A Novel Firefighting approach using Automated High Resistance Robot

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Abstract

Fire incident is one of the dangerous disasters which results in property damage, loss of life and even causes permanent disability to the affected victims. Firefighters are primarily aims to handle the fire incidents, saving the people lives and properties. They even control the fires in woods and saves animals lives while being exposed to higher risks, especially in hazardous environments such as in nuclear power plants, petroleum refineries and gas tanks. They also faces other difficulties, particularly if fire occurs in a narrow and restricted areas, as it is necessary to explore the ruins of buildings and obstacles to extinguish the fire and save the victim. There is a need for technological innovations which could help firefighting with an automated means. Therefore, this project presents the development of a novel Firefighting Robot(FRob) that can detect and extinguish fire without the need of firefighters to be exposed to unnecessary dangers. FRob is designed to be compact in size compared to other conventional firefighting robots in order to ease small location entry for deeper reach of extinguishing fire in narrow space. It is also equipped with an Ultrasonic Sensor which is used for object detection and is used for measuring the distance between obstacle and robot and avoids the robot hitting obstacles. It is capable of identifying the fire location automatically and extinguish the fire. A human operator can monitor the robot performing fire extinguishing operations using the camera mounted on it which is being connected to a smartphone or remote devices.

Keywords:*Fire incidents, Firefighting robots, ArduinoUno,ATMEGA328P*

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1. INTRODUCTION

A Robot is a self-Operating device which aims to perform different functions usually assigned to humans or machines tasked with repetitive or flexible set of actions. Many studies have proved that robot can be advantageous in rescue operation, medicine, rehabilitation, and industry[1]. The industrial robots are being used as multi-function manipulators set for more specialized materials, divisions, gadgets or devices through various programmatic movements to accomplish various functions. Machine learning has also been interested in robotics though only a portion of recent evolution in robotics is combined with machine learning[2].

The Robotic Development projects has embedded machine learning algorithms which are used to build up intelligence in robots. This will result in accelerating the productivity in industry, although reducing the cost and electronic waste in a long run. Various studies have been carried out on the use of humanoid robots for minimizing the injuries and deaths of firefighters as well as increasing efficiency, quality of the task, safety and productivity[3]. Robot can be categorized into groups comparatively Tele-robots, Tele presence robots, Autonomous robots, Mobile robots, Android robots.Tele-presence robots are extensively used in various sectors requiring monitoring capability like child nursery and education and on enhancing older adults Social and daily activities[4]. Mobile robots are designed for the purpose of navigation and various tasks are carried out without human intervention. Meantime, autonomous robots can be able to carry out tasks independently and get the power from the environment, as opposed to android robots[5].

There are several existing methods for firefighting at home and extinguishing forest fires. In this paper work, a novel and automatic firefighting robot proposed which aims to search and extinguish fire automatically.This prototype can be used for fire detection and rescue operations with high security without causing high risk for the firefighters. In other words, humans are being replaced with Robots for performing firefighting operations[6].

2. RELATED WORKS

Many methodologies such as Firefighting robot using RF Communication, extinguishing fire with the help of pumping mechanism, extinguishing the fire by throwing water with high flow rate, extinguishing fire in certain amount of time with the help of sprinklers has been proposed by many authors. A detailed explanation about these methods is as follows.

Durgesh Sharma et.al.[7] has developed a firefighting robot to reduce human life loss that automatically detect flame and extinguish it without the intervention of humans. This device makes use of IR flame sensors for detecting the fire place which are embedded to the arduino uno and controls the movement of motor driver towards the fire place and extinguishes with the help of pumping mechanism. It is observed that this robot model can be further integrated with a camera to observe the robot handling fire accidents.Malabika Chatterjee et.al.,[8]had demonstratedan arduino based firefighting robotic vehicle which can be simply operated from some distance. This robot is simply operated from some distance. This Robot is capable of sensing the flame using smoke sensor. This device can be employed in areas like small entrance and small place because of its compact structure. The firefighting robotic vehicle can be used in various applications such as petro chemical plants, hazardous areas like radioactive environment etc. It is noticed that this device can be mounted with a camera and can be enhanced by increasing the robot's ability of operating from larger distances and in all directions.

V.Mangayarkarasi[9] had presented a Remote controlled firefighting robot, which is a firefighting communication and is set and implemented using ATMEGA16. The proposed system is proved to be very advantageousfor both security and industrial purpose. At present, the robot is able to sprinkle water with high flow rate and in future, the robot will be able to throw water with controlled robotic arms and detect the objects using cameras mounted on it.K.Haiprasaath[10] has developed a robot that consists of flame sensors which can potentially sense the intensity of fire and act accordingly. The robot has been developed to detect the intensity of fire and can be employed at the place where the intensity of fire is more. The application of this robot include rescue operation during fire accident. The robot can be further developed by integrating camera to it and it will have the ability to drive over the obstacles. Poonam sonsale et.al[11] has proposed an intelligent fire extinguisher system which has the ability of sensing and extinguishing fire. The technology has been increased than in the earlier times.The Future expansion of this project can be integrating this intelligent firefighting system into a moving system and also by interfacing camera to it and enable to resist high flames.

N.Tejaswini et.al.,[12] has developed an RF based firefighting robot which is capable of accurately locating the position of the flames by actively scanning the entire place and obstacles so that the fire has more potential to spread. Fire can be detected and extinguished faster which in turn reduces the possibility of fire getting spread and save property from the damage.They aimed to extend their work by using artificial intelligence for automation operations.J.Jalani et.al.,[13]proposed an automatic firefighting robot with notification and is able to detect and extinguish the fire. It is also able to move randomly in a room with obstacle avoidance function. This Robot can be further improved by integrating a camera to it in order to view the firefighting operations performed by it.V.Apoorva Kumar et.al.,[14] has introduced a firefighting robot that works automatically when switched on and detects the fire and extinguish it. This work can be enhanced by adding object avoidance feature through the use of wireless thermal camera. This method fails to track fires incidents at longer distances.

These existing methodologies [7,8,9,10,11,13,14] have few drawbacks such as robots in existing methods are not interfaced with a camera in order to monitor the firefighting operations performed by the robot.Few models [10, 14] proposed do not have the ability to drive over the obstacles. Theseprototypes fails to detect the obstacles from longer distance and do not poses large FoV and are unable to resist the huge flames. Motivated by these failures a novel and robust Firefighting Robot (FRob) is proposed in this work that aims to handle the fire incidents automatically and helps the firefighters in reducing human involvement. It bags the enough number of sensors to track the fire incident situation and can be operated remotely. The rest of this paper presents the required materials and proposed model (section 3), experimental results (section 4) followed with conclusions and future scope.

3. MATERIALS AND METHODS

3.1. Requirements

The proposed FRob prototype requires the following hardware:

Arduino Uno, ESP32 Wi-Fi Cam,Flame Sensor, Ultrasonic Sensor, Relay, Motor Drivers, DC gear motor, Servo motor,Water pump motor.

Arduino Uno is a microcontroller board based on the Atmega328p.It has 14 digital input/output pins (of which six can be used as pulse width modulation outputs), six 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 an AC-to-DC adapter or battery to get started. The presence of fire incidents is sensed by the flame sensor and the obstacle detection is done through the use of ultrasonic sensor. Using these inputs the robot movement and actions over extinguishing the fire is been controlled by the proposed micro controller. The specifications of the required hardware is presented in table 1:

Table 1: Hardware Specifications

S.No.	Hardware Name	Specification
1	Flame Sensor(YL-38)	Wavelength of light : 760nm-1100nm, Detection angle nearly 60^0, Distance: 20cm(4.8V) to 100cm(1V).
2	Ultrasonic Sensor(HC-SR04)	Distance : 2cm-400cm, Angle approximately 115 degrees, Operating Voltage : 5V
3	Motor Driver(L298N)	Maximum Operating Voltage : 46V, Peak output current per channel : 2A, Minimum logic voltage:4.5V
4	DC Gear Motor	Maximum Torque : 3kg-cm at 12V Max Load Current : 330mA at 12V
5	ESP32 Wi-Fi Cam	Image output format : JPEG (onlysupportedbyOV2640),BMP,GRAYSCALE Spectrum Range : 2412 - 2484MHz
6	Arduino UNO(A000066)	Operating Voltage : 5V
7	Servo Motor(SG90)	Operating Voltage : 5V, Rotation : $0\text{-}180^0$, Gear type: Plastic.
8	Water pump motor	Maximum output capacity : 500 Total head : 50 Suction head : 8 Pressure bars : 5
9	Relay	Supply voltage – 3.75V to 6V Relay maximum contact voltage – 250VAC or 30VDC Relay maximum current – 10A

The algorithm of the proposed model is developed in Embedded C and simulatedonArduino IDE. Arduino IDE is an open source platform which is used to program the microcontroller to perform some specific task. In this work, we are using Arduino IDE software version 1.0.6. Arduino IDE supports C and C++ programming languages.

3.2 Proposed FRob model

FRob consists of several sensors, microcontroller, relay, motor drivers, gear motors, Rover Model and water pump motor. Arduino Uno is a microcontroller which is connected with other components. Ultrasonic sensor in FRob detects the obstacles in its way and moves away from them and flame sensor detects the fire and extinguish it by spraying water. A human operator can monitor the robot performing firefighting operations using the camera which connects to a smart phone.The block diagram of FRob is shown in the figure 3.1.

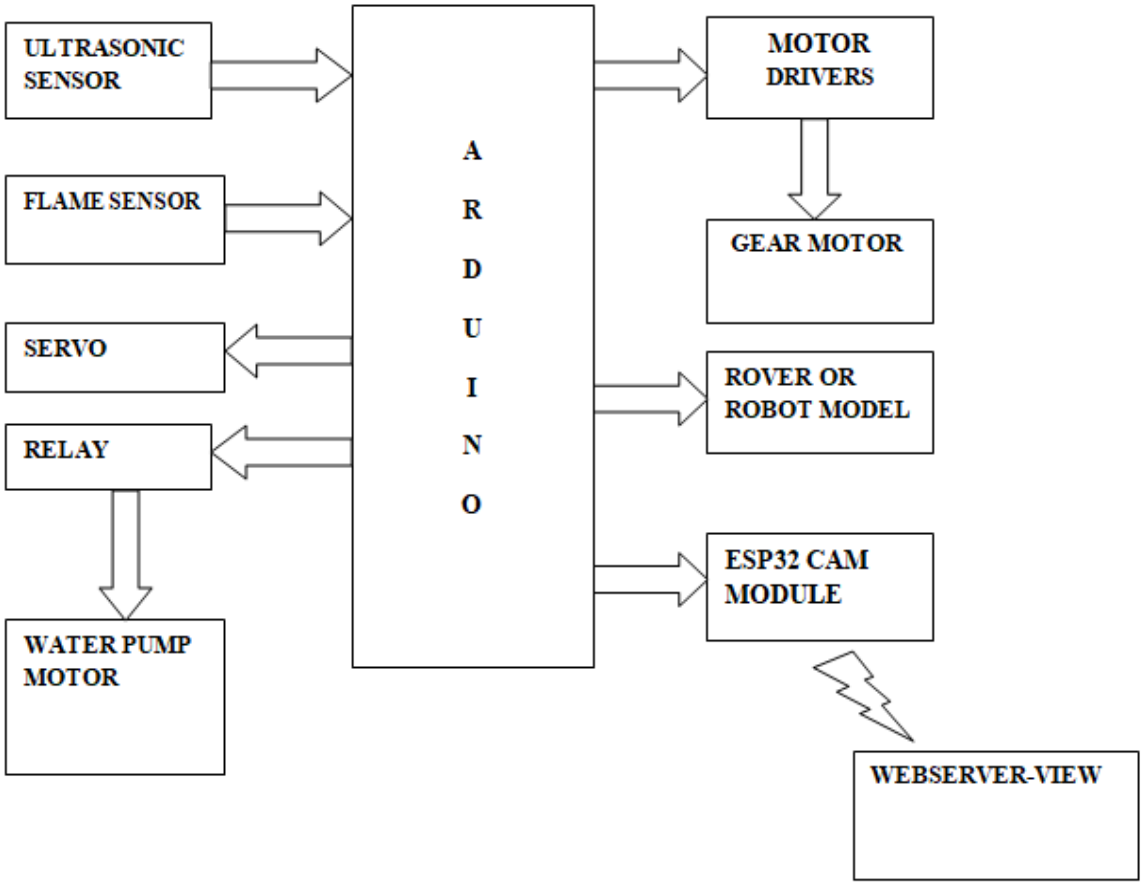

Figure 3.1: Block Diagram of Proposed System

To add some additional features and to modify the project like live video stream through web server with the help of ESP32 CAM Module. Also it detects fire with the help of flame sensor and spray water on the fire. The video will be shown in our smart phone for dedicated web server address (e.g.192.14.63.1).The ESP32 Wi-Fi Cam is of small size and it requires less power to operate. This Camera module is based on ESP32. It consists of an 0V2640 camera and it has on board TF Card slot. The ESP32 can be extensively used in various IOT applications.

4. EXPERIMENTAL RESULTS

The Proposed Firefighting Robot shown in figure 4.1. When the power module is switched ON, the proposed FRob starts detecting the flames and obstacles using the flame and Ultrasonic sensors. If any obstacles detected, the robot moves away from it. If any flame detected, the robot will move towards the flame and extinguish it by spraying water. A human operator can monitor the robot performing firefighting operations using the camera which connects to a Smartphone.

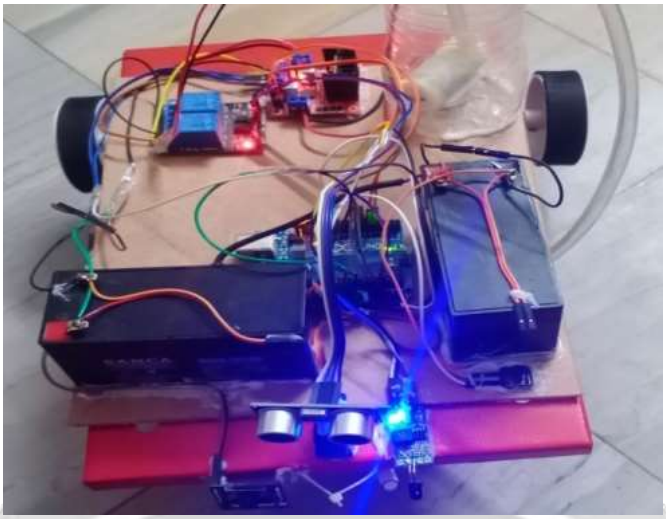

Figure4.1:Proposed FRob Robot

When the power supply is given, the robot starts moving and the ultrasonic sensor detects for the obstacles, if any obstacle is found in its way, the robot stops and send the information to Arduino, then the arduino gives command to gear motors to move away from those obstacles. The robot detecting obstacles is shown in the figure 4.2.

Figure 4.2:Robot detecting Obstacles

After giving power supply to the Robot, it starts moving searching for presence of fire. The proposed robot is equipped with flame sensor which is used for detecting the fire. If the fire is detected by the flame sensor, it will send the information to the Arduino and the arduino will send command to the gear motor to move towards the fire. The Robot detecting fire is shown in the figure 4.3.

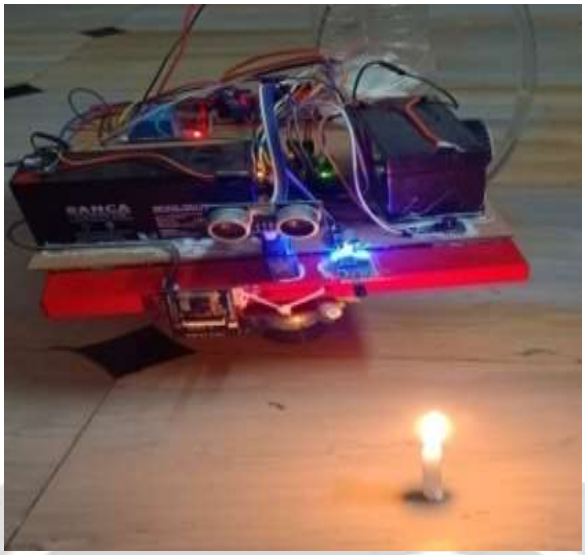

Figure 4.3: Robot detecting fire

The robot extinguishing fire is shown in the figure4.4. The robot starts moving automatically when switched on and starts searching for fire, if any fire source is found then the device moves towards the fire and starts extinguishing it by pumping water on the flame.

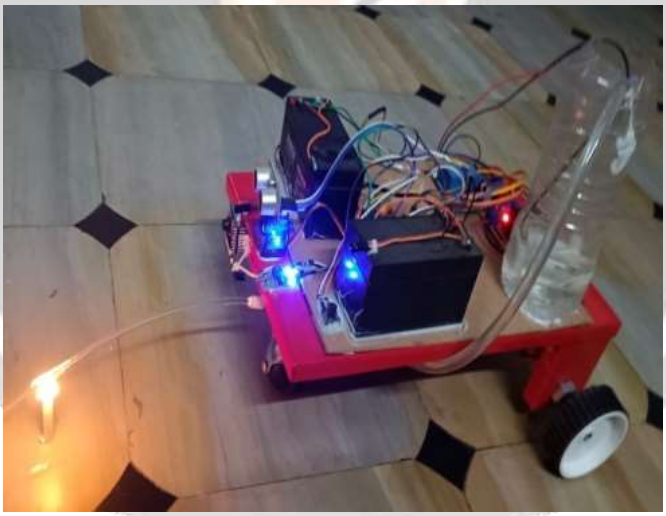

Figure 4.4:Robot extinguishing fire

After detecting the flame, the flame sensor send the information to arduino, Arduino give the command to gear motors to move towards the fire. The robot stops at some distance from fire and starts extinguishing it by spraying water. In this way the robot handles the fire which is shown in figure4.5.

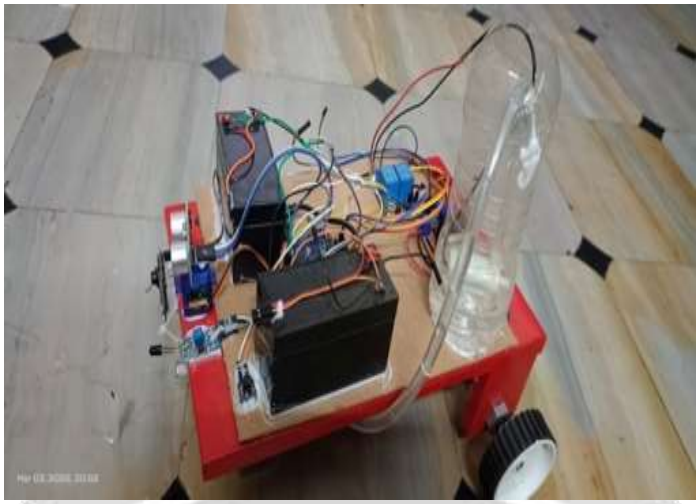

Figure 4.5:Robot handled fire

5. CONCLUSIONS & FUTURE SCOPE

An instinctive firefighting robotmodel is proposed in this work, which has some beneficial features such as capability of detecting the presence of fire automatically because of its compact structure. FRob is capable of avoiding the obstacles due to its provision of ultrasonic sensor. This model can be employed in the narrow and restricted areas. The operator can view the robot performing the firefighting operations using the camera interfaced to it which is connected to a smart phone.

This project work can be further enhanced by integrating few advantageous features such as, 360^0FoV in all the directions with an ability to resist huge flames from longer distances. This enables the human operator to monitor the firefighting operation performed by robot in all the possible directions and can manually assist it.

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