Design and Implementation of Automatic Fire Sensing and Fire Extinguishing Robot using IoT

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Abstract : *Fire incident is a disaster that results in the loss of life, damage to the property and endless disaster to the victim. Fire extinguishing is an exceptionally unsafe undertaking and it might likewise include death risk. Robotics is the answer to ensure the safeguarding of the surroundings and also the life of firefighters. Fire sensing and extinguishing robot is a model which can be used in extinguishing the fire with minimum human intervention. There is a threat to the life of the fire fighters in extinguishing the fire and there are some difficult areas where they cannot reach like that in the tunnels. At similar kind of places this automatic robot is veritably useful to perform the task. This robot can be controlled remotely by mobile phone using Bluetooth module. The robot is equipped with the flame sensors that automatically detects the fire and gives the further signal to the extinguisher units to start the pump and extinguish the fire by spraying water. Arduino uno is used as the microcontroller to operate the whole operation. The proposed robot has been used for various trials and proper evaluation has been done to check the proper functioning and to get the desired result.*

Keywords – Arduino, Bluetooth RC controller, ESP32 cam, Flame sensor, Water Pump

1. Introduction

A robot is an automated device which performs several tasks as that of the humans to ease their work. They are designed to operate in extreme conditions in which a normal human can't work. They are flexible and can be designed according to the need. Now a days robot are used for rescue operations [1]. The need of the current scenario is to develop robots equipped with the latest technology regardless of their types or specifications.

In recent time robots are being developed equipped with Artificial Intelligence, Internet of Things to increase their intelligence and flexibility [2-4]. Machine Learning is also being applied to the robots and as Artificial Intelligence and Machine Learning are budding technologies so they have increased the demand of use of robots in different areas. In this project a fire extinguishing robot has been proposed which is capable in extinguishing fire with minimum human intervention. There are some of the existing robots for extinguishing the fire at home and to extinguish forest fires as well [5]. Our designed robot is capable of detecting the fire and extinguishing the fire according to the direction of flame. The movement of the robot can be controlled remotely a by smart phone. By using such robots fire sensing and extinguishing will become a much easier and safer task without risking the life of fire fighters. In other words, robots can be used to extinguish fire in a much safer way. Being a compact size robot, it can extinguish fire in hazardous conditions and narrow spaces where a human can't reach [6, 7].

The camera mounted on the robot will help to monitor the surrounding environment and to help the robot to move in a proper direction. The live view of the camera can be seen on the smart device. By the help of the camera, we can easily view the environment and can see the extent of hazard occurred.

The proposed robot can sense and extinguish fire and can be controlled remotely. It will help to extinguish fire in a much safer and easier way. The aluminium composite body makes it lightweight and helps to withstand more temperatures.

2. Hardware and Software used
2.1 Hardware
2.1.1.   Arduino Uno

Fig.1. arduino uno

The robot is made up and interfaced with all other components using two microcontrollers known as Arduino uno. The board has some set of digital and analog input/output pins that may be connected to various sensors and other circuits [8]. The board has 14 digital I/O pins (six of them is PWM output) along with 6 analog Input pins, and can be programmed using the Arduino IDE (Integrated Development Environment), by connecting it to a device containing the IDE. The power is supplied by the USB cable or by an external 9-volt battery. It has a voltage limit between 7 and 20 volts.

2.1.2.   L293D Motor Driver

Fig.2. L293D motor driver

L293D is a typical Motor driver circuit board which helps in the movement of DC motor on either direction. L293D is a 16-pin IC which can control a set of four Gear motors simultaneously in both directions. It is used as a shield with Arduino. It can be interfaced with Arduino by mounting it over the Arduino. The movement of gear motors are controlled by the Motor driver.

2.1.3.   Bluetooth Module

Fig.3. Bluetooth Module

HC-05 Bluetooth module provides the connectivity between the smart device and the robot. It helps in controlling the robot using the smart device. Radio waves are used to transmit and receive the commands. The movement of the robot is commanded by sending the commands by the smart device.

2.1.4. Flame sensor module
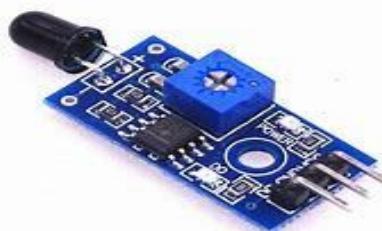
Fig.4. Flame Sensor Module

The Flame Sensor Module can detect flames in the 750 – 1100 nanometer wavelength range [9]. It is used to detect small flames and it can detect a flame at roughly 0.8m. The detection angle is roughly 45 degrees and the sensor is sensitive particularly to the flame spectrum.

2.1.5. Relay Module

Fig.5. Relay module

A 2 channel& 5V relay module can be used as a switch to ON or OFF a device which requires a sudden load of large voltage. It has two outputs which can be used to switch between ON and OFF in a fast way. It has two outputs as normally open and normally closed. The functions of the two pins depend on the connection of the input pins with the ground.

2.1.6. Servomotor

Fig.6. Servomotor

A servo motor is a rotating actuator or linear actuator that takes power and helps in the rotation of small objects along with it in a very precise manner. It controls the angular or linear movement, velocity and acceleration. It consists of a motor coupled with a sensor for controlled movement [10]. In our project one end of the pipe is connected with the servo motor to control the direction of flow of water according to the data received so that the water can be sprayed in the direction of the flame.

2.1.7.   Gear motor

Fig.7. Gear Motors

A gear motor is a rotating motor equipped with gears which is used to move the robot with heavy weight mounted on it. The gears provide the strength to the motor to bear more load.Gearmotors act as torque multipliers and speed reducers which reduces the power consumption to drive a given load.

2.1.8.   ESP32 Cam

Fig.8. ESP32 Cam

The ESP32-CAM is a full-featured microcontroller equipped with an integrated video camera to capture the video and send it to the smart device. In addition to that it also has an integrated slot to store the recorded video. It is cheap and can be used conveniently in those IoT projects which require a camera. It has components on both of its sides. The camera is integrated on one side while the pins are on other side. The camera is replaceable as it is connected through the pins on the top of the board. The camera is of 2 megapixels and its video transfer rate is 15 to 60 fps.

2.2. Software
2.2.1.   Bluetooth RC Controller

Fig.9. Bluetooth RC controller

It is an application available on Play store which is capable of controlling the movement of the robot using Bluetooth module. This app provides a good interface to control the robot and has multiple buttons as shown in Fig.9. The app has options like left turn, right turn, taper turn, horn and headlights to control the robot. The speed of robot can also be controlled by using this application. The app gets connected to the robot using Bluetooth through Bluetooth module.

3. Working

The robot is moved to fire location with the help of Bluetooth RC Controller application which is controlled by the operator operating the robot using a smart device from a remote location. The motor driver and the gear motor help in smooth and hassle-free movement of the robot. The movement of the robot is guided by the ESP32 cam which sends the real time video of the location and the video can be seen on the smart device. When the robot reaches the destination, the three flame sensors fitted on the front side of the robot detects the direction of the flame. These sensors are programmed in such a way that they will send the particular direction of the flame and will help in the movement of pipe by the servo motor in a particular direction. This data is sent to the microcontroller and the pump is switched on by another microcontroller with the help of the relay module.

Fig.10. Bluetooth RC controller

The aluminium composite sheet body helps the robot to withstand more temperature and the gear motor helps to bear more load and also helps in proper movement of the robot. All the real time video is sent to the smart device by the ESP32 camera, which helps in monitoring of the surrounding. The data received by the camera can serve as an aid to detect the amount of damage and also to detect whether there is any person got stuck over there. The robot is designed to reach the compact places like tunnels easily and can extinguish fire in a much more convenient way.
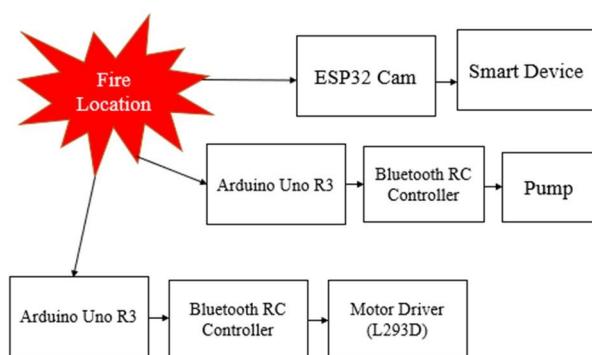

Fig.11. block diagram of firefighting robot

4. Discussion

The movement of the end of the pipe depends on the data received by the flame sensors fitted on the front side of the robot. The sensors are named as F1, F2, F3 from left to right.

a) When $F1 = 1$, $F2 = 1$, $F3 = 1$; servo moves: - 0˚ to 180˚
b) When $F1 = 1$, $F2 = 1$, $F3 = 0$; servo moves: - 0˚ to 110˚
c) When $F1 = 0$, $F2 = 1$, $F3 = 1$; servo moves: - 70˚ to 180˚
d) When $F1 = 1$, $F2 = 0$, $F3 = 1$; servo moves: - 0˚ to 180˚
e) When $F1 = 1$, $F2 = 0$, $F3 = 0$; servo moves: - 0˚ to 45˚
f) When $F1 = 0$, $F2 = 1$, $F3 = 0$; servo moves: - 70˚ to 110˚
g) When $F1 = 0$, $F2 = 0$, $F3 = 1$; servo moves: - 155˚ to 180˚

5. Conclusions

So, a firefighting robot has been successfully developed which can be controlled using smart device. The compact design of robot makes it easy to use in small areas. Moreover, the aluminium composite body helps it to withstand more temperature. The gear motor fitted in the wheels of the robot makes its movement and easier along with the load of the water and the whole body. The camera fitted in the robot makes it much more efficient and is very useful as it acts as an eye of the robot. As a conclusion, our proposed project "Design and Implementation of Fire Sensing and Fire extinguishing robot using IoT" has successfully achieved its aim and objective.

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