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Fire Fighting Robot

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Abstract
Fire disaster is a major problem that can cause loss of life, physical and mental trauma and damage to properties. The innovation in technology leads to robots that can help to extinguish fire without any loss of life. This paper aims to design and implement a firefighting robot which helps in detecting and extinguishing fire using water Raspberry pi 3 microcontroller interfaced to sensors. The ultrasonic sensor and flame sensor is used to manoeuvre through the room and detect the fire. The buzzer sounds to indicate the detection of fire and the fire is extinguished by pumping.

Keywords: *Robot, Raspberry pi 3, firefighting, sensors*

1. Introduction

A robot is an automated device that usually performs functions attributed to people or machines tasked with flexible set of actions. With the development in the field of robotics, robots can be used in the fire scene without getting the firefighters directly involved. The firefighters face challenges like high temperature, dust, low humidity and life threatening situations like explosion and collapsing building in real scene. In such case, a firefighting robot can aid fire fighters in saving life.

Hisanori Amano et al. developed a fire-fighting robot which uses "Master-Slave Operation" but works on human commands. It detects and controls the fire without allowing it to spread around other places. Since it contains a web camera to view the condition around the surrounding, the robot is very large and heavy. It is mainly used in power plant stations, oil stations and gas stations [1]. Altaf et al. designed an Autonomous fire-fighting robot which uses White lines tracking System. The tracking sensor is programmed to track only the white lines to reach its destination fire and put it off. Here the robot's operation is fully controlled by human [2]. Hyorn Hong et al. developed a fire-fighting robot which uses "Ontological semantic technology" i.e., voice operating system. It works on the command passed by the operator from voice source. It comprises of two main parts which is the fire fighter robot and their assistance system. The fire fighter robot is only used to extinguish the fire by spraying water through sprinklers. The assistance system detects the fire and passes the command to the operator. It also has a camera module to view the live stream of the robot [3]. Ahmed Hassanein et al. developed a fire-fighting robot which have many features like traversing a map, obstacle detection, detecting and extinguishing of the fire, live camera feed and map representation via Bluetooth. But this involves both manual and automatic operation. It blows the air around the fire to extinguish it which might result in spreading of the fire. A CO2 extinguisher is used in such worst case scenarios [4]. Jayanth suresh et al. designed an autonomous fire-fighting robot which is fully automated but works only for indoor purposes. The designed robot is very small for detecting the fire at long distances [5]. Megha Kanwar et al. developed a fire-fighting robot which is based on IoT applications. It can give alert messages through mobile application and is controlled by human for its operation. The robot also detects the type of fire and uses either CO_2 or water for extinguishing it. It gives a complete analysis of the fire and sends report to the main station for their reference [6]. ShivaMittal et al. developed a fire-fighting Robot that monitors temperature and air quality of the fire sites. Its main advantage is that it can be used for long range at remote areas. The movement and operation of the robot is controlled by keypad and joysticks. It also provides live stream from the fire sites using camera module. [7].Saravanan et al. has designed and developed an Integrated Semi-Autonomous Fire Fighting Mobile robot with integrated

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ultrasonic sensors and infrared sensors. The wireless camera in the robot captures the video and transmits it to the base station [8]. An intelligent multisensory based security system that contains a fire-fighting system using an adaptive fusion algorithm for fire detection is developed by Poonam Sonsale et al. It uses a smoke sensor, flame sensor, temperature sensor for fire detection. The system detects the fire location and extinguishes fire by using sprinklers. Being an intelligent System, it cuts off the electricity of in affected area and activates the sprinklers inthat area [9]. Remote Controlled Fire Fighting Robot developed by Phyo Wai Aung et al. describes a remote control fire-fighting robot in which two sets of RF modules are used for transmitter and receiver. This helps the base station to know the condition of fire. Microcontroller PIC16F887 controls the robot by using wireless camera mounted on the robot. [10].

This paper aims at designing and implementing a firefighting robot prototype using Raspberry pi 3 microcontroller interfaced to different sensors. The ultrasonic sensor, flame sensor and H bridge IC helps to detect and navigate towards the fire. The DC motor is used to pump the water and extinguish the fire.

Section I gives the introduction to the firefighting robot. Section II explains the design methodology of the firefighting robot. Section III explains the software implementation of the robot. Section IV discusses the results of the firefighting robot followed by section V as conclusion and section VI has the references of the papers.

2. Design Methodology

The Firefighting robot is designed to navigate alone on a modelled room and actively scan the room for flames of fire. This robot is designed in such a way that it searches fire &extinguishes it before the fire could spread out of range &control. This type of firefighting robot can be expected to work with real firefighters and aid in saving many lives. For the desired operation, Raspberry pi 3 microcontroller is interfaced to different sensors to detect the fire, navigate to the fire and extinguish it. The sensors such as flame sensor, ultrasonic sensor and H-bridge are interfaced to the microcontroller. The block diagram of the Robot prototype is shown in Fig 1. The ultrasonic sensor and the flame sensor detect the fire and help in navigating to the destination. L293D H-Bridge is used to send controlling commands for the navigation of the robot through the room in forward, backward, right or left directions searching for the presence of fire. Two motors are interfaced to the Raspberry pi 3 microcontrollers and they are used for the movement of the tyres in the vehicle. The dc motor in the firefighting robot pumps water and spray it on fire.

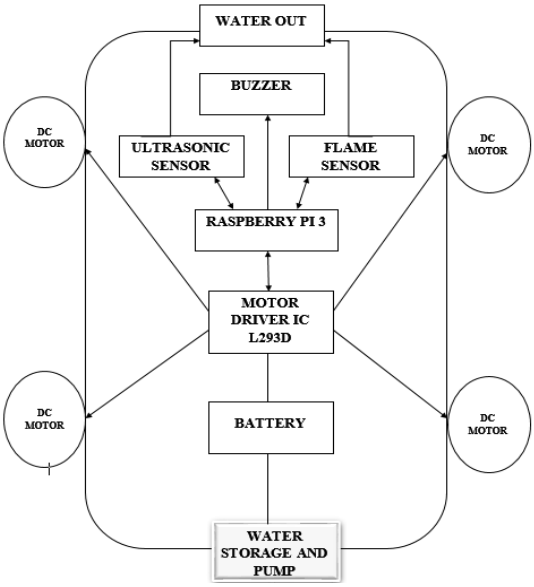

Figure 1: Block diagram of the designed robot prototype

Ultrasonic Sensor

Ultrasonic sensors measure the distance to the obstacle in its path by exploitation of the properties of the ultrasonic waves. The device head emits ultrasonic wave and receives the wave reflected back from the target. The ultrasonic sensor determines the gap to the target by measuring the time between the emission and reception of ultrasonic waves. The distance from the target may be calculated with the subsequent formula:

Distance D = 1/2 × T × V (1),

where D is that the distance, T is that the time between the emission and reception, and V is that the sonic speed. This paper uses HC-SR04 ultrasonic sensor as shown in the Fig.2.

Figure 2: HC-SR04 Ultra-Sonic Sensor

3. Flame Sensor

Flame Sensor sense or detect the flame using infrared flame flash methodology that permits the detector to sense the presence of flame in the surrounding region. The flame sensor IC used in the designed robot is IC4591 shown in Fig. 3.

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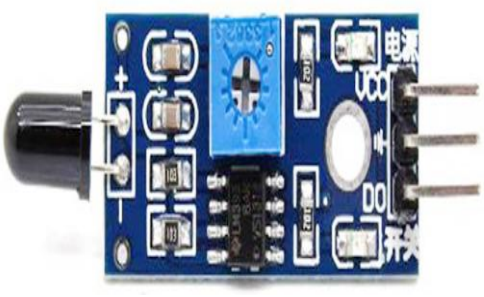

Figure 3: IC 4591Flame Sensor

L293D H BRIGE IC

L293D H-Bridge is used to send controlling commands for the movement of the robot in forward, backward, right or left directions as shown in Fig. 4.

Figure 4: L293D H-Bridge IC

Battery

In this project we are using two 6V Lead Acid batteries for the power supply of the entire system.

Buzzer

A Buzzer as shown in Figure 5 is a 2-pin structure with a continuous beep sound. It is programmed to generate beep sound when it reaches near fire.

Figure 5: Buzzer

Raspberry Pi

The Fire-Fighting robot is fully controlled by the Raspberry pi, so it acts as a controller of the system. All the sensors are controlled by the controller using GPIO pins. Since the main operation of the robot is its movement, L293D IC is interfaced to the controller and decides the direction of the robot. The obstacles are detected by the ultrasonic sensor and a pulse wave from the sensor is sent to the controller which calculates the distance between the obstacles and the robot. This aids in deciding the direction. The Flame sensor is also controlled by the GPIO pin which sends a signal to the controller to extinguish the fire. The controller switch on the pumping motor and it sprays water on the flame. To indicate the presence of flame, a buzzer is also interfaced with the controller.

4. Software Implementation

The Raspberry Pi is programmed using Raspbian Jessi. The ultrasonic sensor returns a pulse whose period is equal to the time taken for ultrasonic pulse to travel from the sensor to the object and back to the sensor. This signal is sent to the controller and it directs the system to either change the direction of the robot or stop the robot. The GPIO pins are used to control and monitor the system effectively and operate the robot. When the flame sensor detects the flame and it gives signal to the controller. The controller operates the pump motor to spray water on the flame. The flowchart of the software implementation is shown in Fig. 6.

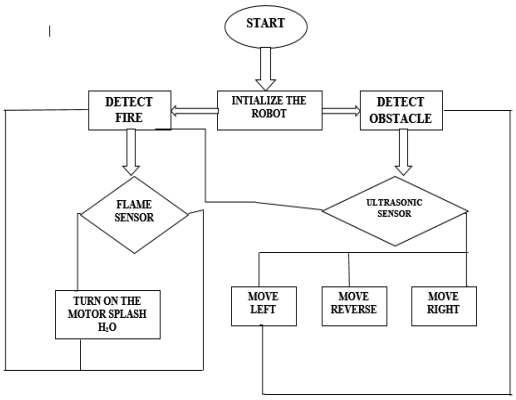

Figure 6: The Flow Chart

5. Results and Discussions

A candle or lighter was used to test the robot. The lit candle was placed in one end of the room. The powered on robot manoeuvre across the room with help of the ultrasonic sensor and detect the fire using flame sensor which send signal to the Raspberry pi controller. The fire activates the buzzer and the controller directs the dc motor to pump water across the fire. The designed firefighting robot prototype is shown in Fig. 9. The designing of this robot was very cost effective

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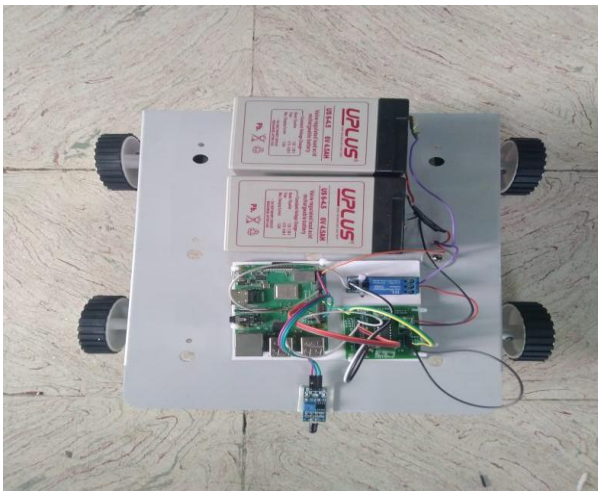

Figure 7: Fire Fighting Robot

6. Conclusion

Fire can cause huge harm and loss of human life and properties. Sometimes, due to explosive materials, smoke and high temperatures, it is difficult for firefighter to reach the vicinity of flames. This project aims at designing a cost effective firefighting robot. This will aid in fighting fire disasters effectively and safely. The movement of the robot is controlled by the sensors that are fixed to the robot. This provide security from fire mishaps for our home, laboratory, office, factory and building as future work, we aim at developing an intelligent multi-sensory security system which includes a fire-fighting system for our daily lives. The designed robot can only extinguish fire in the present room, and cannot navigate to all other rooms to extinguish fire. The robot could also not operate through the batteries because the current circuit level rises to about 0.8A at certain times, which is very high and cannot be achieved with batteries.

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