Fire Search And Rescue Robot using Robotic Arm

Zainab Patel
B.E. (EXTC), DJSCOE,
Mumbai, India.
patelzainab20@gmail.com

Karan Shah
B.E. (EXTC), DJSCOE,
Mumbai, India.
karan4637@gmail.com

Srishti Shukla
B.E. (EXTC), DJSCOE,
Mumbai, India.
misssrishtishukla@gmail.com

Prof. Mrunalini Ingle
Assistant Professor,DJSCOE,
Mumbai, India.
mrunalini.ingle@djsce.ac.in

***Abstract*— Robot technology is emerging for applications in disaster prevention with devices such as fire-fighting robots, rescue robots, and surveillance robots. In this paper, we suggest an portable fire evacuation guide robot system that can be thrown into a fire site to gather environmental information, search displaced people, and evacuate them from the fire site. This spool-like small and light mobile robot can be easily carried and remotely controlled by means of Zigbee. It mounts a temperature sensor on it.. This robot system moves on a robotic car which will be controlled by Bluetooth of the phone. The sensors mounted on the robotic car are gas sensors for measuring CO gas concentration and an ultrasonic sensor to detect an obstacle. A camera unit is also installed on the car to capture the site. Laboratory tests were performed for evaluating the performance of the proposed evacuation guide robot system.**

I. INTRODUCTION

Recently, mobile robots capable of ubiquitous computing have become very popular; these robots can be used at all times under all conditions. They can be widely used in areas such as military, the medical profession, and in various industries. However, for the deployment of robot systems in fire environments, a number of unsolved problems remain. The most representative examples of such problems are as follows.

1) Presently available robots are not able to function at high temperatures of over 1500°C, which occurs after flashover, and in the presence of water supplied by fire trucks, which would prevent firefighters from entering the site if a robot is being used. This implies that an evacuation robot needs to be equipped with temperature protection, waterproofing, and impact resistance mechanisms.

2) In general, when a fire or some other disaster is reported, firefighters are sent to the site in order to cope with it as soon as possible. Therefore, the evacuation robot also needs to be not only light weight but also easy to carry for rapid emergency response. Moreover, it is important that the firefighter can safely withdraw the deployed robots, because the efforts for withdrawing include additional dangerous activities in fire sites.

3) Due to the poor information regarding indoor space at fire sites, it is very difficult to decide when or how should firefighters enter a building. Therefore, the robot employed for evacuation purposes should be able to not only monitor the situation at fire sites but also report the gathered information to remote firefighters by using a manipulator.

4) In addition to the above drawbacks, there can be other unexpected problems that need to be addressed, such as poor vision in smoke-filled areas and limited RF communication Channels. In order to resolve these unsolved problems, many applications that use caterpillar and fire extinguisher equipment have been proposed. However, they have several limitations due to their large sizes and high cost of maintenance. Therefore, the firefighters cannot easily carry or operate such robots in emergency situations.

In this paper, we report the design and development of a portable evacuation guide robot with various sensing systems that can monitor indoor disasters such as fire, and it can also be used for victim detection and atmosphere observation. In addition, by using a LED guidance lamps, the robot can help in rescuing the victims. In order to cover large fire areas, several robots can be organized into a group, and they can transmit gathered information to the firefighter's controller at a remote site. The rest of the paper is organized as follows. In Section 2, we review related work on robot systems such as fire field robots and portable mobile robots. Section 3 shows the proposed design architecture of the evacuation robot system and its implementation with user application. Section 4 gives a brief overview of the components used in the making of the project. In Section 5, the implementation of the project is shown. In Section 6, the applications of this project has been explained briefly. Finally, in Section 7, concluding remarks and ideas for future work are summarized.

II. RELATED WORK

In the past decade, several mobile robots have been proposed for rescuing people in fire sites such as buildings that have collapsed due to earthquakes or sites where fire has been caused by explosions. In order to tackle these requirements for disaster management, many robot designs have been proposed [2] [3]. However, they have been not developed or fielded for real fire environments. The first robot's trial for urban search and rescue took place during World Trade Center (WTC) disaster [4].

As more pragmatic approaches to robot rescue, various robotic systems are introduced as follows. BEAR is a versatile, humanoid robot capable of lifting and carrying victims. Its main functions are casualty extraction, building evacuation, heavy lifting, searching, rescuing, etc. However, because of high development costs, affordable services are limited except for military or research purposes. Jet Fighter is another fire-fighting robot introduced by the Tokyo fire department. This robot is operated by a remote user and performs fire-extinguishing activities after determining the origin of a fire. In addition, it provides monitoring services by a wireless communication system, and it also has obstacle avoidance mechanisms to enable autonomous driving. Fire Searcher is a type of scouting robot for use in fire sites with high temperatures and poisonous gas. It monitors victims and the internal situation in a building and then transmits the acquired information to remote users by using an applied manipulator [1].Tehzeeb is also a rescuing robot, which employs a laser scanner module along with a manipulator and map generation algorithms for localizing itself while exploring in lightless or dense smoke areas [5]. Mobile robot system with wireless sensor network is an autonomous exploring robot, which is equipped with Zigbee wireless communication module to facilitate video or audio data transfer [7]. It helps to track the location of the robot by analyzing signal strength of the wireless sensor network. Although these robot systems are well designed for monitoring, driving, and firefighting in extreme fields, they are still too heavy and large to be transported by firefighters. Moreover, due to the high costs of large devices and systems, the robot maintenance costs and additional overheads such as user education and repair cost also increase, which is not conducive for the commercialization and popularization of these devices.

III. System Architecture

The block diagram shown in Figure 1 shows the basic working of this project.

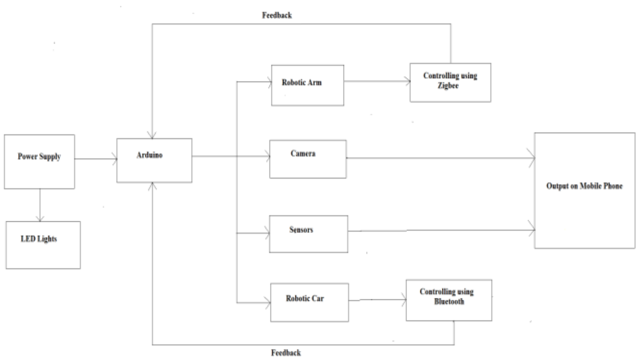


Figure 1: Block Diagram

The working principle of the project is explained below.

i. The codes written on the Arduino boards serve to perform the desired actions of the arm (Arduino Mega) and robotic car (Arduino Uno).
ii. The movements of the arm are controlled using the ZigBee module by giving the feedback to the Arduino to perform the desired action.
iii. The movements of the car are controlled using the Bluetooth module by giving the feedback to the Arduino to perform the desired action.
iv. The temperature, CO concentration and the images of the site are displayed on the mobile phone.
v. The readings of the ultrasonic sensor is fed to the Arduino which takes the appropriate actions as required.

IV. Components Overview

The components used in the project include Arduino, ZigBee, Bluetooth, temperature sensor, CO concentration sensor, camera, ultrasonic sensor, servo motor, DC motor, LED display and power supply. The robotic arm requires 6V 3A for powering it while the robotic car requires 9V 1A for it's working.

A. Arduino

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control the physical world. We have used Arduino mega for giving the instructions to the robotic arm and Arduino Uno for giving instructions to the robotic car and the sensors. Arduino Uno and Arduino Mega is shown in Figure 2a and 2b respectively.

(a) (b)

Figure 2: Arduino Board

The Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

B. Communication Models

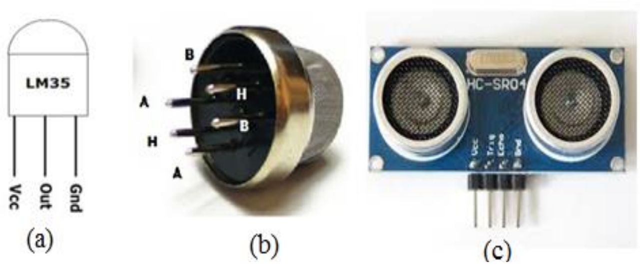
(a) (b)

Figure 3: Communication Modules

For communication with the robotic arm, we use ZigBee and for the robotic car we use Bluetooth Module. Both ZigBee and the Bluetooth module works at 2.4GHz and their range is around 10 to 30 feet. As both are low cost, they are the most suitable for low cost project. The communication modules i.e. ZigBee and Bluetooth are shown in Figure 3a and 3b respectively.

C. Sensors

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly- proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient centigrade scaling. The diagram of LM35 is shown in Figure 4(a) The LM35 device does not require any external calibration or trimming to provide typical accuracies. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air.



. Figure 4: Different Sensors configured in the project

For measurement of different gases, we use MQ-6 gas sensor. Sensitive material of MQ-6 gas sensor is SnO2, which with lower conductivity in clean air. When the target combustible gas exist, the sensor’s conductivity is higher along with the gas concentration rising. Convert change of conductivity to correspond output signal of gas concentration. MQ-6 gas sensor has high sensivity to Propane, Butane and LPG, also response to Natural gas. The sensors can be used to detect different combustible gas, especially Methane. Due to the low cost, it is suitable for different application. Figure 4b shows the MQ-06 sensor

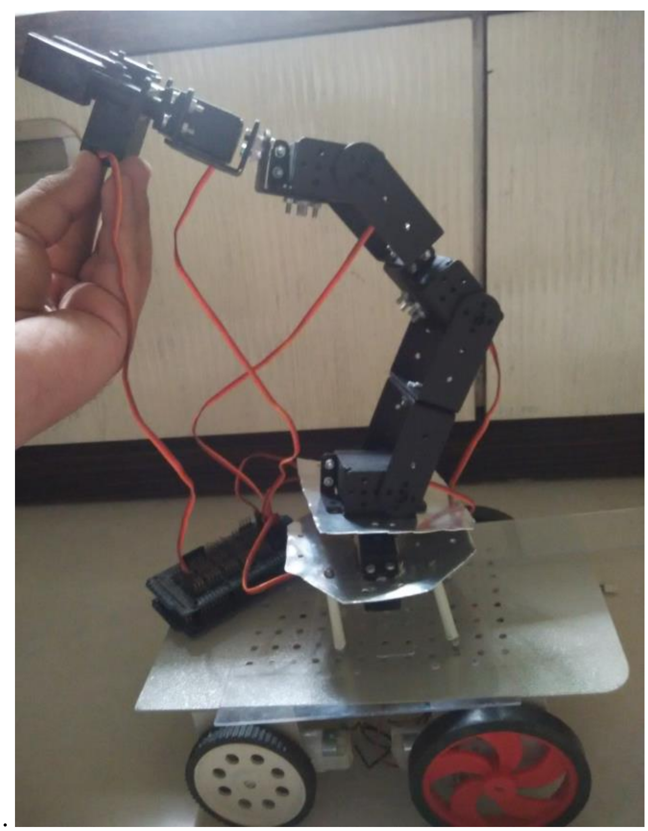
Ultrasonic Ranging Module HC - SR04 is shown in Figure 4c. It is used for measurement of the distances between the sensor and the object. It provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work depends on using IO trigger for at least 10us high level signal, sending eight 40 kHz and detect whether there is a pulse signal back and if the signal is back, the Test distance is given by (high level time×velocity of sound (340M/S)) / 2. We have also used a camera module, which captures the images at the site and sends it to the mobile, which is used by the person controlling.

D. Motors

Servo motors are small but pack a big punch and are very energy efficient. Because of this, they can be used to operate remote-controlled or radio-controlled toy cars, robots and airplanes. They are used in industrial applications, robotics, in-line manufacturing, pharmaceutics and food services. The DC motors having an RPM of 225, are used for controlling the robotic car.

V. IMPLEMENTATION

The hardware consists of robotic arm and robotic car. The mechanical design of the arm is based around 2 universal bracket designs along with a number of smaller brackets. The pivoting parts are made from standard servos and small flanged bearings in order to keep the design as simple as possible. All of the parts are designed in libreCAD (an open-source 2D CAD package). All parts are made from acrylic sheet because it is lighter than aluminum. Each bracket part is designed in the form of a template for simplicity. The bracket template is then printed out and cut to size using a sharp hobby knife and a metal ruler. The arm consists of servo bracket, C bracket, End arm bracket, Mid arm bracket, Turn table, base, End effector module. The assembled arm and chassis is shown in Figure 5.



.

Figure 5: Completed Arm and the car

The Robotic Car consists of a chassis made from aluminum, DC motors, and the different sensors. The robotic car is controlled using mobile phone through Bluetooth module. The software part consists of Arduino IDE and using app inventor software for designing the application, which helps to controls the robotic car and robotic arm. The app is designed using MIT app inventor V2.

VI. Applications

The robotic arm can be used in many military and industrial applications. The robotic arm can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application. For example, robot arms in automotive assembly line perform a variety of tasks such as welding and parts rotation and placement during assembly.

In space, the space shuttle Remote Manipulator System, have multi degree of freedom robotic arms that are used to perform a variety of tasks such as inspections of the Space Shuttle using a specially deployed boom with cameras and sensors attached at the end effector.

The robot arms can be autonomous or controlled manually and can be used to perform a variety of tasks with great accuracy. The robotic arm can be fixed or mobile (i.e. wheeled) and can be designed for industrial or home applications. Robotic hands often have built-in pressure sensors that tell the computer how hard the robot is gripping a particular object. This keeps the robot from dropping or breaking whatever it is carrying. Other end effectors include blowtorches, drills and spray painters, which can improve their performance.

In medical science: "Neuroarm" uses miniaturized tools such as laser scalpels with pinpoint accuracy and it can also perform soft tissue manipulation, needle insertion, suturing, and cauterization. In search and rescue operations, the arm can pick up the saviors and transfer them to a safe place. It can be used to clear the path of debris or any other object obstructing the path for rescuers.

VII. Future Scope

One of the major drawbacks is the robot cannot reach high places or cannot move through heavy debris. This can be overcome by converting the bot into a quad copter. This will help the bot to fly in places where the bot can’t reach by driving.

Other scope is to make it self-sufficient by adding solar powered batteries or by generating the power through the heat being generated inside the fire.

As the arm cannot handle heavy weight, the design of arm should be rethinked. Instead of using normal servo motor, high torque generating and high durability motors should be used.

The arm and the car should be designed using heat resistant materials as the flames from the fire can harm it. Special care should be taken while designing the electrical components as the fire can harm the components which may hamper the working of the robot.

Acknowledgement

We would like to thank our project guide Prof. (Ms.) Mrunalini Ingle for her guidance and counsel. We would also like to show our gratitude towards Dr. Amit Deshmukh (Head of department) and also to the teaching and non-teaching staff of Electronics and Telecommunication Department for their support and motivation.

References

[1] P.H. Chang and Y.H. Kang, et al., “Control Architecture Design for Fire Searching Robot using Task Oriented Design Methodology”, SICE-ICASE 2006, Oct. 2006.

[2] Kobayashi, A. and Nakamura, K., “Rescue Robot for Fire Hazards,”Proc. of International Conference on Advanced Robotics, 1983

[3] Ko, A. W. Y. and Lau, Y. K. H., “An immuno robotic system for search and rescue”, Proceedings 6th International Conference on Artificial Immune Systems (ICARIS 2007), August 2007

[4] Snyder, R.,”Robots assist in search and rescue efforts at WTC”, IEEE Robot. Automation Magazine, vol. 8, pp. 26-28.

[5] S Suthakorn, J., Shah, S.S.H., Jantarajit, S., Onprasert, W., Saensupo, W., Saeung, S., Nakdhamabhorn, S., Sa-Ing, V., Reaungamornrat, S., “On the design and development of a rough terrain robot for rescue missions”, IEEE ROBIO 2008, Feb., 2009

[6] Albert Ko and Henry Y.K.L., “Robot Assisted Emergency Search and Rescue System With a Wireless Sensor Network”, International Journal of Advanced Science and Technology, Vol.3., Feb., 2009

[7] Zigbee Alliance, URL://www.zigbee.org/en/index.asp

[8] Niramon Ruangpayoongsak, Hubert Roth, Jan Chudoba, “Mobile Robots for Search and Rescue”, Proceedings of the 2005 IEEE International Workshop on Safety, Security and Rescue Robotics, Kobe, Japan, June 2005, p. 212-217.

[9] Ritesh Kumar, Sugam Anand, Ritesh Gautam, “Robotic Arm”, IIT Kanpur.