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# Smart Fire Detection and Extinguishing System using Raspberry Pi

M. Lakshmi, Sana Afreen, M. Harshini, G. Jagruthi Reddy, G. Deepti Reddy
Department of ECE, GNITS, Hyderabad

**Abstract - The danger of fire continues to remain a huge risk in both domestic and commercial environments, causing major losses of life and assets. All conventional systems are limited to detection and alarm generation, requiring manual intervention in order to tackle the problem. This work presents a low-cost automated fire detection and extinguishing system implemented on a Raspberry Pi microcontroller. It constantly detects the presence of any fire by using flame sensors and alerts immediately by sending a telegram notification as well as actuates a motor-driven fire-extinguisher device. Rapid reaction, affordability, and simplicity are the key factors taken into consideration while designing the system.**

**Keywords: Raspberry Pi, Fire Detection, Flame Sensor, Motor Driver, Automation, Telegram Notification**

## I. INTRODUCTION

Fire accidents are still considered one of the most common and dangerous threats in households, industry, and commerce. Late discovery and delayed reaction typically lead to substantial property damage, destruction of assets, and, in extreme cases, fatalities. Traditional fire alarm systems rely mostly on smoke detectors or human observation, lacking the ability to provide a rapid response and alert during emergencies. With advances in embedded systems and IoT technology, there is a potential to develop advanced fire protection measures. This paper proposes a project for building a smart fire detecting and preventing mechanism using Raspberry Pi technology. The system will be able to detect fires and alert authorities about them using Telegram messages in real time. It will be also capable of performing some basic firefighting operations by controlling motors through the motor driver module. The approach proposed provides fast reaction and reduced dependence on human interaction. It is efficient, reliable, and scalable for different applications, especially where there is a need for round-the-clock monitoring.

## II. EXISTING SYSTEM

Many research works in the domain of fire detection systems utilizing embedded and IoT technology have been undertaken. In general, the traditional fire detection system uses sensors such as smoke and temperature. These kinds of systems are inexpensive and easy to build, yet their major disadvantage is that they tend to delay the fire detection process and trigger alarms based on inaccurate data, especially when the environment contains dust or steam or has slight heat differences.

The latest developments concentrate on implementing microcontrollers and single-board computers like Raspberry Pi to increase accuracy and allow live monitoring. Several researchers have adopted the method of installing a camera to detect fire utilizing image processing. For instance, a fire detection system using Raspberry Pi, fisheye camera, and OpenCV algorithms was designed to detect fire in real-time conditions and find the fire's location by analyzing the images transmitted wirelessly. These types of systems offer larger coverage and accurate results but need more computational capabilities and network stability.On the other hand, IoT-based surveillance systems are recommended to incorporate both sensors and cameras to detect fires and alert users via GSM services, emails, or cloud storage.

Machine learning and deep learning methods are applied by utilizing image databases and models that can detect fire in varying illumination conditions for detecting fire at any time of the day or night. But such systems are costly to implement.

Another method that is extensively used for detecting fire is sensor-based systems, which include flame, smoke, and gas sensors. In addition, some researchers have employed combinations of such sensors together with algorithms to minimize alarm errors.

However, while there have been great advancements in fire detection techniques, all of them face problems in terms of being expensive, complex, or inaccurate to some degree. Thus, there is a necessity to create a system that would balance the advantages and disadvantages of existing solutions. Such a system should be able to work efficiently

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and cost-effectively while being capable of performing detection tasks and taking further actions.

## III. PROPOSED SYSTEM

### a) PROPOSED METHODOLOGY

The suggested method is intended to provide an automatic fire detection and reaction system that does not require human intervention. The system consists of a Raspberry Pi as a main controller, combined with flame sensors, a motor driver module, and motors.

At the starting stage, three flame sensors are mounted in various positions to constantly observe the environment. Flame sensors have the ability to sense the infrared radiation that emits from fire.Using more than one sensor allows increasing the efficiency of detection and avoiding ignoring the source of fire.

Outputs of all sensors are connected to the Raspberry Pi through GPIO pins. The Python code keeps monitoring the status of all sensors on the Raspberry Pi. Once the flame is detected, the system immediately identifies it as a fire and performs further actions. In case the fire is detected, two events take place simultaneously. The first one is the sending of an instant notification message to the user using the Telegram service. This provides an opportunity to apply some additional measures. The second action is related to triggering the motor driver module that controls the connected motors and starts the process of firefighting with water flow or nozzle positioning towards fire.

### b) BLOCK DIAGRAM

The above block diagram shows the overall architecture of the designed smart fire detection and extinguishing system. The system makes use of sensing, processing, control, and communication modules to ensure automatic detection and response to fire.

The first stage consists of the sensing module that is made up of several flame sensors installed in different places. Each of these sensors monitors the environment for fire by detecting the infrared energy emitted by fire. Once a fire is detected by one of the sensors, it produces an electronic output signal. Using multiple sensors ensures accuracy and helps in estimating the location of the fire by figuring out which sensor was activated.

The second stage is the processing module and here the Raspberry Pi acts as the controller. All sensors connect to it through GPIO pin connections, from where it reads their data using the programmed algorithm. After processing the incoming data, it makes decisions accordingly, especially when fire is detected by one or more sensors.

The last component is constituted by the control and actuator section. The Raspberry Pi sends signals of control to the motor driver module like the L298N. It is important that the Raspberry Pi cannot supply a lot of energy, especially to drive loads such as motors. Therefore, the motor driver serves as a bridge between the Raspberry Pi and DC motors since it is used to change low energy into high energy. The driver then triggers the connected DC motors that drive the fire extinguisher into action. The DC motors can be used to drive a pump or even direct the spray gun towards the fire.

Moreover, other than being used to suppress fires, the device has a communication section whereby the Raspberry Pi uses its in-built WiFi to send notifications through the Telegram bot.Ultimately, the entire system is powered by a regulated power supply. Although the Raspberry Pi and sensors operate on 5V, the motor driver as well as the motors operate at higher voltages. All devices in the circuit are tied to one common ground for effective signal reference.

In conclusion, the diagram shows an entirely automated process incorporating sensing, decision-making, and actions aimed at providing an instant response to any fire risk detected.

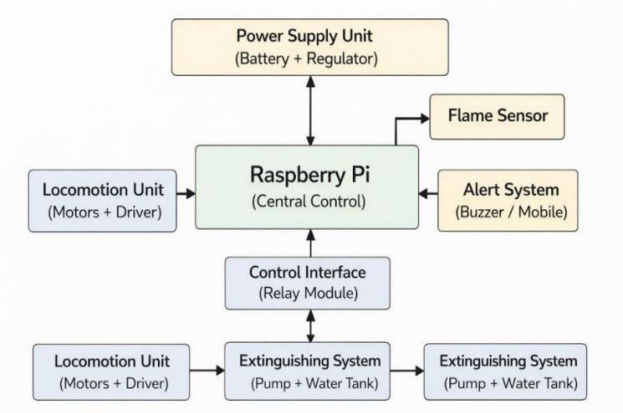


**Fig 3.1 Block Diagram**

## IV. IMPLEMENTATION

The whole setup works on the principles of Raspberry Pi, which works as the controller for the entire system while connecting all the parts. The flame detectors are installed in the monitored area and connected to the GPIO pins of the Raspberry Pi, which detects whether fire is present or not.

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The system uses a Python program, which runs on the Raspberry Pi and continuously checks the outputs of the sensors. The software used in detecting fires is able to understand fire conditions without responding to any random stimuli.

When a fire situation is detected, the Raspberry Pi transmits signals to the motor driver module which then drives the DC motors to actuate the mechanism used to control the fire by moving the mechanism close to the fire. Additionally, there is a relay module that is used to drive a water pump. This relay module acts as an electrical switch which helps in controlling the activation of the water pump by the raspberry pi to release water to put out the fire.

In terms of communication, the raspberry pi has the ability to communicate with other devices by making use of a telegram bot which sends alerts to the users. There are two different power supplies for this circuit: one is a regulated 5V supply for the Raspberry Pi and its sensors, while the other supply is used to power up the motor drivers and the water pump.

## V. SYSTEM WORKING

This system works by constantly checking the environment and then making automatic responses in the case where fire is detected. There are various sensors used that detect infrared rays that are produced by fire sources. The sensors will always produce an output signal in cases where a fire source is detected.The Raspberry Pi serves as the controller unit and constantly receives data from the sensors through the GPIO ports. The system works normally by remaining in a stand-by mode when there is no fire source detected in the environment. Once the fire source is detected, the Raspberry Pi evaluates the situation and makes sure it is true.

After verifying the condition, the controller executes various commands that include sending signals to the motor driver module that powers the DC motors.On the other hand, Raspberry Pi triggers the relay module that turns on the water pump. The pumping begins to spray water to put out the fire. Additionally, there is an automatic alarm sent to the user through Telegram via a WiFi connection. This process is repeated until the fire goes out; then, all the components are placed back to stand-by mode.

## VI. RESULT

### 1) Flame detection using sensor-based monitoring system.

Testing of the fire detection and fire suppression system that we have suggested has been conducted under laboratory conditions to see how effectively the system functions. Indeed, the system was capable of detecting the occurrence of a fire by way of flame sensors and reacted immediately.

**Fig 6.1 Flame Detection**

Upon bringing a flame near the sensor, the sensors detected the presence of the flame promptly and sent the necessary signals to the Raspberry Pi, which were received by the controller.

### 2) Automatic fire suppression using a water pump mechanism.

As soon as the fire alarm had been sensed, the detection information was instantaneously fed to the Raspberry Pi, serving as the controller. Control information from the controller was sent to the motor drive circuit and relay circuit within no perceptible time period. The DC motors were able to respond instantaneously, providing the capability of moving (where the device is mounted on a mobile base) and the relay turned on the water pump. Water was ejected towards the fire, thereby dampening it and eventually putting it out.

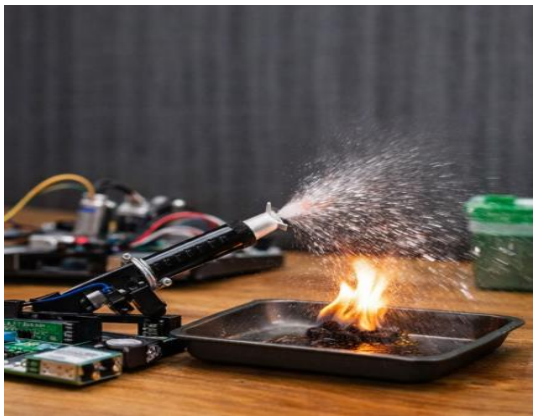

**Fig 6.2 Fire suppression using a water pump**

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### 3) Telegram Alert

Not only does this process include physical reaction, but communication is made possible too. A notification message was sent out to the user using the Telegram application following the detection of the fire. This enables the user to monitor the system remotely at any point in time.

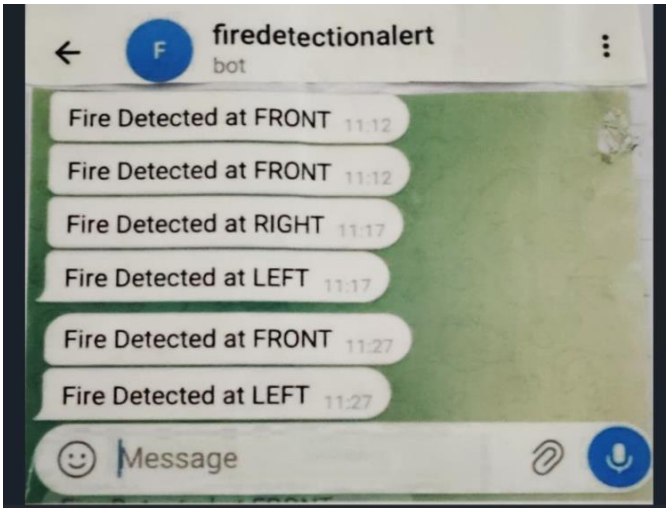


**Fig 6.3 Real-time alert notification via Telegram**

From the general outcomes obtained, it is clear that the system works efficiently in terms of detecting fire, starting its extinguishing process, and alerting the occupants. It can be seen that the time of reaction of the system was very quick; therefore, the system can be used in a smaller environment.

## VII. CONCLUSION

It is worth nothing that the created system represents an efficient solution to the problem of fire safety with timely reaction and appropriate actions taken right after the detection of danger. The system incorporates flame sensors as well as Raspberry Pi that allows the user to have constant monitoring and quick response if there is a fire.

The developed project is not complicated in terms of implementation, and it can be used in small areas requiring fast reactions to potential dangers. The incorporation of all functions into a single system results in increased efficiency. The future improvements might include installation of additional sensors, larger area monitoring, and development of an algorithm to increase the accuracy and speed of actions performed by the system.

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