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Convolution Neural Network Based Fire Fighting Robot

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Abstract - *In this paper, proposed system detects and extinguishes fire using Image Processing. It is not practical to always rely on human patrol to detect and extinguish fire at a fire accident scene in real life. We can create an automated system for early detection and extinguishing of fire there by making the work of fireman easy and reduce loss of human life. Here we have built a model based on image processing and Raspberry Pi serial communication. At the user end, the fire images will be fed in the form of video frames. These images will be further processed. The proposed system uses RGB color space. It consists of hardware such as Raspberry Pi and USB Camera, for the surveillance. This camera will give a real-time video output to the user on the laptop or computer. In this way fire will be detected using this model.*

Key Words: **Image Processing, Raspberry Pi, RGB color space, USB Camera.**

1. INTRODUCTION

A fire accident is characterized as a harmful incident that produces heat, smoke, or flame. Because of the difficulty and risk involved in rescuing victims from a fire, fire accidents are a serious type of accident that can result in a significant number of fatalities. There is a substantial risk of firefighter fatalities when such circumstances include firefighting units. It is not practical to always rely on human patrol to find and put out fire at a fire accident scene in real life. We can have an early warning system if an automated system is created to monitor the perimeter for fire mishaps. This will be particularly helpful in a fire mishap in buildings and neighbourhoods where there is a high risk of fire. In order to do this, we need to find a strategy that can spot a flame, find it, and put it out before it causes a harm to anyone nearby. It would be great to send a firefighting robot that could locate the fire and put it out in dangerous conditions. Effective monitoring, quick detection, and fire extinguishing are issues that require rapid attention. Firefighting robots can be utilized in such circumstances to lessen the chance of human fatalities. The autonomous robot is made to stop the fire from spreading further, which could result in potential human casualties or property damage. Firefighting robots will aid firemen in performing their duties efficiently. The importance of the proposed thesis is to make a reliable, safe, and smart system to reduce limitations and faults like false alarms, which cause panic among the people and even the loss of money with the use of new technology and make the places safe from the hazardous fire.

2. Related Study

2.1 Existing system

Systems today simply use the analogue sensor's output [1] which has unreliable values and a propensity for quick fluctuations. Therefore, counting solely on these sensors in an emergency won't work. In this area of firefighting, autonomous robots cannot be manually operated [2] when necessary. Robots that are manually operated require a human operator near a potentially dangerous fire.

2.2 Drawbacks of existing system

Values from analogue sensors vary depending on the environment and are not sufficiently reliable. The autonomous robot may occasionally wander off the firing line. In the current system, manually operated devices can only operate to a certain extent.

2.3 Proposed System

In this work both image processing [3] and analog sensors is being implanted to detect fire and automatically extinguish the fire by the spraying water over it. There are many types of color model such as RGB, CMYK, YCbCr, YUV, HSL, HSV, HIS. However, each of color spaces has their advantages and disadvantages[4].In this system RGB module is used. The block diagram shown in **Fig 1** briefs the overall design of the robotic model.

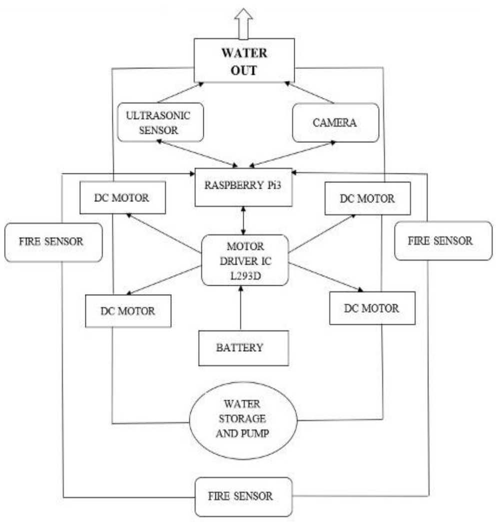

Fig 1: Proposed system

The main approach used in the implementation of the project is:

- USB camera captures the image and provides input to the processor.
- The image captured is compared with the images of previously assigned dataset and desired signal is sent to the servo motor and motor drive.
- According to the signal received, the robot moves to the area where fire is detected and extinguishes the fire by pumping out the water.

3. Requirements

3.1 Raspberry Pi B+:

The vast array of enhancements and functionality found in the Raspberry Pi 3 Model B+ will help designers, programmers, and even engineers who wish to incorporate Pi systems into their creations. The features are Quad core 64-bit processor clocked at 1.4GHz, 1GB LPDDR2 SRAM, Dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2 / BLE, Higher speed ethernet up to 300Mbps, Power-over-Ethernet capability (via a separate PoE HAT)

Figure 2: Raspberry Pi B+

3.2 USB Camera:

USB Cameras are imaging cameras that use USB 2.0 or USB 3.0 technology to transfer image data. The same USB technology used by the majority of PCs is used by USB Cameras to connect quickly to specialized computer systems. he 480 Mb/s transfer rate of USB 2.0 and the ease with which USB technology is available in computer systems make USB Cameras perfect for many photography applications. Additionally, a growing number of USB 3.0 cameras with data transfer rates of up to 5 Gb/s are readily accessible.

Figure 3: USB Camera

3.3 Ultrasonic Sensor:

An ultrasonic sensor is an electronic device that emits ultrasonic sound waves to measure the distance of a target object and converts the reflected sound into an electrical signal. The configuration pin of HC-SR04 is VCC (1), TRIG (2), ECHO (3), and GND (4). The supply voltage of VCC is 5V and you attach TRIG and ECHO pin to any Digital I/O in your Arduino Board to power it. Features are DC 5V Power Supply, 40Hz Working Frequency, 2cm – 400cm/4m Ranging Distance, 0.3 cm Resolution, 15 degrees Measuring Angle, 10uS Trigger Input Pulse width.

Figure 4: Ultrasonic Sensor

3.4 L293D Motor Driver:

The L293D motor driver has two H-bridges in it. The simplest circuit for managing a motor with a low current rating is an H-bridge. L293D is a 16-pin IC that has the ability to simultaneously operate two DC motors in either direction.

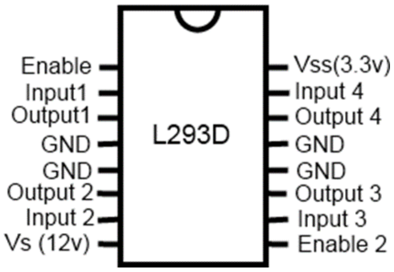

Figure 5: Pin Diagram of L293D

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Specifications are 12V Supply Voltage Range, 36V Output current capability per driver, Separate Input-logic supply, It can drive small DC-geared motors, bipolar stepper motor, Pulsed Current 1.2-A Per Driver, Thermal Shutdown, High-Noise-Immunity Inputs.

Figure 6: Motor Drive

3.5 Relay Motor Driver:

An electrically controlled switch is a relay. Solid-state relays are one type of working principle, although many relays employ an electromagnet to mechanically operate a switch. When a low-power signal is required to control a circuit (with perfect electrical isolation between the control and controlled circuits), or when multiple circuits must be controlled by a single signal, relays are utilised. Specifications are 12 VDC @ 84 mA Input, two SPDT relay Output, 5 A @ 230 VAC Relay specification, 2 ~ 5 VDC Trigger level, Berg pins for connecting power and trigger voltage, Relay status is indicated on each channel of LED, Power Battery Terminal (PBT) for easy relay output connection, Four mounting holes of 3.2 mm each, 49 mm x 68 mm PCB dimensions.

Figure 7: Relay Motor Driver

3.6 Fire Sensor:

The Fire sensor is used to detect fire flames. The module makes use of a Fire sensor and comparator to detect fire at a distance of up to one metre. Features are allows your robot to detect flames from up to 1 M away, 1 m Typical Maximum Range, Calibration pre-set for range adjustment, Indicator LED with 3 pin easy interface connector, +5VDC Input Voltage.

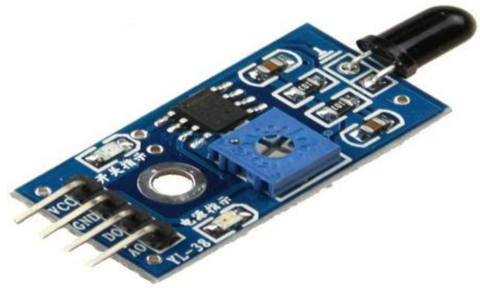

Figure 8: Fire Sensor

3.7 DC Motor:

The main benefit of using DC motors in robotics is their high torque. They have a high starting torque that can be used for accelerating applications and moving heavy loads into position. They are also capable of constant torque over a given speed, where shaft power varies with speed.

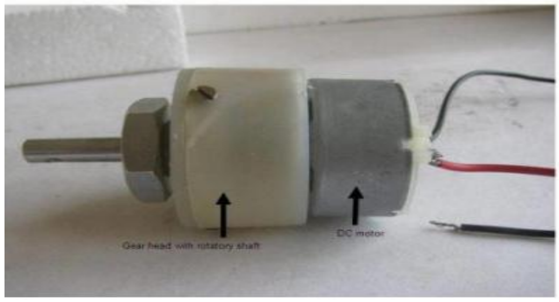

Figure 9: DC Motor

3.8 Pump:

A pump is a mechanical device used to transport fluids (liquids, gases, or occasionally slurries). Depending on how they move the fluid, pumps can be divided into three main categories: direct lift, displacement, and gravity pumps. Pumps use a mechanism to move the fluid (usually reciprocating or rotational), which requires energy to accomplish. This pump operates at 12V. Features are 12V motor, 12W operation, 1/4" barbs, 0-16" Hg vacuum range.

Figure 10: Pump

3.9 PYTHON:

The all-purpose, high-level programming language of choice is Python. Python improves code readability as compared to languages like C, C++, and java. The main benefits of utilising Python are its interoperability and ease of use. Python offers developers more freedom to create and complete projects because it supports 30 different libraries and frameworks. NumPy is one of the libraries that the system uses. Matplotlib, a charting toolkit that provides visual datasets and is useful for data statistical analysis, is a crucial library for the multidimensional array function. Python is primarily utilised in R&D due to its simplicity. Python is now mostly used for artificial intelligence and machine learning.

3.10 OPEN CV:

A machine learning library and open-source software package called OpenCV is made for real-time computer vision applications. The cross-platform library OpenCV supports a wide range of computer languages, including Python, Java, C++, and C. This library is available for use without charge under the open-source BSD licence and was initially created by the Intel Corporation. It is one of the most often utilised libraries for the implementation of 2D and 3D feature toolkits, deep learning applications, video detection, image detection, and machine learning. More than 2500 algorithms, including those for computer vision and machine learning, are available in the library.

3.11 Raspbian:

A computer operating system for the Raspberry Pi based on Debian is called Raspbian. Raspbian comes in a number of variations, such as Raspbian Stretch and Raspbian Jessie. It has been the primary operating system for the Raspberry Pi single-board computer family since 2015, according to the Raspberry Pi Foundation. As a stand-alone undertaking, Mike Thompson and Peter Green developed Raspbian. The preliminary construction was finished in June 2012. Operating system development is still ongoing. The low-performance RASPBERRY PI CPUs of the Raspberry Pi family are well suited to Raspbian.

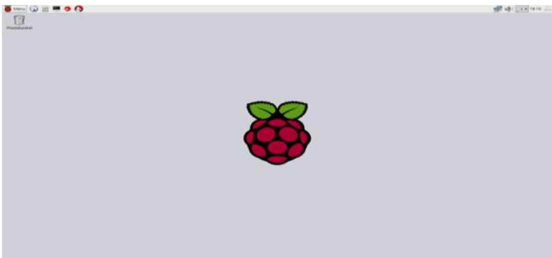

Figure 11: Raspbian

4. Design and Implementation:

4.1 FLOWCHART:

The flowchart shown in the figure 12 briefs the overall flow of the fire detection procedure. First the camera records the live video and sends the video to Raspberry Pi. The Raspberry Pi process the image captured to check whether the fire is detected or not. If the fire detected it gives message to the pump system and extinguishes the fire by spraying water.

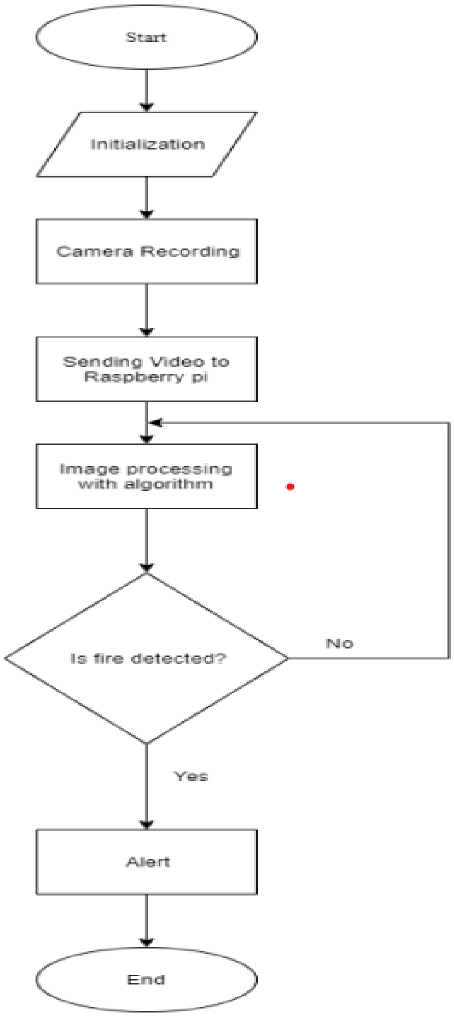

Figure 12: Flowchart of the system

4.2 Block Diagram

Block diagram shown in figure 13 is the input and output given to the Raspberry Pi.

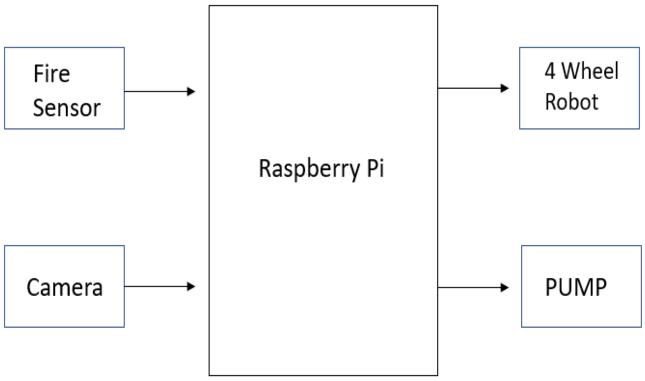

Figure 13: Block diagram of the model

4.3 Working

The Raspberry Pi is powered using USB cable connected to Power Bank. Upon power up, the relay gets energized, the motors attached to the two back wheels of the robot start running, setting the robot in motion. If any obstacle is detected which is sensed by the ultrasonic sensor, the robot immediately stops, waits for programmed amount of delay and robot moves backwards and moves in the direction which does not have any obstacle. When the fire is detected in the camera, the raspberry Pi gives command for the water spraying mechanism, water is pumped to extinguish fire.

When the fire is detected by the fire sensors present in the peripheral sides of the motor, the motor attached to the back wheels of the robot change the direction of the robot to the fire detected side and the raspberry Pi gives command for the water spraying mechanism, water is pumped to extinguish fire.

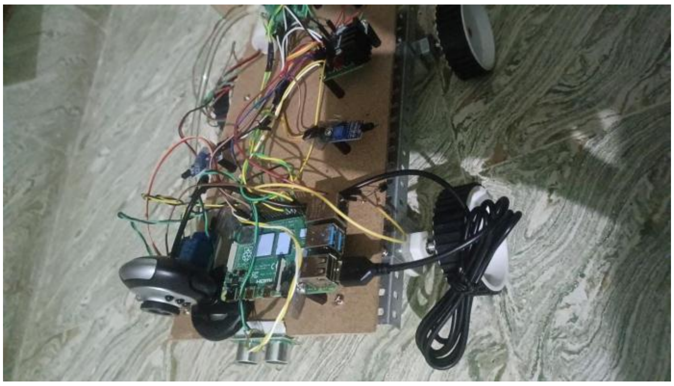

Figure 14: Hardware Model

5. Results and Discussion:

When the system reboots and power supply is given to the robot it moves forward. This is shown in the snippet given in the figure 14 where the robot will be in 'stop' condition or rest and starts to move 'forward' when powered on.

```
Warning (from warnings module):
  File "/home/pi/Desktop/Project/Project.py", line 47
    GPIO.setup(IN6,GPIO.OUT)
RuntimeWarning: This channel is already in use, continuing anyway.  Use GPIO.setwarnings(False) to disable warnings.
stop
forward
```

Figure 14: Starting condition of the robot

When the robot is powered ON, the relay gets energized and the robot moves forward, distance the robot moves is also be mentioned in the window which is shown in the figure 15

```
Distance:42.92
forward
Distance:43.1
forward
Distance:48.5
forward
Distance:61.1
forward
Distance:44.56
forward
Distance:62.27
forward
Distance:60.49
forward
Distance:43.19
forward
Distance:43.23
forward
Distance:45.32
forward
Distance:45.93
forward
Distance:46.77
forward
Distance:47.93
forward
Distance:44.37
forward
Distance:44.73
forward
Distance:34.61
forward
```

Figure 15: Robot is powered ON

When any obstacle is detected by the ultrasonic sensor the robot stops and the wheels of the robot moves backwards which is shown in the figure 16

```
Distance:54.66
forward
Distance:62.25
forward
Distance:2.46
object Detected
stop
backward
forward
Distance:3.93
object Detected
stop
backward
forward
Distance:3.67
object Detected
stop
backward
forward
Distance:49.3
forward
```

Figure 16: Obstacle detected

When fire is detected by right fire sensor then the robot moves left and extinguishes the fire which is shown in the figure17

```
forward
Distance:56.56
Fire_RV detected
stop
stop
left
left
left
left
left
left
stop
forward
Distance:54.49
forward
Distance:53.14
forward
Distance:51.6
forward
Distance:52.04
forward
```

Figure 17: Fire Detected by the flame sensor

6. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

The automated fire-fighting robot is capable of detecting fire and extinguishing the fire source successfully. The raspberry pi controls the DC motor and ultrasonic sensor for movement of robot. In this project, Fire Detection System has been developed using Image Processing. This system has the ability to apply image processing techniques to detect fire. This system can be used to monitor fire and has achieved 90% accuracy for single webcam. The system works on real time, as it provides continuous monitoring. For detecting the fire in the peripheral region of the robot Fire Sensors are used, which helps in efficient working of the robot and to avoid damage to the robot.

6.2 Future Scope

The goal of this research is to create a system that can detect fires and provide assistance. By switching out the water for a carbon dioxide carrier and making it capable of being operated by humans via IOT, it can be converted into a true fire extinguisher. As the implementation restrictions and the design simplifications imply, our project is primarily a proof-of-concept. Also, a 360-degree rotating camera can be used which can detect fire in peripheral areas as well. In place of fire sensors, USB cameras can be implemented which can overcome the disadvantages of sensors. A feasible autonomous fire-fighting system must, in particular, consist of a group of robots that can communicate and work together to complete the job. Such a system also needs to be able to take instructions instantly while performing an activity. All of these issues fell outside the purview of this initiative. However, many of these topics have been studied in many contexts, such as mobile agent coordination, on-the-fly communication between humans and mobile agents, etc. It will be interesting and difficult to combine all of this information into a useful, independent fire-fighting service.

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