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A Review On Implementation of a Fire Fighting Robot Using Arduino

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Abstract – *The project is designed to develop a fire fighting robot using XBEE module for remote operation. The wireless communication is used to control the robotic vehicle which is loaded with water tank and a pump to throw water. An Arduino is used for the desired operation. At the transmitting end using GUI, commands are sent through transmitter to the receiver which decodes it before feeding to other Arduino to control the movement of the robot that is to move the robot in forward, backward, left or right directions. At the receiving end three motors are interfaced to Arduino UNO where two of them are used for the movement of the vehicle and remaining one for the pump. The appropriate signals from transmitting end are used to carry out the operation of robot based on the Arduino UNO output. The robot body is mounted with a water tank and a water pump. A motor driver IC is interfaced to the Arduino UNO through which the controller drives the motors. Also a temperature sensor and gas and smoke detector is interfaced so that after crossing the threshold values, the water pump turns on automatically. Further a wireless camera is interfaced so that the person controlling it can view operation of the robot remotely on a screen.*

Key Words: Arduino UNO, XBEE Module, GUI, Fire Sensor, Driver IC

1.INTRODUCTION

A robot is machine which is capable of performing human tasks or behaving like a human. The expertise and complex programming is required to build a robot. It involves building of system and assembling various components together. Advances in economic growth in modern industrialized society have resulted in factories, complex office buildings, and dense apartment blocks located in metropolitan areas. Associated gas stations, oil reservoirs, and LNG storage facilities, which are all vulnerable to fire due to inflammable materials, are also found in these areas. When a fire occurs in such places, fire-fighting is difficult due to mazes of crowded buildings, high temperatures, smoke and the danger of explosion.

Current fire-fighting systems are based on humans using water guns and chemical fire repression systems. However, humans cannot work effectively in all fire environments. In this case, it is desirable to extinguish a fire quickly using fire-fighting robots. A fire-fighting robot is one having a small fire sensing and extinguishing system attached to it. With the help of automation, the robot can be made human controlled. This paper includes the design and construction, working, implementation and future scope of a fire-fighting robot based on Arduino UNO which is used as a controller. The following concepts are implemented in our robot: environmental sensing, proportional motor control.

In order to control fire-fighting robots in remote places, robust radio communication systems are necessary. In our project the XBEE communication system is used for this purpose. The robot is monitored through a wireless camera present on it's top from the remotely situated control station using XBEE module. Thus according to the status of the various sensors of the robot, user can take required action.

Also in the other case, the water pump on the top of robot is automatically switched on and the robot sounds alarm with the help of buzzer provided to it when the output value of temperature and smoke sensor is above a certain threshold. This project helps to create the innovations and interests in the field of robotics while working towards a practical and approachable solution to save lives and mitigate the risk of property damage

2. RELATED WORK

One of the major concern for both industrial and residential areas is the loss due to fire damage. Fire causes enormous damage to life and property. The first fire department was

established in Korea in April 1925 and then thereafter such facility spread quickly so that nowadays the fire stations are located all over the country in all the countries. Current fire-fighting systems are based on humans using water guns and chemical fire repression systems. However, humans cannot work effectively in all fire environments. In this case, it is desirable to extinguish a fire quickly using fire-fighting robots. The research on fire-fighting robots has advanced in many countries recently, in order to cope with catastrophic fire related accidents. The main problem with these robots was a heat resistant body. In this model, we have tried to overcome this drawback. Here we have used asbestos to cover the body of robot in order to minimize the heat transfer to the internal circuitry. The various models and prototypes have been developed and the research is still going on to make fire-fighting robots more efficient and to overcome their drawbacks.

3. SPECIFICATIONS OF ROBOT

To build this robot, many technical concepts from different arenas such as electronic, electrical, mechanical and pneumatic systems where used. Because of this the students team exercised their technical and practical knowledge. The robot is briefly described in this section. Basically, the robot structure can be described by referring the numbers:

- Pneumatic components (1)
- Transmission components (2)
- Batteries (3)
- Flame detector sensor board (4)
- motors (5)
- Robot chassis (6)
- Robot controller (7)
- Driver (8)

1) Pneumatic components*:* The pneumatic component used here is sprinkler which is being driven by a water pump. But, based on the tested methods, the best way to extinguish fire was by means of compressed air. In fire extinguisher approach, a pneumatic system can be developed using a pneumatic reservoir (with pressure calibrated at 8 bar) and one pneumatic solenoid valve used to shoot air. Every time the robot find a fire focus one air shot is released. The reservoir is sized to release at least twenty shots.

2) Transmission components*:* The transmission between step motors and robot wheels uses a couple of gears with 1:2 relation driven by a synchronized belt.

3) Batteries*:* Three sets of batteries (26V = 12V + 5V+ 9V) are used in this project. One is connected to drives and motors and sensors, while the other one which is of 5V provides power to Arduino and 9V battery is used for camera.

4) Flame detector sensor board*:* For detection of temperature, we have used temperature sensor, gas and smoke detector with some range. So if the value of these sensors exceeds the respective threshold value, and if the condition meets which is specified in the Arduino program, the buzzer will turn on and hence the flame is detected.

5) Motors: Here, two D.C motors are used. A device that converts a direct current electrical power into mechanical power is called as a DC motor. Most type of DC motor produce rotary motion; a linear motor directly produces force and motion in a straight line.

6)Robot Chassis: The framework of an artificial object, which supports the object in its construction and use is known as chassis. The chassis consists of a frame or other internal supporting structure on which the circuit boards and other electronic components are mounted. The metallic material such as aluminium alloy or MS are used in construction of chassis due to the more superior stiffness and compressive strength of metals as compared to wood or synthetic polymer.

7) Robot Controller: An Arduino is the controlling unit of the Fire-fighting robot. Here we have used two Arduino boards: One at the transmitting side and other at the receiving side.

8)Drivers: Here we have used one relay driver namely ULN2803 and one motor driver which is L298.As the current supplied by Arduino is not enough to drive motors so here we have these two drivers. They fulfill the current requirement of the motors and relays respectively.

4. WORKING OF ROBOT

Block diagram fig 1 shows the components of fire-fighting robot. The main controlling unit of this robot is Arduino, which is connected with fire sensing unit. The fire sensing unit consist of temperature sensor and smoke sensor. The robot consists of wireless camera which will transfer front view of robot to the receiving unit which is controlled by user. The receiving unit consist of XBEE, Arduino, computer and camera receiving unit. While at the transmitting side there is a Arduino which controls the actions of robot based on the conditions and commands given by the user.

The project consists of main control part to which sensing part, fire-extinguishing part, communication part, driving part and power part are connected. The sensing unit senses the temperature around the robot and get information, and also the video image in front of robot is sensed and reported to the main control computer. The extinguishing part contains a water pump which is used for water sprinkling from a miniature water tank, this sprinkler will be driven by motors and water pump. The communication part consists of XBEE transmitter and receiver system. The driving part consists of a motor driver and a relay driver. The 4 wheels can be operated using 2 motors in which 2 front wheels are operated by one motor and back wheels are operated by the other one by providing suitable logics with the help of Arduino Uno software. The power part consists of a high power battery of 12 V and 5V is used.

Transmitting side:

The transmitting side consist of XBEE transmitter connected to Arduino, a personal computer or a laptop having MATLAB software installed in it to run GUI. The GUI developed in MATLAB consists of 7 buttons which are left, right, up, down, stop, sprinkler and camera depending upon the buttons pressed, the particular characters are sent to the Arduino for each button i.e. 'l' for left, 'r' for right, 'f' for up, 'b' for down and 's' for stop. The Arduino will decode these characters whose meaning is already specified in the Arduino program and respective commands will be given to the receiving side through XBEE transmitter.

Receiving side:

At the receiving side, the XBEE receiver will receive the commands in the form of characters and will send it to Arduino which will further decode it. In Arduino program, the meaning of this characters are already specified. According to the received commands, Arduino will give instructions to the specific components. The two wheels M11 and M12 will be controlled by motor 1 and the other two wheels M21 and M22 will be controlled by motor 2. Depending upon the character received, the Arduino will give high or low logic to M11, M21, M12 and M22 respectively and hence the robot will move in forward, backward, right and left directions. If '5' is received, the Arduino will give high logic to pump. Hence the sprinkler will turn on. This is shown in the Table 1. Here we have used one relay driver namely ULN2803 and one motor driver which is L298.As the current supplied by Arduino is not enough to drive motors so here, we have these two drivers. They fulfil the current requirement of the motors and relays respectively.

Motors	Logic	Character received	Directions
M11, M21	High	F	Forward
M11, M12	High	B	Backward
M11	High	L	left
M21	High	R	right

Table 1: Motion of the robot according to the logics

The robot unit also consist of motors and motor driving unit L298 as per the requirement Arduino can control the motors. When the sensing unit data is above threshold level i.e. high temp and smoke is detected the sprinkler will be switched on. This unit consist of sprinkler pump, water tank, relay and relay driver circuit. The robot unit supplied with powered with battery of specification 12 v,1.2amp.

In-order to sense fire we use the Fire sensor (Temp sensor) which is used to detect the fire. The output pin (DO) will give 0V(LOW) and if the is no fire the output pin will be 5V(HIGH). So, we place two such sensors in two directions of the robot to sense on which direction the fire is burning. We detect the direction of the fire we can use the motors to move near the fire by driving our motors through the L298.

5. ROBOT DESIGN COMPONENTS

The development of fire-fighting robot needs a team to design a mechanical system consisting of motor placement, mounting and gearing; motor drive system sensing system for flame and smoke detection and real time software that can read the sensor data and issue motor control commands. Successful completion of these stages help in development of technical skills including layout designing, soldering, component mounting, wiring and other construction methods

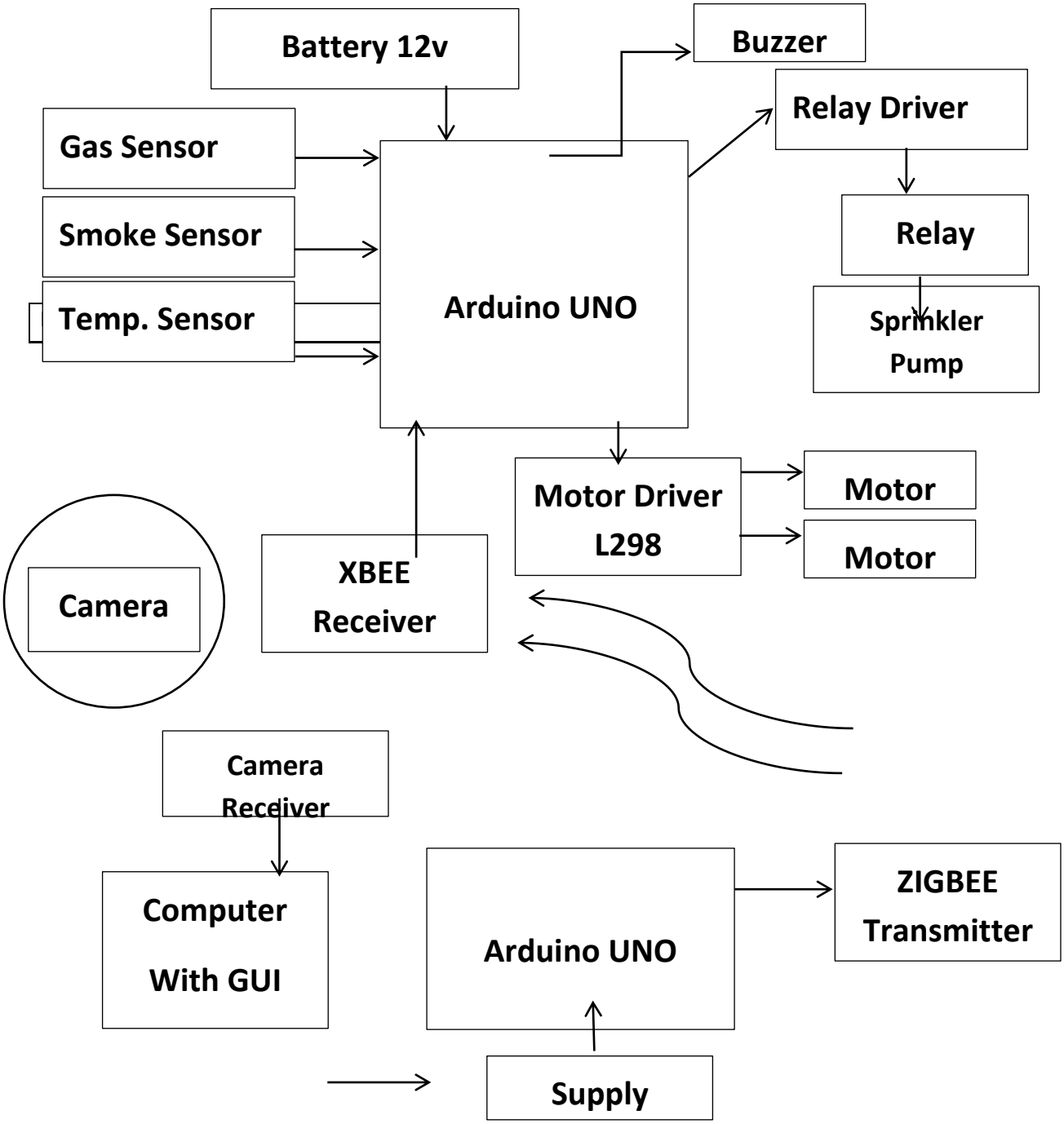
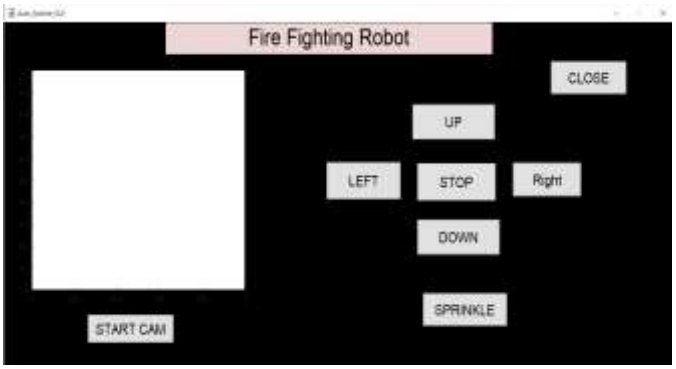


Fig1. Block diagram of Industrial fire-fighting robot

6. RESULTS

Arduino 1.8.5, MATLAB (R2016) and eagle software are used for simulation Arduino UNO library for eagle files in the library folder of eagle software and code the program in Arduino 1.8.5. It is the simplest and easiest way of coding a program. We have used Eagle software for printed circuit board layout design. We have design a graphical user interface (GUI) using MATLAB software. This GUI consist of seven buttons that is forward, backward, left, right, sprinkler and camera respectively. The MATLAB GUI is shown below:



6.1 Simulation output

When the UP button is pressed, the character 'f' is received on the XBEE receiver and Arduino will provide the logic high to wheels M11 and M21 respectively and low logic to wheels M12 and M22 respectively. This will move the robot in the forward direction.

When the DOWN button is pressed, the character 'b' is received on the XBEE receiver and Arduino will provide the logic low to wheels M11 and M21 respectively and logic high to wheels M12 and M22 respectively. This will move the robot in the backward direction.

When the RIGHT button is pressed, the character 'r' is received on the XBEE receiver and Arduino will provide the logic high to wheel M21 and logic low to wheels M11, M12 and M22 respectively. This will move the robot in the right direction.

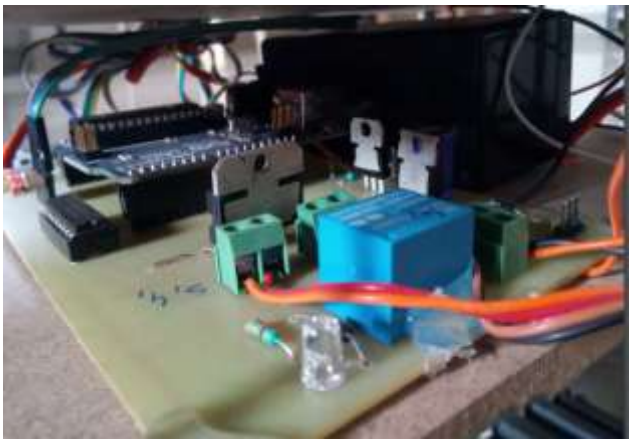
When the LEFT button is pressed, the character 'l' is received on the XBEE receiver and Arduino will provide the logic high to wheels M11 and logic low to wheels M12, M21 and M22 respectively. This will move the robot in the left direction.

When the STOP button is pressed, the character 's' is received on the XBEE receiver and Arduino will provide the logic low to all the wheels. This will stop the robot.

When the SPRINKLE button is pressed, the character '5' is received on the XBEE receiver and the sprinkler will turn on. On pressing the CAMERA button, the camera turns on.

6.2 Hardware Setup

The figure below refers to the hardware setup of this project. The main components of this project are Arduino UNO, XBEE module, batteries (12+5+9), LM35, MQ2, ULN2803, L298, Voltage Regulator IC 7805, relay, water pump, water tank, sprayer, motors, wheels, chassis, camera module. Based on the output values of sensors or the commands given by the person controlling robot, it will perform the respective tasks. The components involved are shown below:



7. CONCLUSIONS

This paper gives a detailed mechanism about the real time industrial fire-fighting mobile robot that can move through a model structure, sense the occurrence of fire accident continuously, intimates the respective personnel and then extinguish it with the help of pumping mechanism. Thus if any fire accident occurs, the robot will first warn the people in accident prone area by blowing a buzzer and then start throwing the water immediately in the direction where the temperature and smoke is recorded to be maximum. Also the respective personnel who is operating the robot remotely can control the actions of robot by viewing the images from

camera. The results show that the proposed fire-fighting robot prototype is successfully implemented.

8. FUTURE SCOPE

In the present condition the motion of our robot can be controlled only up to certain distance. It can be extended and improved by using a more robust and long ranged communication system. Presently our robot has a water tank and pump to extinguish a fire. It can be extended to a real fire extinguisher by replacing the water tank by a carbon-dioxide carrier which can enable to extinguish the fire of all types. We have used asbestos in the body of our robot to protect the internal components and circuit. The performance of robot can be improved by using more effective heat reflector for the body of robot. The camera can also be modified by using heat resistant glass. The robot can also a fully automated to detect the obstacles and handle them as well.

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