Fire Fighting Robot Using Machine Learning

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***Abstract*- Here a Raspberry pi-based robot will detect fire in the real-time video feed obtained from the camera. A robot runs on DC motors and is powered through a battery bank that will spray water in the direction of fire. On detection of fire, the robot will automatically turn on pumps to extinguish the fire and also provide buzer alert to provide a signal to the surrounding area. The robot automatically moves forward while checking for fire and as fire extinguishers. To detect the fire from images, a machine learning algorithm will be used and designed with the OpenCV tool. Raspberry pi board is at the center of this project. Since Raspberry Pi doesn't have an inbuilt power supply, it needs an external power adapter. Here, for capturing images, a camera module is needed. Whereas the DC pump is used to pump the water and motors are used to drive the robot. Since Raspberry pi doesn't provide sufficient power to drive motors and pumps. A separate motor driver is needed**

***Index Terms*: Firefighting Robot, Raspberry Pi, Image Processing, Tensorflow, Machine Learning.**

I. INTRODUCTION

In this new era of automation & artificial intelligence, identifying objects automatically and performing necessary actions is most important in most of the systems. With the rapid development of social science and technology, high-tech products have brought great convenience to our study and life. Various intelligent products are constantly emerging. Intelligent robots assisting labor or even replacing labor will become an inevitable trend.

Research on a smart indoor firefighting robot for intelligence prevent fires in the home, reduce fire safety hazards, solve practical problems, provide convenience for production and life, and demonstrate the social value of science and technology. A machine learning library by Google, named Tensorflow is the most advanced machine learning library with huge number of features. In robotics & automation, independent processors like Raspberry Pi have a wide scope with the capability to run image classifiers & Tensorflow. Python become the most popular & powerful programming language for machine learning & AI.

II. LITERATURE SURVEY

1. Fire Detection using Artificial Intelligence for Fire-Fighting Robots

Here author says[1], sensors such as flame sensors are currently used to detect fire in firefighting robots. The disadvantage of using sensors is that fire beyond a threshold distance cannot be detected. Using artificial intelligence techniques, fire can be detected in a wider range. Haar Cascade Classifier is a machine-learning algorithm that was initially used for object detection. The results obtained using Haar Cascade Classifier were not very accurate, especially when multiple fires had to be detected. Transfer learning from a trained YOLOv3 model was then used to train the model for fire detection to improve accuracy. The benefits and drawbacks of using deep learning for object detection over machine learning are highlighted. The algorithm used to obtain the target location the robot must move to use bounding box coordinates is also discussed in this paper.

2. Design and Manufacture of Indoor Intelligent Fire Fighting Robot

Paper presents a robot o meet the needs of fire prevention and rescue for families with high floors and no one at the time, a family firefighting robot with STM32F103ZET6 as the core was designed. The robot[2] carried out firefighting operations. Robots are very powerful. The one-to-many communication mode is adopted to carry out real-time monitoring of each easy fire point. Data transmission is carried out through the industry-level NRF24L01 module. Remote control is carried out with the camera and the WIFI module connected to the Internet. The experimental results show that the control of the robot through the WIFI wireless module is stable, achieving the expected effect of extinguishing agent injection, reducing the workload of firefighters to a certain extent, effectively reducing household fire risk and reducing social losses.

3. Research On Key Technologies Of Intelligent Fire Fighting Robot Based On Zigbee Network

At present, the existing fire extinguisher robots in China are generally unable to take into account the problems of autonomous movement, real-time monitoring and untimely extinguishing. In this paper, the intelligent fire-fighting robot based on Zigbee networks combined with Zigbee wireless sensor network technology, by building a network topological

structure of the wireless sensor network (WSN), to acquire and transmit real-time robot's own position and the work area of environmental data, such as path finding independent planning to fire extinguishing work, effectively solve the fire-fighting robot problems such as save not in time, make the fire-fighting robot is widely used.

4. Autonomous and Wireless Control Fire Fighter Robot:

The aim of this paper is to explore a new model to extinguish fire without much human effort. There has been a renewed and sustained interest towards safety in both public and private sectors. During the year 2016, 3,515 people died by fire or fire related injuries in the USA alone. The total estimated economic value of fire related damages in 2017 exceeds $300 billion. Industries are the most possible places of fire accident particularly those related to chemical/hydrocarbon manufacturing and or processing. An advanced autonomous fire extinguishing system can combat fire accidents and minimize damage to both human lives and property without exposing fire fighters to additional risks. The proposed robot can autonomously detect and extinguish fire before it spreads. The robot can, without any human input, navigate through hallways or corridors of any complexity, even places unreachable by a human, to reach the origin of the fire before it is allowed to spread further. The robot can automatically recognize and avoid obstacles to reach its destination. The robot, therefore, can not only be used to effectively fight fire but can also be deployed to assist in search and rescue operations at natural disasters such as floods, hurricanes, tornadoes, volcanic eruptions, earthquakes, tsunamis, and other geologic processes. It can also be utilized to carry up to 1kg of equipment or emergency supply to hard to reach places. Its camera view can be live streamed, and if needed controlled by an authorized personal using a smartphone from a safe place through its wireless capabilities.

5. Arduino based firefighting Robot

A fire fighter's work entails detecting and extinguishing fires. In this rapidly evolving technological age, the world is gradually moving toward automated systems. Firefighters, on the other hand, are often in danger of losing their lives. The majority of the deaths were caused by toxic gases found in the firefighting environment. As a result, to resolve these issues, our system was developed.

6. Fire Extinguishing Robot Using Arduino

In this paper, a fire extinguishing robot has been proposed and designed which detects the fire location and extinguishes fire by using sprinklers to trigger the pump. This robot uses three flame sensors for accurate fire detection. This proposed model of a Fire Extinguishing Robot using Arduino is used to detect the presence of fire and extinguish it automatically without any human interference. It contains gear motors and motor driver to control the movement of robot when it detects any presence of fire and will automatically start the water pump to extinguish that fire breakout. This model robot has a water ejector which is capable of ejecting water at the fire breakout place. The water ejector pipe can be moved toward the required direction using a servo motor. The whole operation is controlled by an Arduino UNO micro-controller.

III. PROBLEM STATEMENT

Fire accidents cause many deaths every year. It has become one of the major reasons for accidents worldwide. If the fire cannot be stopped early, it goes increasing the area and become very difficult to stop. This causes more damage to life and property. So in case of fire accidents, its important to detect and prevent fire automatically and as early as possible. It's also important to provide alert to the surrounding area so that people from that area will become alert.

IV. OBJECTIVES

After research on existing systems, bellow objectives are finalized for the project

- Successful implementation of fire detection algorithm using machine learning
- The system must detect fire in the visuals from the camera and turn on the water spray to eliminate the fire.
- The system must provide an audio alert in case of fire detection.
- The robot must move forward and check the next area for fire detection.
- To achieve the maximum possible accuracy & good detection speed.

V. CONNECTION DIAGRAM

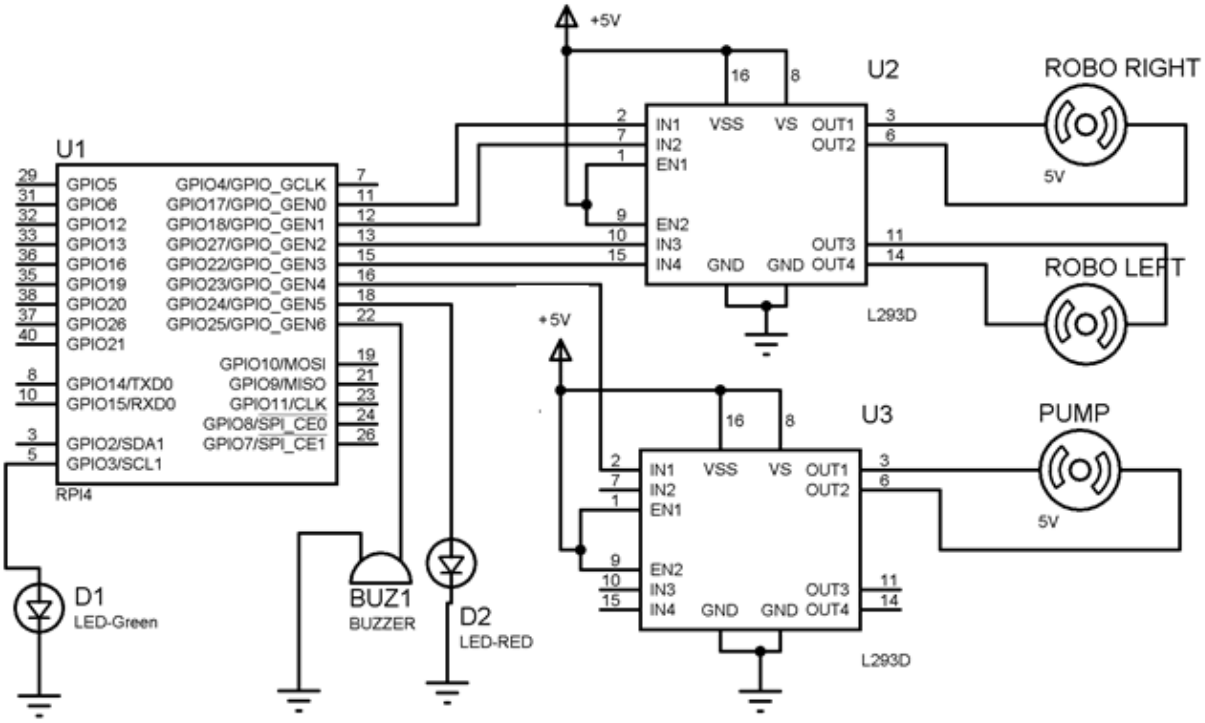

Figure 1: Connection Diagram of System

Here camera will be connected to Raspberry pi camera port, whereas the raspberry pi and complete system will be powered through 5V power bank. Raspberry pi captures images from live video feed of camera and detect fire using ML algorithm. If no fire detected, robot will move forward using robot motors. To dive the robot, two DC motors of 5V will be used. Both motors will be controlled by L293D motor driver module depending on the signal given by raspberry pi. Similarly, on detection of fire in image, raspberry pi will stop the robot and turn on the pump by giving signal to the second L393D module. At same time, it will turn on buzer and red LED.

VI. SOFTWARE IMPLEMENTATION

Implementation of software part has bellow steps:

- Install OS in Raspberry pi
- Install TensorFlow
- Install OpenCV
- Design a classifier to detect flames in the image
- Code to control the robot in the direction of fire

Figure 2 shows the steps involved in fire detection process. Whereas Figure 3 shows the flowchart for robot operation.

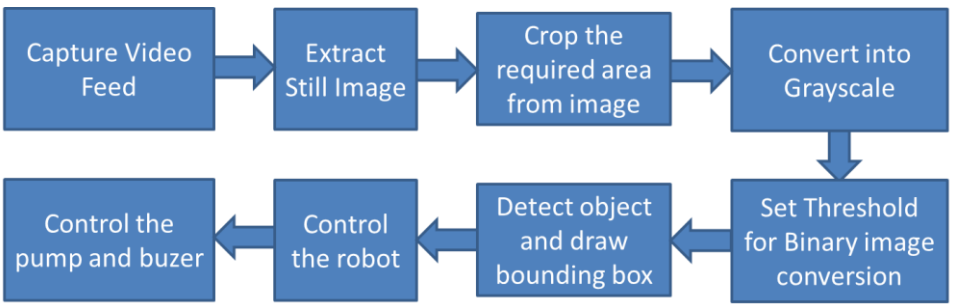

Figure 2: Steps To Detect Fire In Image

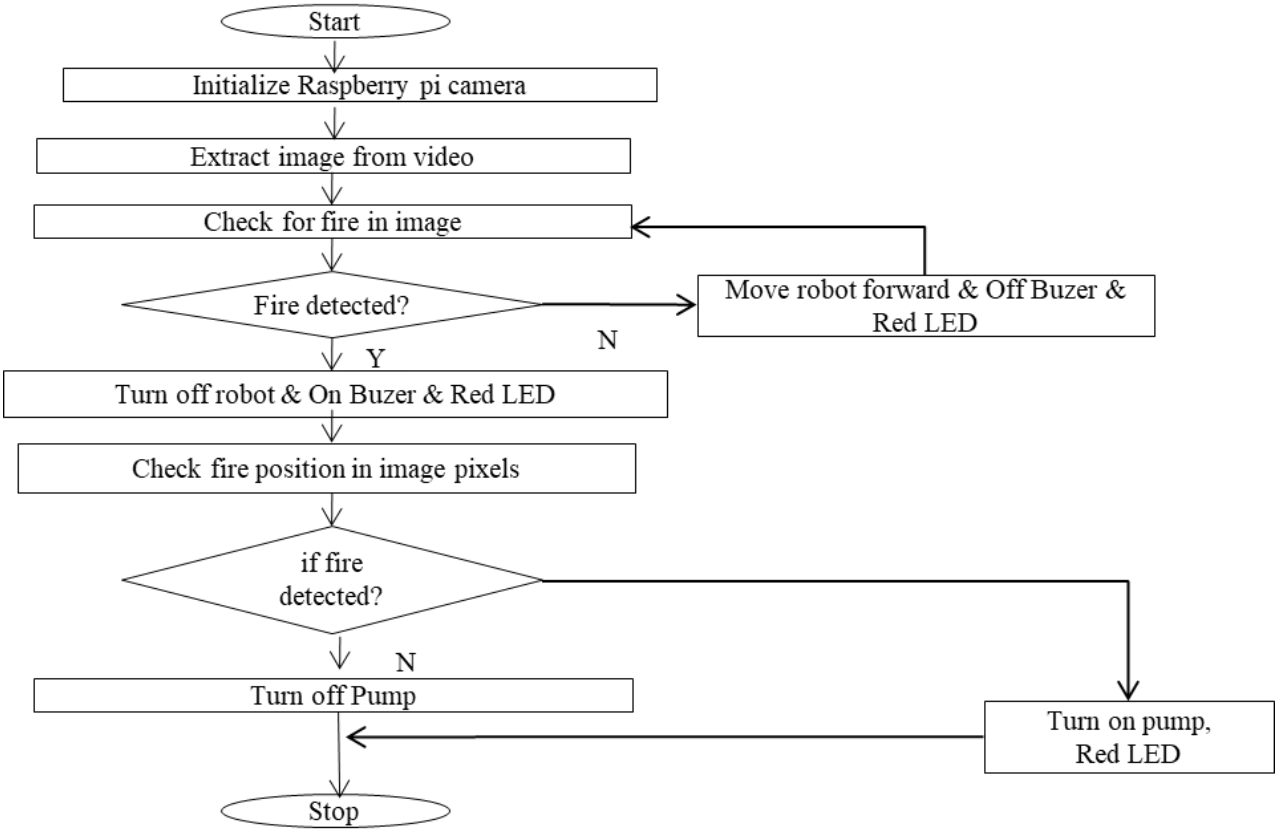

Figure 3: Flowchart for Robot Operation

VII. IMPLEMENTATION &TESTING

On running fire detection code in Python, it detects fire in the live camera feed. Here the image is divided into 2 quadrants. The result shows the text message contains the quadrant number in which fire is detected

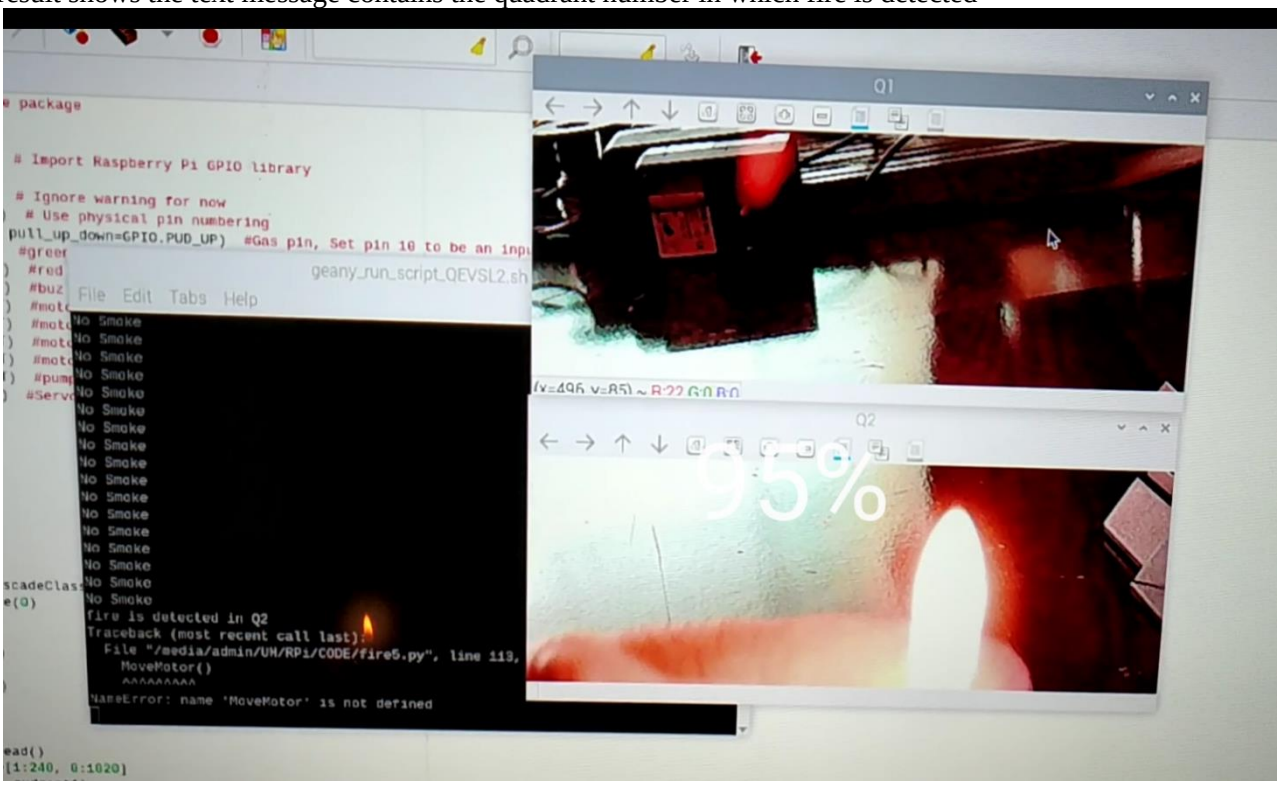

Figure 4: Fire Detection in 2nd Quadrant

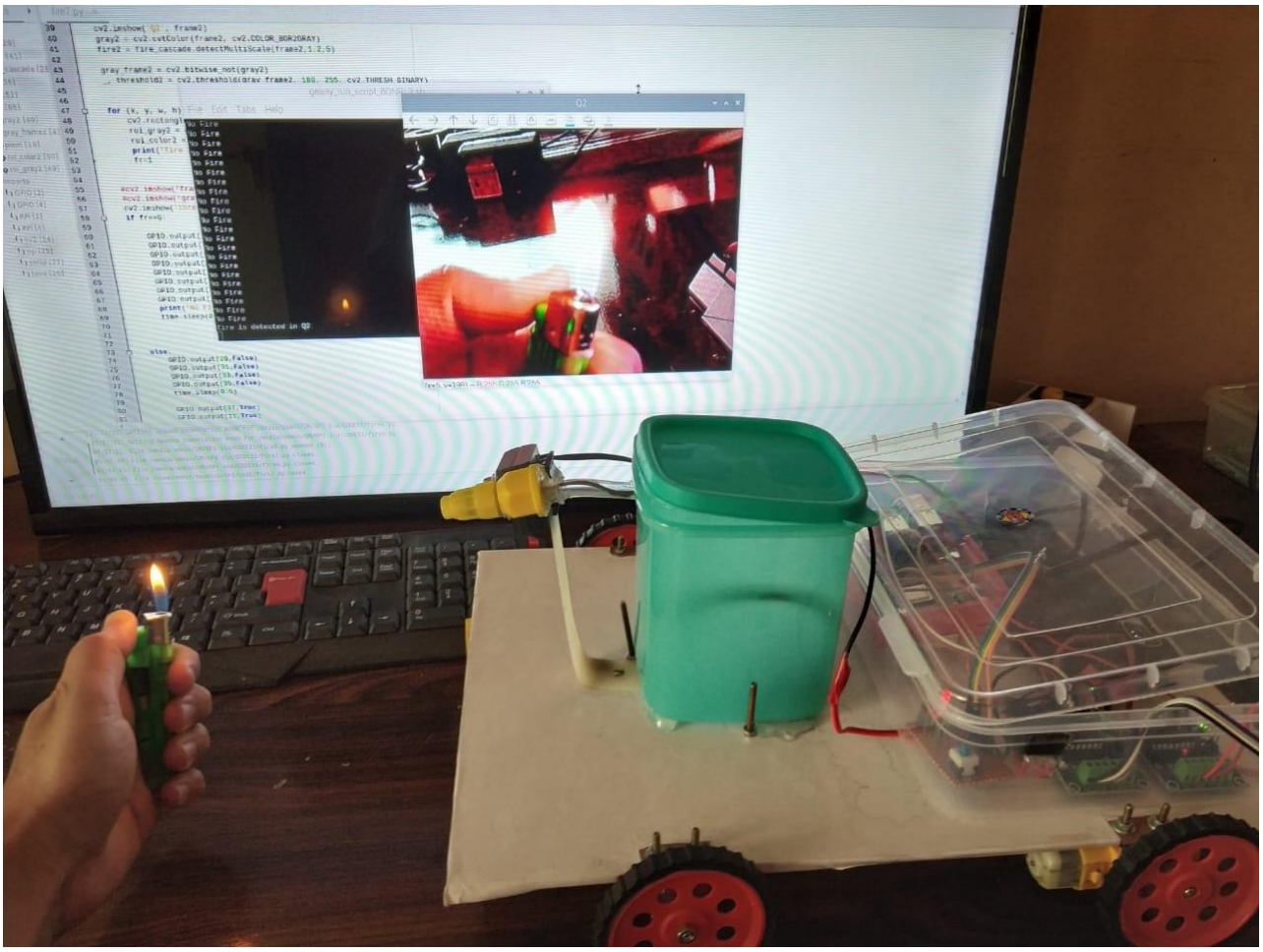

Figure 5: Complete Demonstration Setup

Here complete setup of robot containing raspberry pi with camera and water spray is shown.

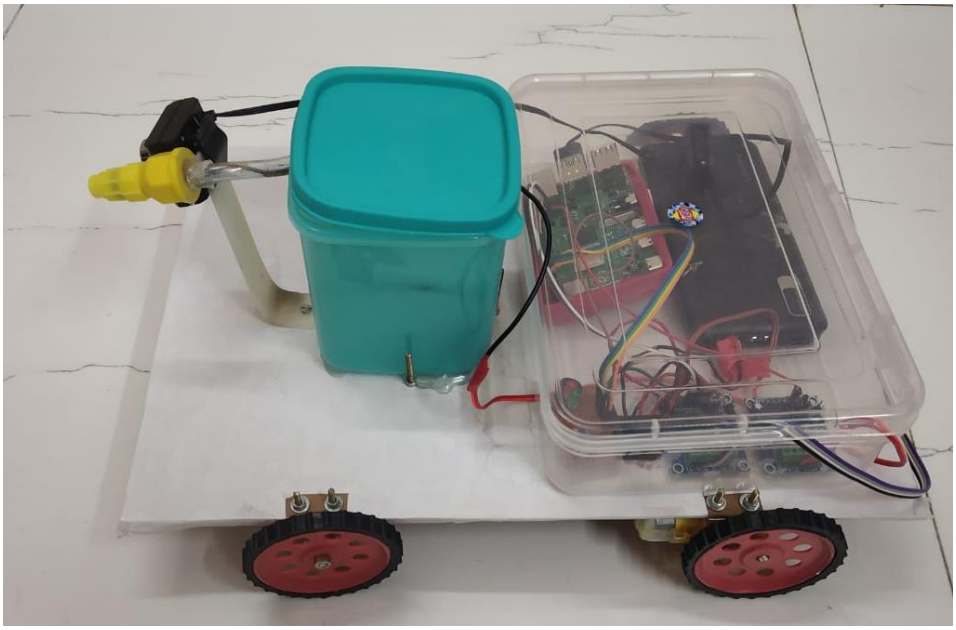

Figure 6: Robot Structure

VIII. RESULT & DISCUSSION

Here fire detection and extinguisher robot is implemented successfully. Specialty of robot is, it can detect fire in live video feed from camera and spray water to stop the fire. For this, an machine learning algorithm is used along with tools like raspberry pi, OpenCV, Python programming language. On detection of fire in video, robot stops and generate sound alert, turn on red light indicator and turn on the pump to spray water. A small buzer and LED are used to demonstrate the sound alert and LED indicator. This can be replaced with large size devices.

The complete system results are as follows:

- Detection accuracy 98%. Its high in low ambient light and decreases with increase in amount of light in environment. This happens because in high light environment, the flames are not visible.
- Detection distance is 5ft with small size 2-3cm flame height. Detection distance increases with increase in flame size and high resolution camera. If the flame size is large, it can be detect from far away.
- Detection time is less than 1 second. Since the camera used here provides 30 frames per second, system takes some more time around 500msec to detect the flame depending on ambient light and flame size.

Table 1: Final System Specifications

Sr. No.	Parameter	Value
1.	Detection Accuracy	95%
2.	Detection Distance	5ft
3.	Detection Time	1 Sec
4.	Audio Alert	5V Piezo Buzer
5.	Visual Alert	Red LED Of 5mm Size
6.	Water Spray Capacity	6-7 Lit/ Minute
7.	Water Storage Capacity	800 ml
8.	Camera Frame Speed	30 FPS
9.	Camera Resolution	640×480 Pixel
10.	Robot Speed	20 Meter/ Minute
11.	Battery Capacity	5000mAH
12.	Battery Backup Time	20-25 Minutes

IX. ADVANTAGES

- Detects fire automatically
- Spray water to stop the fire whenever necessary.
- As fire extinguished move forward and check the next area for fire.
- Runs on battery, so portable.
- Automatic operation makes it run 24x7.
- A buzzer sound signal will make a surrounding alert in case of fire detection.

X. LIMITATION

System cannot detect flames in direct sunlight since the wavelength and Colour of flames matches with the radiation present in sunlight.

XI. APPLICATION

Proposed robot can be used to detect and stop the fire automatically. This robot can be used at:

- Homes
- Offices
- Hotels
- Schools
- Super market & Shops
- Cinema Theaters
- Gardens
- Temples

XII. CONCLUSION

Main aim of the project was to identify and eliminate the fire using automatic robot. Here image processing method is used to detect fire. To trace the fire in image, image is divided into 2 quadrant which makes the decision when to spray

the water. Use of raspberry pi in this project was the best advantage due to its low cost and small size. With python programming language, fire detection in image was effective and quick. All the decided objectives are achieved successfully. Though its demonstrated on prototype vehicle here, actual implementation needed major modifications in vehicle structure.

Detection accuracy, detection distance and detection time are 95%, 5ft and less than 1 sec respectively. These parameters depends on camera quality, ambient light and size of flames.

XIII. FUTURE SCOPE

Research & development is endless process and it has no limitation. Though the project is working fine and all objectives are achieved, there can be some advancement can be done in future. One biggest need is to detect the flames in direct sunlight.

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