people are closed in tunnel and they often cannot escape from tunnel. It has dangerous factors as collapse, gas explosion, CO poison gas, CO_2 gas, low O_2 content, high temperature, smoke, coal dust, fire, water, etc. All these factors can kill people in mine. Gas is intergrowth with coal. When coal is mined, gas is released. Gas is push off by forced ventilate system.

But if forced ventilate system is faulty or there is gas explosion from coal layer, gas is filled in tunnel. A fire point can cause a big gas explosion. Mine tunnel is a tube; gas explosion wave can destroy any thing in tunnel. All devices and people may be damaged. After disaster, gas, CO, CO_2, low O_2 content, high temperatures, smoke, coal dust, are filled in tunnel. Because forced ventilate system has been damaged also, all gas cannot be push out and accumulate in tunnel. A fire may cause a second gas explosion. Rescuer on ground doesn't dare to go into explosion mine tunnel. Because situation is not known, any one may be killed by second explosion. So detect mine tunnel situation is the first problem to rescuers. Robot is a good device in this situation. Robot used in coal mine tunnel has many special characters which are difference to robot on ground. [1]

Coal mine tunnel is a special environment. The first problem is explosion gas is everywhere in tunnel. Any fire can cause an explosion. Robot must be designed as a flame-proof device to avoid robot as a fire point when robot is fault. The second problem is tunnel is narrow and rugged. The middle tunnel is rail track. One side is belt transmission. The other side is a narrow road on coal. Road is a coal road, rugged, many obstacle. Robot is difficult to move on mine tunnel. Varies obstacle must be crossed. This is only normal tunnel. After explosion, all things are damaged by explosion. Tunnel became ruins. Coal block and dust is filled on tunnel, wire is twined, tube is twist, and pole is stick on coal pile. Robot wants cross pile is very difficult. [2].

II. ROBOT STRUCTURE

2.1 BASIC STRUCTURE OF ROBOT

Basically the robot is composed of mechanical institution, control system, motion system, communication system, sensor system and power system. [1] The system structure of the robot is shown in figure.

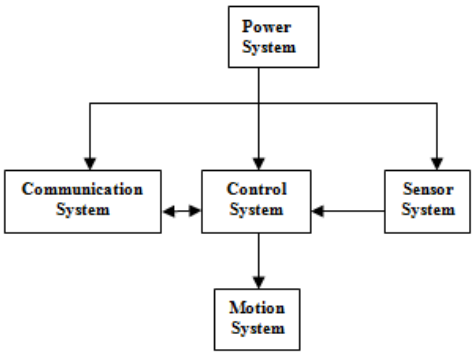


Fig 1: Basic Robot Structure

2.2 Structure of Mine Rescue Robot

The rescue robot is sent inside the mine to detect the internal environmental conditions and it also tracks the proper path by avoiding the collisions with obstacles on its way. To achieve these things mine rescue robot is equipped with different sensors along with signal conditioning circuits and microprocessor as main building blocks of our system.

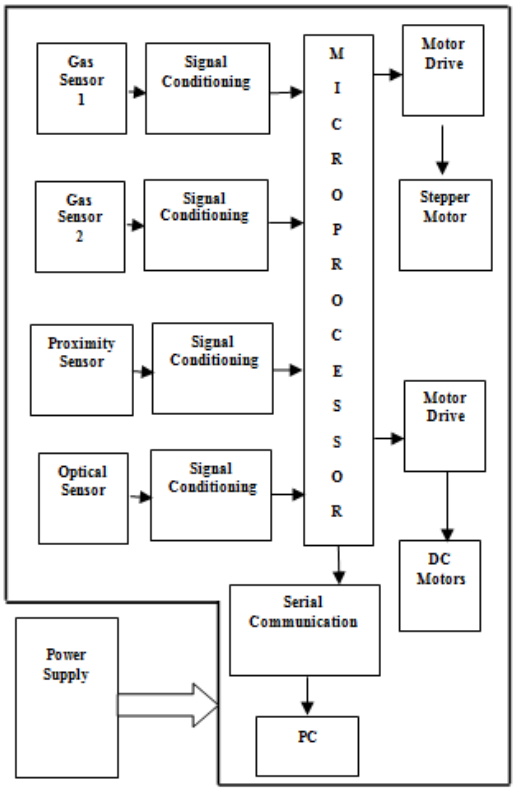


Fig 2: Mine Rescue Robot Structure

The Microprocessor is the main heart of our system. Microprocessor is the electronic device which contains processing Power, memory and IO ports to interact with different connected devices. In this system microprocessor is the brain of system which decides the sequence of output signal that should be given to motors. The robot is powered by DC power supply with proper specifications. This supply can be provided from batteries. Gas Sensors 1 and 2 will be used to detect harmful Gases and notify microcontroller about the level of such gases in the surrounding atmosphere. As the outputs of sensors are not compatible to the microcontroller, we have to provide proper signal conditioning to make it compatible with microcontroller.

Proximity Sensor senses the obstacles present in the path of mine rescuer systems and hence helps in selecting proper path avoiding collision. We can use IR sensors as transmitter and receiver pair. The IR sensors are cheap, and easy to adjust. The basic operation of these sensors is based on reflection of the IR beam. The transmitter emits the IR radiation, which on hitting a target reflects back and is received by the transmitter. Initially the output voltage of the sensor is high and on receiving the radiations it becomes low. [5] Output of the proximity sensor (IR) needs signal conditioning. When the IR sensor detects an object its gives one voltage level and when no proximity is present it gives another voltage level. These two voltage levels are not sufficient to be given to the microcontroller therefore need for signal conditioning arises. LM324 is a comparator which is used in the inverting mode and the output is given to microcontroller. The reference of the comparator is set between the two voltage levels obtained across the IR sensors. Thus the output is clamped to Vcc and GND. High logic indicates that there is no obstacle and logic low indicates that obstacles are present.

Stepper Motors are used to rotate the sensors in the required direction for the operation of the mine rescuer System. Stepper motors operate much differently from normal DC motors, which simply spin when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central metal gear and rotates in steps according to the applied sequence to stators. DC motors are used to move the vehicle in proper direction and also move the vehicle as per desire. The complete motion depends upon operation of these dc motors. DC motors are widely used in robotics.

Serial Communication is used to transfer the data inside the microprocessor to the PC so that it can be analyzed properly and suitable actions are taken accordingly. The microcontroller receives the signals from sensors and processes this data. This data can be transferred to a PC outside the mine via serial communication. Then this data can be displayed on a PC screen and can be observed by the rescue persons. Form this received information from the robot the rescue persons can take the required action. Today, RS232 is the most widely used serial I/O interfacing standard. This standard is used on PCs and numerous types of equipments.

III. SYSTEM IMPLEMENTATION

3.1 LDR Circuit

The LDR is connected to series resistor to form a potential divider network. The output of the potential divider network is given to the ADC.

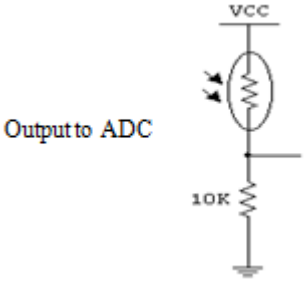


Fig 3: LDR Connection

3.2 Proximity Sensor Circuit

We have used IR sensors TIL38 and TIL81 as transmitter and receiver pair. The basic operation of these sensors is based on reflection of the IR beam. The transmitter emits the IR radiation, which on hitting a target reflects back and is received by the transmitter. Initially the output voltage of the sensor is high and on receiving the radiations it becomes low. IR sensors needs signal conditioning. It produces two voltage levels corresponding to the ON and OFF of the receiver. These levels have to clamp to 0 and Vcc which the microprocessor is compatible with. The LM324 consist of four independent, high gains, internally frequency compensated operational amplifiers, which were designed specifically to operate from a single power supply over a wide voltage range.

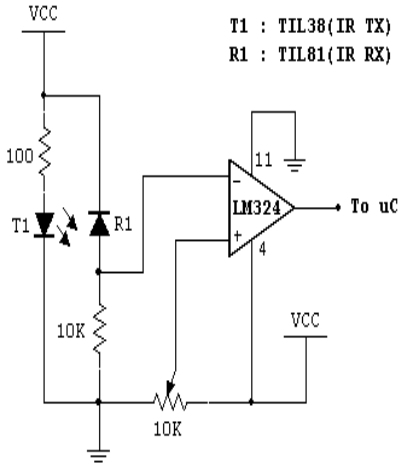
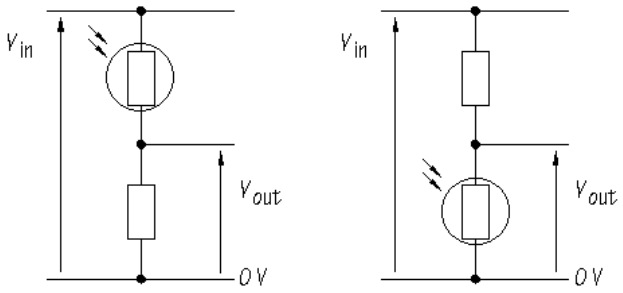


Fig 4: Signal Conditioning for IR Sensors

The figure above shows the output of the sensor stage is fed to these comparators those reference is set between the voltage obtained when the obstacle is absent and the voltage when the obstacle is present. Thus it is compared and the output voltage is high or low (compatible with the microcontroller) depending on whether the obstacle is present or absent respectively.

3.3 Testing of LDR and IR Sensors

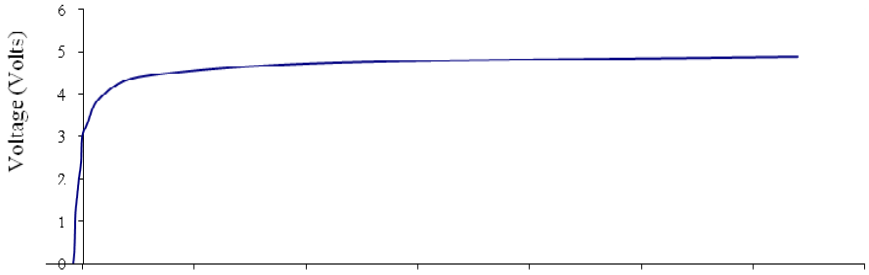
There are two ways to connect a LDR in a circuit diagram. Both configurations are shown below. There are just two ways of constructing the voltage divider, with the LDR at the top, or with the LDR at the bottom:



(A) (B)

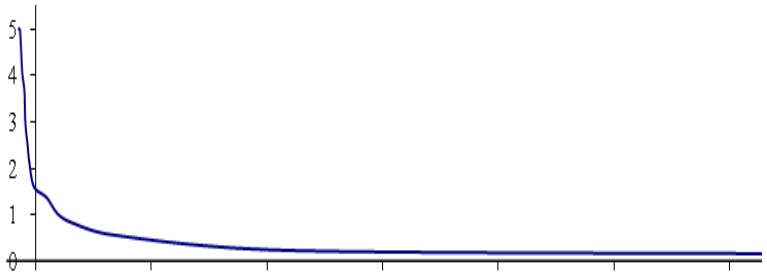
Fig 5: LDR in different configurations

Both the configurations are tested their results are shown below. First circuit diagram (A) was implemented. A dimmer stat was taken and connected a lamp load across it, slowly the voltage was increased from 0 volts and at a certain point the lamp starts to glow. Then the intensity of the lamp was noted and the output voltage was varied up to 240 volts. Same procedure was followed for circuit B also. In (A), as light intensity increases, output voltage increases. In (B), as light intensity increases, output voltage decreases.



Light Intensity

Fig 6: Characteristics of LDR in (A)



Light Intensity

Fig 7: Characteristics of LDR in (B)

The above comparison of testing results of both the circuit we can see for circuit A it is observed that there is a very significant variation of voltage that is from 3 volts to 5 volts, whereas for circuit B the variation of voltage is from 1.3 volts to 0 volts which is not very significant and it is tough for processing. Hence circuit (A) is implemented.

IR sensors are used as proximity detectors .The IR sensors will sense any nearby obstacle and it would tell microcontroller to take appropriate action. It consists of transmitter and receiver.TIL 38 is used as transmitter. TIL 38 emits a high frequency infrared beam. When this IR beam hits an obstacle it reflects back and received by the receiver. At the receiver side phototransistor TIL81 was used. When the IR beam falls on the phototransistor it starts to conduct and the voltage across it decreases.

Table 1: Testing of IR Sensors

Sr.No	Distance between IR sensor & Obstacle (cm)	Voltage(Volts)
1	1	5
2	2.5	4.9
3	4	3.4
4	6	1.2
5	8	0.45
6	10	0.20
8	14	0.05

From the results it is evident that the sensing starts from 8 cm .it means it can detect any obstacle which is in the 8 cm vicinity. Actually it should sense the obstacle from 15 cm but because of many problems it reduces down to 8 cm. The problems are explained below.

Alignment: The IR sensors are very sensitive to their positions .and their alignment has drastic effect on their range. Actually the alignment means the angle between the reflected and the incident beam. For different angles we will be having different ranges.

Ambient light: As we know that every light has an IR component associated with it. So if there is enough ambient light present the receiver is fooled by the surrounding IR radiations and as a result range
the range of the sensors reduces. We can avoid this problem by covering the IR sensors properly.

Improper reflection: As explained earlier this is one of the major problems associated with the IR sensors**.** If the reflecting surface is improper the reflection would be improper too as the result the intensity of the reflected IR would be low consequently output voltage will also be low.

IV. CONCLUSION

Our project is a growing application in Robotics field. Many new features are being added to enhance the Rescue Operations using recent technologies. Our attempt is to design the best prototype for the same. The coal mine detect and rescue robot will be designed to help people execute tasks of detecting and rescuing after gas explosion in the underground coalmine. Coal mine detect and rescue robot is a kind of mobile robot. Many factors of mine are considered. It has many characters suitable to mine tunnel. It can go into explosion environment and detect gas content. The data can be sent to control man in safe field. It includes various fields i.e. mechanical, electronics, computer, communication etc.

REFERENCES

[1] Zhu Jianguo, Gao Junyao, Li Kejie, Lin Wei, Bi Shengjun *"Embedded Control System Design for Coal Mine Detect and Rescue Robot" 978-1- 4244-5540-9/10/$26.00 ©2010 IEEE*

[2] GAO junyao, GAO xueshan, ZHU jianguo, ZHU wei, WEI boyu, WANG shilin "*Coal Mine Detect and Rescue Robot Technique Research" 978-1-4244-3608-8/09/$25.00 © 2009 IEEE.*

[3] A. Davids "*Urban search and rescue robots" Tragedy to technology, Intel. Syst. IEEE 17(2), 81–83, 1541–1672 (2002)*

[4] Shahram Bahadori, Daniele Calisi, Andrea Censi Alessandro Farinelli, Giorgio Grisetti, Luca Iocchi, Daniele Nardi, Gian Diego Tipaldi "*Autonomous Systems for Search and Rescue"*

[5] Gow Moh Kee, Zainah Md. Zain, Rahmatul Hidayah Salimin "*Design and Development PIC based Autonomous Robot" 978-1-4244-1676-9/08/$25.00©2008IEEE*

[6] Robin R.Murphy, Jeffery Kravitz, Samuel L.Stover, Rahmat Shoureshi "*Mobile Robots in Mine Rescue and Recovery" 070-9932/09/$25.00ª2009 IEEE, IEEE Robotics & Automation Magazine*

[7] http://www.robot.electronics.co.uk/rescuework/automation

