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A Smart Fire Detector using Raspberry Pi and OpenCV-Python

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Abstract*: Fire detection systems are necessary in big organizations as well as in many different big or small organizations to provide more security as well as to get secure from damage caused because of fire. There are many existing fire detection systems based on sensors etc but the limitations of such existing systems are they can detect fire within a limited area and they are using smoke detection techniques. To overcome previous method limitations in the proposed work we have a Raspberry Pi module and OpenCV python libraries for fire detection in real- time through a Raspberry Pi camera. Even if there is no fire detected the display will show the 'Fire Condition: Normal' and when there is a fire detected it will display 'Fire Condition: Fire detected' on the LCD screen. When fire is detected RED color LED will glow and in normal conditions GREEN color LED will glow. In the condition of fire detected even start starting motor pump to start the water for fire suppression.*

Keywords: Fire detection, Raspberry Pi, GSM module, LEDs, Python Programming, Motor Pump.

I. INTRODUCTION

In industrial areas as well as in many fields, fire detection plays an important role in reducing fire damage and providing more security. There are many applications for fire detection in existence that have limitations in terms of complexity and cost. We created a proposed solution by combining a Raspberry Pi with a small single-board computer for fire detection. With the help of cameras and sensors, the Raspberry Pi system detects fire easily. [1]

Residential areas, small corporate offices, and industries can utilise this system. It not only detects the fire, but also sends alerts via sound and SMS. This enables us to promptly mitigate the harm.

Fire detection systems are essential for safeguarding both large and small organisations from potential fire hazards. Traditional fire detection systems, often relying on smoke sensors, have limitations such as restricted detection areas and delayed responses due to their dependence on

smoke presence. To overcome these limitations, we propose an innovative fire detection system that utilises Raspberry Pi and OpenCV-Python for real- time monitoring and detection.[2]

The fire detection system serves as a security mechanism, identifying fires and activating alarms to warn individuals about potential fire hazards. Python and the OpenCV computer vision library implement this system. It employs the HSV colour algorithm to accurately detect fires. The project introduces a computer vision-based method for detecting and assessing dangerous fires using video footage captured by a standard camera.

Fire detection systems are crucial for ensuring safety in both large and small organizations. Traditional fire detection systems, often based on smoke sensors, have limitations in detecting fires within a confined area and rely heavily on smoke presence. To address these limitations, we propose a smart fire detection system that uses Raspberry Pi and OpenCV-Python for real- time fire detection through a Raspberry Pi camera.

In this system, the Raspberry Pi module processes video data to detect fires using computer vision techniques. We use the OpenCV library and the HSV colour algorithm. The system continuously monitors the environment, displaying 'Fire Condition: Normal' on an LCD screen when no fire is detected and switching to 'Fire Condition: Fire detected' when a fire is identified. Additionally, a red LED lights up in the presence of fire, while a green LED indicates normal conditions. When the system detects a fire, it can also activate a motor pump to initiate water suppression, enhancing safety measures. This advanced approach provides a more comprehensive and responsive fire detection solution compared to traditional methods.[3]

Globally, fire poses a significant threat to life and property, often resulting from the combustion of materials that release heat and light. Fire detection systems aim to identify fires by sensing various fire-related changes. There are two primary types of fire detectors: traditional sensor- based systems and vision-based systems. Sensor- based detectors respond to pressure, temperature, heat, and smoke but they have disadvantages such as high cost, slow response times, and limited detection ranges. Additionally, they are impractical for outdoor use due to sunlight and wind interference.

In contrast, vision-based detectors can quickly detect and analyse fire locations by examining the colour, shape, and movement of flames using spectral and spatial models. While vision-based systems offer several advantages, they are prone to false detections, which limits their effectiveness. This highlights the need for new, more efficient models that can address the shortcomings of existing systems.

Our proposed system leverages Raspberry Pi and OpenCV-Python to create a real-time, vision- based fire detection solution that enhances accuracy and response times, overcoming the limitations of traditional methods. This system aims to overcome the limitations of traditional detectors by leveraging real-time video processing for fire detection. The Raspberry Pi module, equipped with a camera, captures live video feeds and uses OpenCV-Python libraries to detect fire. The system displays the fire condition on an LCD screen and activates different colored LEDs to indicate normal and fire-detected conditions. Additionally, in case of fire detection, the system triggers a motor pump to start water flow for fire suppression.

II. LITERATURE SURVEY

Fire detection using image processing requires robust systems that can eliminate disturbances. This paper presents a method for detecting fire flames by analysing space-time fluctuation data along the contours of flame-coloured areas. The proposed algorithm utilises a colour CCD camera to identify fire flames. We provide experimental results to demonstrate the effectiveness of this method. [4]

Vision-based fire detection systems have gained popularity over traditional sensor-based systems, driven by the need for effective video surveillance in public, industrial, residential, and business settings. Fire identification primarily relies on detecting flame colours, which can vary widely and often resemble non-fire objects. Techniques such as motion detection, edge detection, flame area analysis, smoke detection, fire growth, and background segmentation combine with colour detection to enhance accuracy. Thresholds based on area type and brightness levels further refine detection. This paper compares five recent vision- based fire detection systems, highlighting one that utilises LUV colour space and hybrid transforms for improved performance. [5]

This paper proposes a fire detection system based on light detection and analysis. Using HSV and YCbCr colour models, the system separates orange, yellow, and high-brightness light from background and ambient light under specific conditions. The system analyses and calculates fire growth using frame differences. Experimental results demonstrate that the system achieves an overall accuracy of over 90%. [6]

The primary goal of the Fire and Rescue Service is to safeguard human life, property, and natural resources from fires and other emergencies. Given the fluctuating demands on the service, it is crucial to equip firefighters with the best techniques, training regimes, and equipment to meet public expectations. Today, the emphasis on mitigation, preparedness, and risk management has increased due to the challenges facing the fire service. Effective planning and preparedness are essential for achieving rapid response times. Consequently, we have designed a fire detection monitoring system using an Arduino microcontroller. This system includes a buzzer, a smoke sensor, and a camera. A monitoring system wirelessly transmits data collected from the smoke sensor and camera for real- time display and analysis. [7]

We design the proposed fire alarm system as a real-time monitoring solution that detects smoke and captures images when a fire occurs. The system uses Raspberry Pi and Arduino Uno as the primary embedded systems. A key feature of this system is its ability to send remote alerts upon detecting a fire. Upon detecting smoke, the system records a room image and presents it on a webpage. It then requires user confirmation before reporting the event to the firefighter via Short Message Service (SMS). This method lessens the possibility of the firefighter reporting false alarms. Additionally, the system consumes minimal power and storage as the camera only captures images when it detects smoke. [8]

Laptop vision-based fire detection using image processing can be beneficial. To differentiate fires from other visual stimuli, the fire detection algorithm uses visual characteristics such as edge trembling, spectral flicker, spectral texture, color, brightness. Traditional fire detection techniques include infrared sensors, thermal detectors, smoke detectors, flame detectors, and optical smoke detectors. However, the reliability of these methods is often questionable, as they frequently identify fire by-products such as UV radiation, infrared, heat, smoke, or gas, which can also originate from other sources, resulting in false alarms. Utilising laptop vision and image processing techniques can yield more accurate results than traditional systems, as images provide more reliable information. [9]

Fire outbreaks are increasingly common and can cause significant damage to both nature and human property. Consequently, fire detection has become crucial for protecting lives and property. This paper focuses on an algorithm for fire detection using image processing techniques, specifically colour pixel classification. Unlike traditional systems, this fire detection system does not requirespecial sensors and can monitor large areas, depending on the camera quality. The objective is to design a methodology for fire detection using images as input. The proposed algorithm employs colour pixel classification, utilising image enhancement techniques and RGB and YCbCr colour models to differentiate fire pixels from the background and separate luminance from chrominance. The proposed system achieved an average fire detection rate of 90%. [10]

III. PROPOSED METHOD

Proposed method is implemented using python software and OpenCV libraries.

Our proposed method aims to enhance fire detection accuracy and response times by leveraging the capabilities of Raspberry Pi and OpenCV-Python for real-time monitoring. The system is designed to address the limitations of traditional sensor-based detectors and provide a robust solution for both indoor and outdoor fire detection.[11]

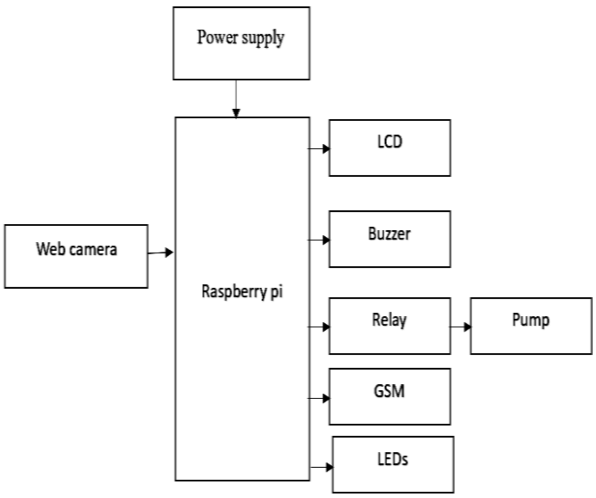


Fig. 3.1 Block Diagram of Proposed Work

1. System Components:

- **Raspberry Pi:** Acts as the main processing unit, handling data acquisition and analysis.
- **Camera Module:** Captures live video feed for real-time monitoring.
- **OpenCV-Python Library:** Utilized for image processing and fire detection algorithms.
- **LED Indicators:** Provide visual alerts (RED for fire detected, GREEN for normal conditions).
- **LCD Display:** Shows the current fire condition status.
- **Motor Pump:** Activates water suppression when a fire is detected.

2. Image Acquisition:

- The camera module continuously captures video footage of the monitored area

3. Image Preprocessing:

- The captured images are processed using the HSV color algorithm to enhance the detection of fire by isolating the specific color ranges associated with flames.

4. Fire Detection:

- **Color Analysis:** The system uses the HSV color space to detect the characteristic colors of fire.
- **Shape and Movement Analysis:** By examining the shape and movement patterns of the detected flames, the system differentiates between actual fires and false positives.
- **Algorithm Implementation:** The processed images are analyzed using OpenCV algorithms to identify potential fire outbreaks.

5. Alert System:

- When fire is detected, the system triggers a series of actions:
  - **Visual Alerts:** The RED LED lights up, and the LCD display shows "Fire Condition: Fire detected."
  - **Water Suppression:** The motor pump is activated to start the water flow for fire suppression.

- **Normal Conditions Monitoring:**
- If no fire is detected, the GREEN LED remains on, and the LCD display shows "Fire Condition: Normal."

6. Validation and Testing:

- The system's performance is validated using various test scenarios to ensure accuracy and reliability. Comparisons with traditional fire detection systems are conducted to demonstrate improvements.

IV. HARDWARE AND SOFTWARE

Hardware Modules used

- Raspberry pi
- Web camera
- Buzzer

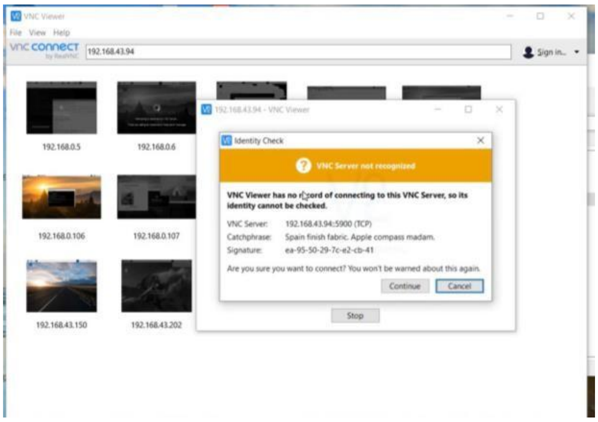
- Relay
- Pump
- GSM
- Power Supply
- LCD

Software Programming used

- Python IDE

V. RESULT ANALYSIS

Here we pasted step by step results of complete procedure we followed for designing project on fire detection using Raspberri pi module.



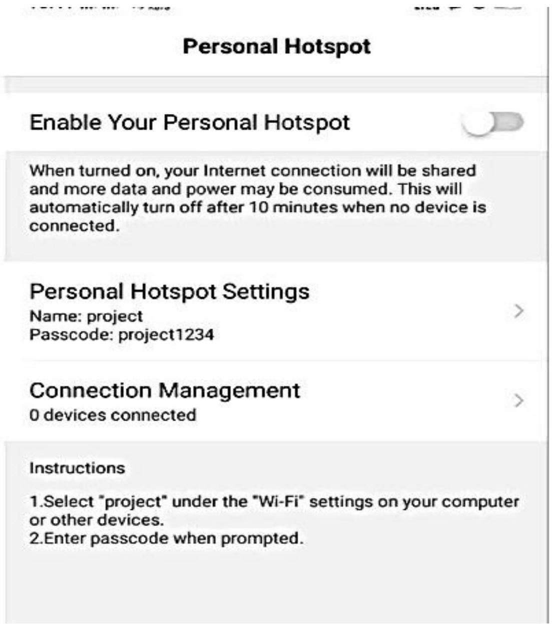


Fig.5.1 Hotspot Setting from mobile phone

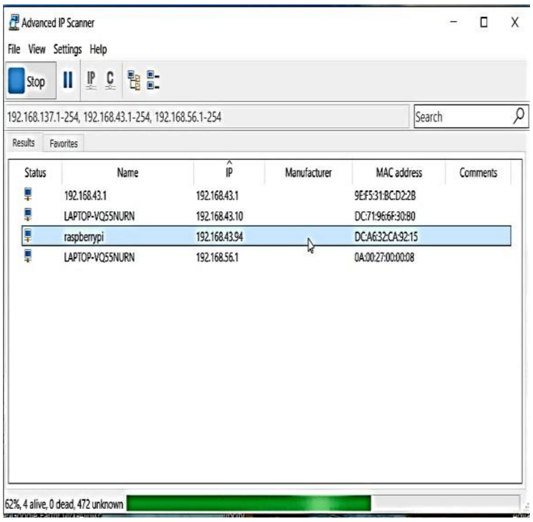


Fig.5.2 searching for Raspberry Pi Model in Advance IP Scanner

Fig.5.3 Connecting raspberry Pi using IP address using VNC Scanner

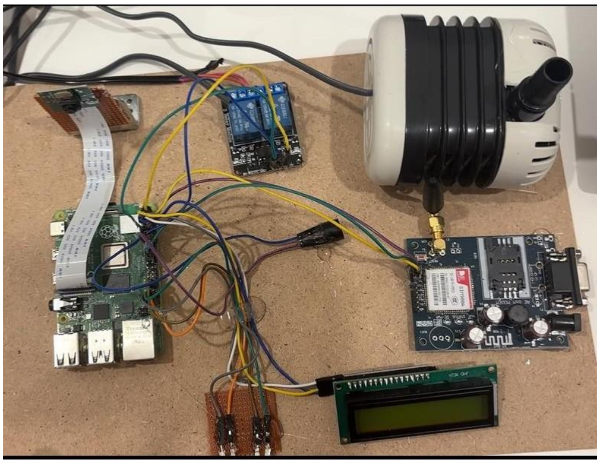
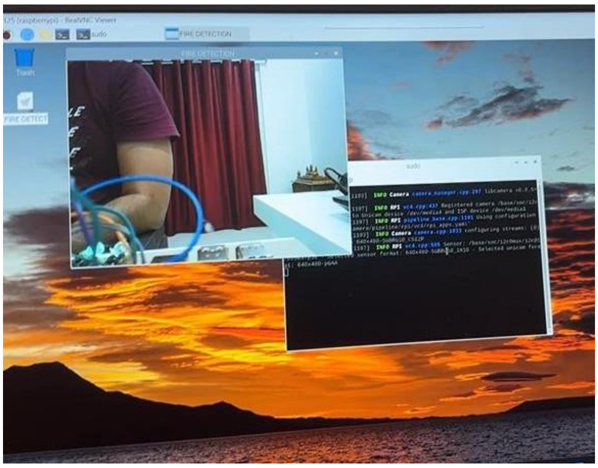


Fig.5.4 Hardware Setup of project



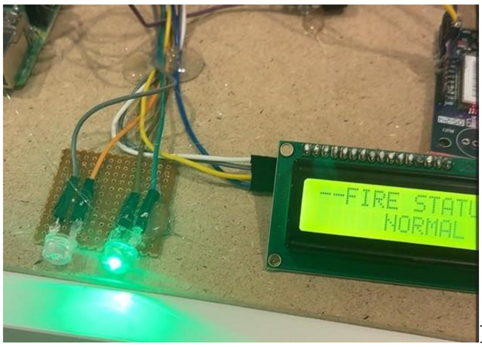


Fig.5.5 Camera is on but there is no fire

Fig.5.6 When Fire status is normal Green LED will be glowing

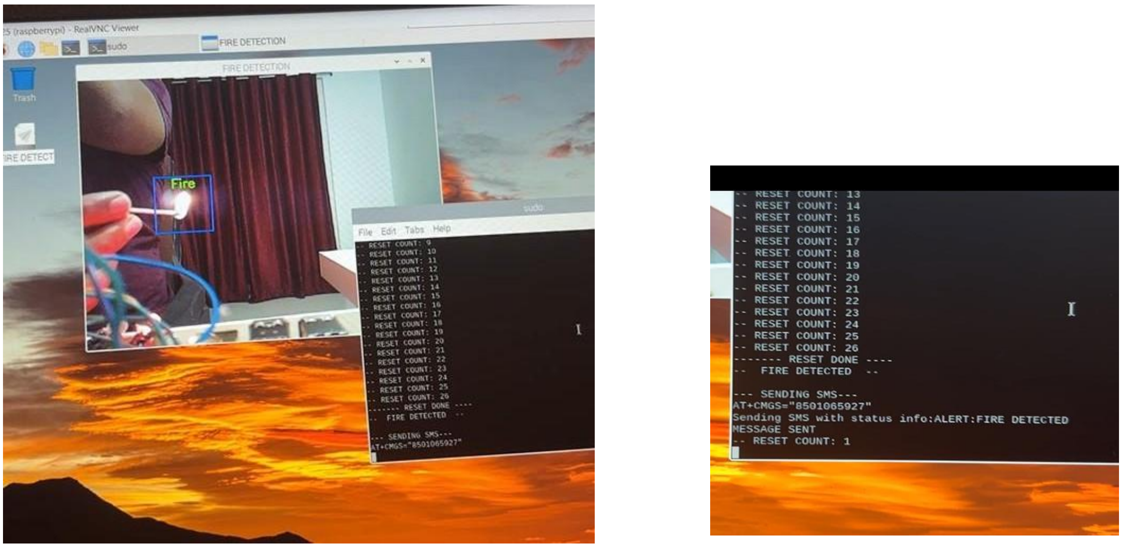


Fig.5.7 Fire Detected and shown using Bounding Box

Fig.5.8 displaying Fire status on LCD Display

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Fig.5.9 Fire status sent Via SMS to Registered Mobile Number

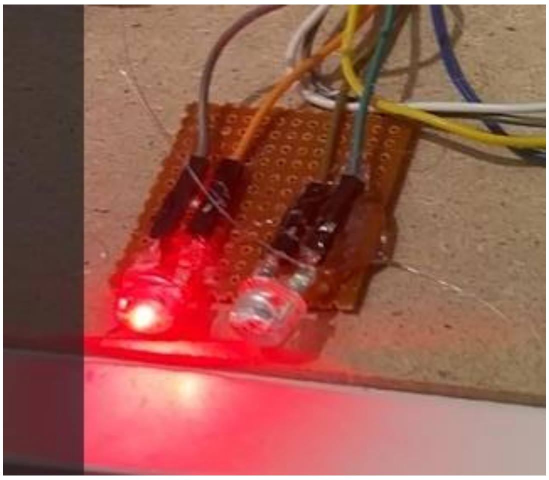

Fig.5.10 Red LED will be glowing

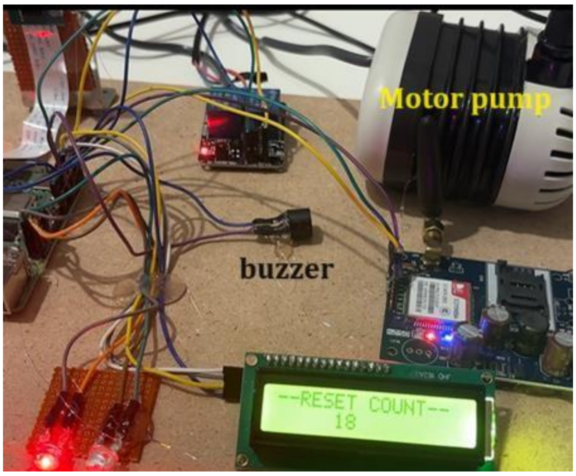

Fig.5.11 Buzzer will get ON and Motor Pump will also get ON

VI. CONCLUSION

Using Raspberry Pi module and OpenCV library in python we have successfully implemented our application for detecting Fire from web camera. Fire detection systems are essential for enhancing security and preventing fire damage in various organizations. Traditional systems, often based on sensors and smoke detection, have limitations such as restricted detection range. To address these issues, we proposed a real-time fire detection system using a Raspberry Pi module and OpenCV Python libraries. This system uses a Raspberry Pi camera to detect fires and provides real-time feedback on an LCD screen. In normal conditions, the display shows 'Fire Condition: Normal' and a green LED glows. When a fire is detected, the display shows 'Fire Condition: Fire detected,' a red LED glows, and a motor pump activates for fire suppression. This approach overcomes the limitations of previous methods, offering a more effective solution for fire detection and response.

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