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# Development of Autonomous Fire Fighting Robot

**Aditya Nikhare[1], Snehal Shrikhande[2], Chetan Selote[3], Gandhar Khalale[4]**

[1,2,3,4] *Final year students, Government College of Engineering, Nagpur-441108*

**Abstract –** *Fires have been one of the most common and catastrophic calamities in recent years, causing immense damages to national property and individuals. Firefighters extinguish the fire to protect the lives of people and to avoid loss of property but firefighters are susceptible to burns, smoke, inhalation, and crush injuries from collapsing structures. Due to continuous contact with fire, firefighters suffer from long-term ailments such as asthma, dreadful diseases, etc. Recently, firefighting robots have been developed to eradicate the problems that occurred due to fire and provide safety to firefighters. In this paper, a firefighting robot is proposed which detects and extinguishes fire without any human assistance. The proposed robot is designed to be able to work on its own or be controlled remotely. Using such robots, fire detection and rescue operations can be carried out with greater security and without putting firefighters in risky situations. The proposed firefighting robots have been developed for both autonomous and manual modes. This robot is worked in manual mode by making use of the HC-05 Bluetooth module. This mode allows the user to navigate the robot via a mobile application on an android device. The fire-fighting robot has been successfully tested in a simulation software like Proteus and the above results are validated with the help of an experimental prototype.*

***Keywords- fire-fighting robot, flame sensor, autonomous, manual, ultrasonic sensor***

## I- INTRODUCTION

Currently, the discipline of robotics is developing and evolving at a very quick speed. Robots are now being employed to undertake occupations that were previously dangerous, filthy, or dull. Robots are being employed on a huge scale in sectors such as automobiles, from painting to welding. According to World Robotics, the total number of robots installed worldwide is anticipated to be over 50 million.

Fires have been one of the most common and catastrophic calamities in recent years, causing immense damages to national property and individuals. A fire-fighting robot can replace fire crews in approaching a fire scene to perform firefighting and rescue operations, as well as perform various fire field reconnaissance tasks. In situations where firefighters are constantly at risk of getting injured, inhaling fumes, and a host of other problems, the use of a fire-fighting robot would greatly improve the fire department's ability to put out invasive fires. Robots can be operated manually or autonomously. Manually operated robots can be controlled over Bluetooth from an Android device, whereas autonomous robots have an obstacle avoidance system built into their autonomous operation. These robots can also be frequently outfitted with cameras to photograph the scene of the fire, as well as sensors to measure temperature and CO2 and O2 concentrations. It allows us to send and receive data, such as video and audio, as well as track the robot's location. Robots are built for extreme environments; thus, they can tolerate high temperatures, are waterproof, and can withstand shock.

Research published in (IJACSA) International Journal of Advanced Computer Science and Applications describes the creation of QRob, a firefighting robot that can extinguish fires without exposing firefighters to undue danger. QRob has an ultrasonic sensor to prevent it from colliding with any obstacles, as well as a flame sensor for fire detection. As a consequence, QRob was able to demonstrate the capacity to automatically identify fire spots as well as the ability to extinguish fires from a distance. QRob is set to locate the fire and come to a complete halt at a distance of 40 cm from the flames. And one of the papers describing the design and development of a network-based autonomous

firefighting robot is presented in this research. It discusses the use of a spray cannon and pumps to put out a fire using a water-based extinguishing technique. Gas sensors are combined to form a network system that guides the robot to the desired distance. The algorithm for obstacle avoidance is crucial to proper navigation.

In this paper, a firefighting robot is proposed. The function of this robot is to detect and extinguish a fire without any human assistance. The proposed robot is designed to be able to work on its own or be controlled remotely. Using such robots, fire detection and rescue operations can be carried out with greater security and without putting firefighters in risky situations.

## II-PROPOSED TOPOLOGY

The development of firefighting robots is based on autonomous fire detection, fire extinguishing, and manual operation.

In this model, a variety of components have been incorporated. Arduino UNO is a microcontroller that is commonly used in robotics and is based on the ATMega328P. It features a total of 28 pins, which may be used as inputs or outputs, including 14 digital pins and 6 analog pins. HC-SR04 ultrasonic sensor is used for obstacle avoidance that determines the distance within the range of 5cm to 200cm, transmits waves into the air, and receives reflected waves from the object. A flame sensor is an infrared sensor that is especially sensitive to the IR waves released by fire and has a detection distance of up to 100 cm with a 60-degrees detection angle. When there is a fire incident, the IR sensor receives the infrared radiation and gets activated which gives a signal to the robot through a microprocessor to move in the direction of fire. The body of the robot is covered with an acrylic sheet to protect the components and circuit from water. The acrylic sheet is also resistant to heat of up to $200^0$ C. Motor Driver (L293D) powers the motors associated with wheels, which are placed two at the front and two at the rear side responsible for the movement of the robot.

In autonomous mode, robots search for fire in the premises using the flame sensors onboard. Simultaneously, it also avoids obstacles in its path within a distance of 30cm, if it encounters any. Once the robot is at a distance of 50cm from the fire, it stops and activates the water pump. Water is pumped from the container through a nozzle which releases a pressurized spray of water and extinguishes the fire.

The proposed robot is designed to work in manual mode as well, by making use of the HC-05 Bluetooth module. This mode allows the user to navigate the robot via a mobile application on an android device.

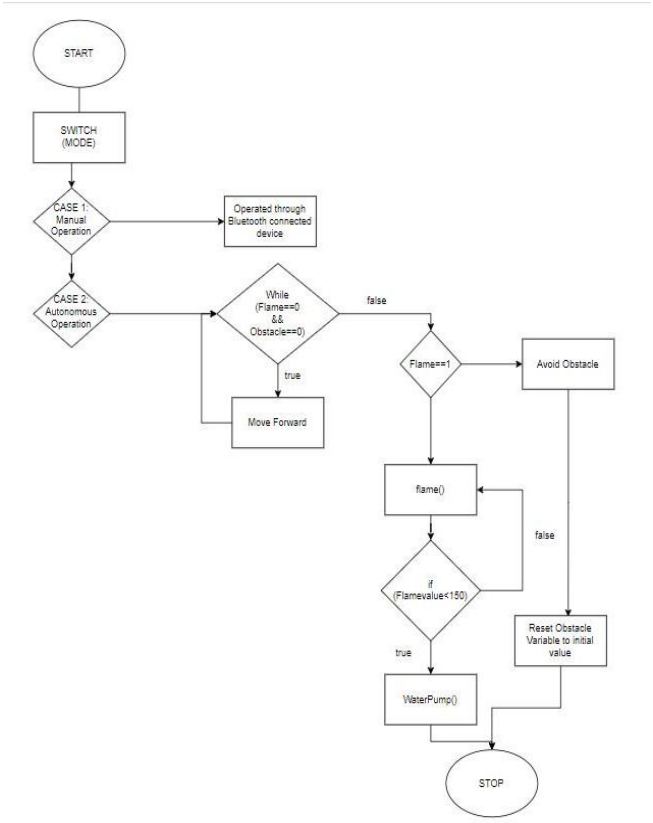


Fig. 1- Flowchart of operation of the proposed fire-fighting robot

When the robot is turned on, the operating mode (autonomous or manual) has to be selected using the android device. If manual mode is selected, then the robot has to be controlled and navigated manually using the android device. Else if the autonomous mode is selected then the robot works on the Arduino code uploaded on the microcontroller. The code is composed of obstacle avoidance, flame detection, and flame extinction algorithm. The robot checks for obstacle or flame in its surrounding simultaneously and updates the 'flame detection' and 'obstacle' variable until obstacle and fire are not detected (flame==0 and obstacle==0). If the while condition remains true the robot moves forward. If the robot detects any obstacle, then the 'obstacle' variable is updated and set to '1', and if the fire is detected 'flame detected' variable is updated and set to '1'. If any of these two conditions become true i.e., '1', the program flow comes out of the while loop. If the 'flame' variable has affected flame function is executed. The flame function reads the values from the flame sensor and navigates the

robot towards the direction of fire until flamevalue>150. If flamevalue becomes <150 then program flow is shifted to water pump() function which activates the pump and the water extinguishes the fire.

If the program flow comes out of the while loop because of the 'obstacle' variable becoming 1 then the obstacle avoidance algorithm is executed. The robot avoids the obstacle and resets the 'obstacle' variable back to 0.

## III - RESULT

A) Hardware Implementation:

Table 1- List of components

| Sr. No | Components | Specification |
|---|---|---|
| 1 | Arduino uno R3 | ATmega328P, 5V, 16 MHz |
| 2 | Flame sensors | 5V, 20 mA |
| 3 | IR sensor | 5V, <30cm |
| 4 | DC motors | 100rpm, 3V-9V |
| 5 | Motor driver, L293D | 4-channel driver |
| 6 | Ultrasonic distance sensor, HC-SR04 | 5V, 2cm to 4 meters |
| 7 | Servo motors (SG90) | 3.0V~ 7.2V, 1.2kg-cm |
| 8 | Bluetooth module, HC05 | 2.4GHz ISM band, 3.3 V |
| 9 | Water Pump | 5V |
| 10 | Relay | 5V 2mA |

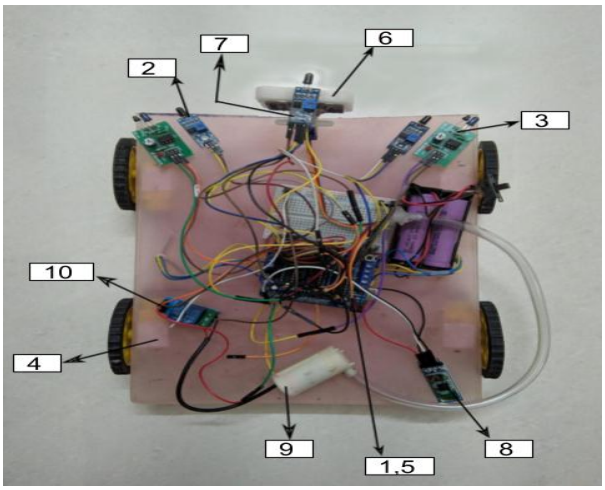


Fig.2-Firefighting robot (top view)

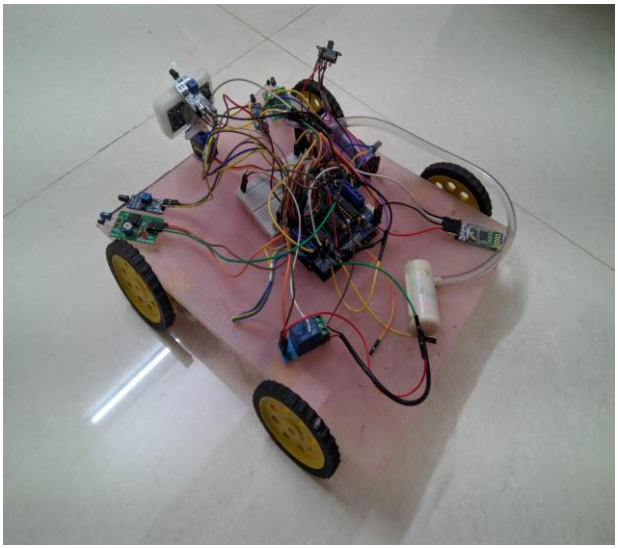

Fig.3- Firefighting robot (side view)

The list of all components employed in the fabrication of firefighting robot have been displayed in Table 1. The specifications of all the components are also indicated along with the component list.

B) Software Implementation:

(i) Proteus Simulation

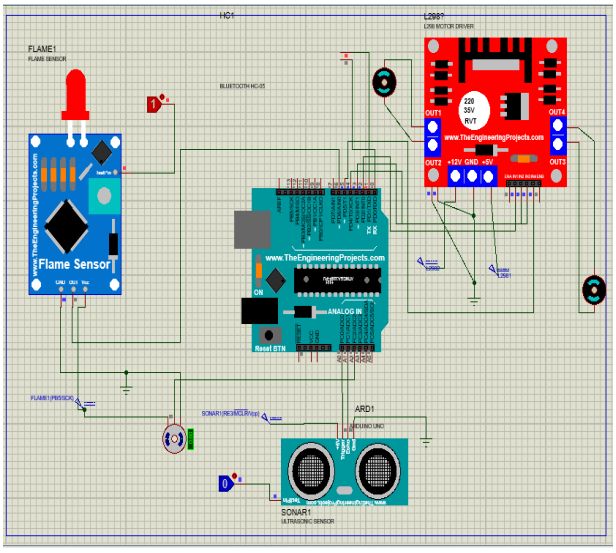


Fig.4- Firefighting robot in a Proteus simulation

Fig.4. shows the circuit diagram of Fire Fighting Robot in Proteus Software. A logical toggle is attached to the flame as well as the ultrasonic sensor's test pin. On simulating, initially both the logical toggles are set to logical '0'. When it sets the flame sensor's toggle to logical '1' (simulating as if the fire is detected by a sensor in real-time), the motors connected to the driver

start running (simulating the robot moving towards the direction of fire in real-time).

(ii) Arduino output

1. Obstacle Detection

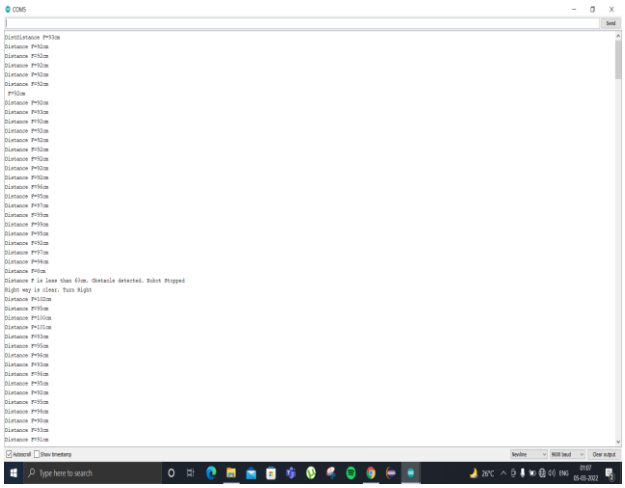

Fig.5- Readings obtained in a serial monitor for obstacle detection

Fig.5 shows the readings obtained by an obstacle sensor in a serial monitor. The Arduino constantly calculates the distance by using an Ultrasonic Sensor. When distance F is greater than 60cm, the Robot continues to move forward. As soon as distance F becomes less than 60cm (obstacle is detected), the robot stops. It searches for a clear path on Left and Right. As seen in the Serial Monitor, the robot finds the Right way as a clear path and turns towards the Right side. It again continues to move forward (calculating the distance 'F' simultaneously) until it encounters another obstacle.

2. Fire Detection and Extinction

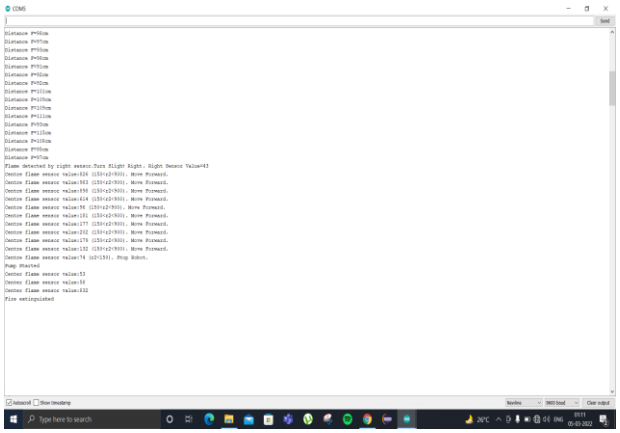

Fig.6- Readings obtained in a serial monitor for fire detection and extinction

As seen from the serial monitor shown in Fig.6., the right flame sensor of the robot has detected fire. The robot turns slightly so that the center flame sensor comes in the line of sight with the fire source. The center flame sensor then calculates the sensor value. Until the center flame sensor's value lies between 150 and 900, the robot continues to move forward in the direction of fire. As soon as the center flame sensor value becomes less than 150(On Serial monitor Center Flame sensor value becomes 74(which is <150), the robot stops and Pump is Started. The pump() function calculates the center flame sensor value simultaneously while the pump is running. As soon as the fire is extinguished, the center flame sensor value becomes greater than 800(On Serial monitor value is 832 which is greater than 800), and the Serial monitor displays "Fire extinguisher".

## IV - CONCLUSION

A firefighting robot equipped with a flame sensor and obstacle sensor has been fabricated and tested in a simulation environment. The same results have been validated with the help of an experimental prototype. It IS concluded that a robot can be deployed in lieu of people, lowering the firefighters' danger of death. This firefighting robot can be utilized in our homes, labs, and offices, among other places. This robot improves our ability to notice the flame and extinguish it before it becomes uncontrollable and a hazard to life. As a result, this firefighting robot has the potential to play a critical role. The firefighting robot is tested for both the modes i.e., automatic and manual mode. Both the modes have been properly tested in both the simulation and in the experimental prototype. The proposed firefighting robot is reliable, cost-effective and efficient and it can be employed in firefighting operations to eliminate the problems faced by firefighters.

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