# Fire Detection Based on Computer Vision Using OpenCV

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## I. ABSTRACT

Fire hazards pose a significant threat to life and property, making early detection crucial for minimizing damage. This project focuses on AI-based fire detection and alarming using computer vision and deep learning techniques. The system employs CCTV cameras or laptop cameras to capture real-time video feeds, which are analysed using Python, OpenCV, and deep learning models to detect fire accurately. A Convolutional Neural Network (CNN) or YOLO (You Only Look Once) object detection model is trained on fire datasets to distinguish fire from non-fire scenarios, reducing false alarms. Once fire is detected, the system triggers an alarm sound and can also send notifications via SMS, email, or IoT-based alerts to concerned authorities. This AI-powered solution is designed for high accuracy and efficiency, making it suitable for smart surveillance, industrial safety, and residential fire monitoring. The integration of edge computing devices like Raspberry Pi or Jetson Nano can further enhance real-time processing. The proposed system aims to improve fire safety measures by providing automated, real-time fire detection, reducing response time, and preventing large-scale disasters.

## II. KEYWORDS

Fire Detection, Real-time Fire Monitoring, Computer Vision (CV).

## III. NTRODUCTION

In recent years, fire detection technology has expanded beyond traditional sensors, such as smoke and heat detectors, to include computer vision-based systems. Fire hazards remain a major concern across multiple domains, from industrial safety to home security, prompting continuous innovation in early detection methods. With advancements in image processing and computer vision, it is now feasible to detect fire through visual data, making it possible to alert people more rapidly and accurately. This project leverages OpenCV, a popular open-source library, to develop a system capable of detecting fire through real-time video analysis, utilizing color, shape, and motion characteristics to differentiate fire from other objects and movements.

The field of computer vision has seen significant growth, and fire detection is one of its critical applications in safety and surveillance. Traditional fire detection systems, such as smoke detectors, can be hindered by environmental factors (like open spaces or wind) that may delay the detection of smoke or heat. Computer vision-based systems, however, offer flexibility and improved accuracy by analyzing video feeds to detect fire based on its visual characteristics. This allows for wider applications, including high-risk areas such as warehouses, forests, and large industrial sites where sensor-based systems are not as effective.

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OpenCV offers various tools for image processing and object detection, making it suitable for building fire detection systems. By integrating algorithms that can analyze fire's distinctive colors (typically shades of red, orange, and yellow), motion, and flickering behavior, OpenCV provides a foundation for detecting fire in dynamic environments. With fire detection systems built on computer vision, alerts can be generated more quickly and effectively, potentially saving lives and minimizing damage. In recent years, fire detection technology has expanded beyond traditional sensors, such as smoke and heat detectors, to include computer vision-based systems. Fire hazards remain a major concern across multiple domains, from industrial safety to home security, prompting continuous innovation in early detection methods. With advancements in image processing and computer vision, it is now feasible to detect fire through visual data, making it possible to alert people more rapidly and accurately. This project leverages OpenCV, a popular open-source library, to develop a system capable of detecting fire through real-time video analysis, utilizing color, shape, and motion characteristics to differentiate fire from other objects and movements. The field of computer vision has seen significant growth, and fire detection is one of its critical applications in safety and surveillance. Traditional fire detection systems, such as smoke detectors, can be hindered by environmental factors (like open spaces or wind) that may delay the detection of smoke or heat. Computer vision-based systems, however, offer flexibility and improved accuracy by analyzing video feeds to detect fire based on its visual characteristics. This allows for wider applications, including high-risk areas such as warehouses, forests, and large industrial sites where sensor-based systems are not as effective.

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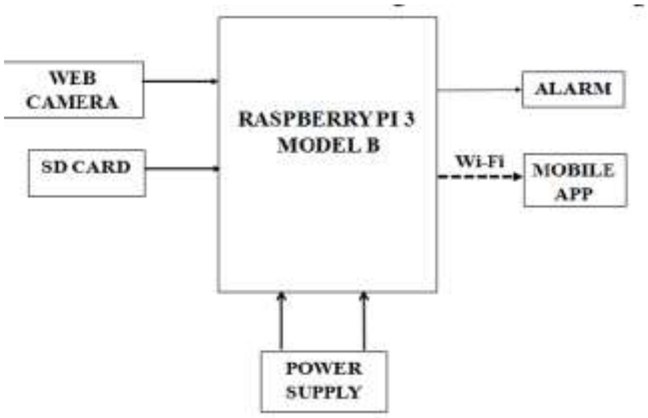


**Fig1. Theoretical Framework**

## IV. REVIEW OF EXISTING WORK

Fire detection systems are essential for safeguarding lives and property across industries, residences, and public spaces. Traditionally, fire detection systems have primarily relied on smoke and heat sensors. However, these systems face limitations, particularly in environments with high ceilings, open spaces, or areas where smoke and heat might not be immediately present. In recent years, advancements in computer vision and image processing have paved the way for fire detection systems that use visual data to detect fire. By analyzing visual characteristics of flames and smoke in real-time, these computer vision-based systems offer an enhanced method for early fire detection and address many shortcomings of traditional methods.

This overview examines the existing fire detection systems, specifically computer vision-based methods utilizing libraries like OpenCV. We will look at related work in academic research and discuss real-world examples of implementations by companies pioneering in this technology.

The most common fire detection systems in homes and businesses are based on smoke and heat sensors. Smoke detectors typically work by detecting particles in the air using ionization or photoelectric sensors. Heat sensors, on the other hand, detect temperature changes to signal the presence of fire. While these sensors are effective in enclosed spaces, they may fail to respond quickly in open areas or under certain ventilation conditions. For instance, a warehouse or industrial facility with high ceilings may experience significant delays in smoke reaching a detector, limiting the effectiveness of these sensors.

IR-based fire detection systems detect thermal radiation emitted by fire, which can be particularly effective in dark environments or when visibility is compromised. However, these systems are often costly and may require extensive calibration. Additionally, IR sensors may struggle with background heat sources that can lead to false alarms.

Thermal imaging cameras have been increasingly adopted in fire detection, particularly in industrial and large outdoor settings. They detect heat rather than visible light, making them useful for detecting fire even in low visibility. However, they are costly, and environmental factors like
reflective surfaces or other heat sources can lead to false positives. Examples include thermal cameras used by companies like FLIR Systems to detect temperature changes in high-risk industrial sites.

Computer vision-based fire detection systems aim to overcome the limitations of traditional sensors by analyzing visual characteristics of fire in real-time. These systems use cameras to monitor the environment and apply algorithms to detect features such as flame color, flickering patterns, and smoke movement. OpenCV, an open-source computer vision library, is widely used in these systems due to its extensive image processing capabilities and flexibility.

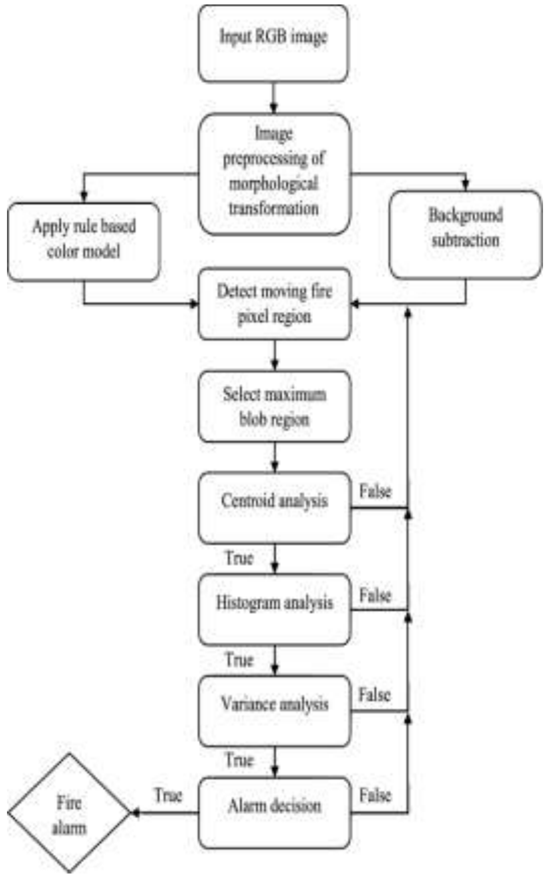


**Fig2. Flow chart of the process**

## V. SYSTEM DESIGN

Based on the provided document, the system design for "Fire Detection and Alarming by Artificial Intelligence using Python" follows a structured approach integrating computer vision, image processing, and automation. Below is the system architecture and design overview:

**1. System Architecture Overview**

The fire detection system is composed of three main modules:

- Input Module (Captures real-time video feed)
- Processing Module (Fire detection using AI and OpenCV)
- Alert and Response Module (Triggers alarm and notification)

**2. System Components**

- Camera Module (Input Device)
  - Captures real-time video feed from CCTV or laptop webcam.
  - Can be an IP camera, USB webcam, or surveillance camera.

- Processing Unit (Computer Vision & AI)
  - Uses OpenCV, Python, and deep learning for fire detection.
  - Processes video frames and applies image processing techniques.
  - Colour-based filtering (Detecting red, orange, and yellow flames).
  - Shape and motion detection (Recognizing flickering patterns of fire).
  - Optional: YOLO / CNN-based fire detection model for high accuracy.
- Microcontroller (Control Unit - Optional)
  - If hardware automation is required, Arduino, Raspberry Pi, or ESP32 can be used to trigger alarms or external devices.
- Relay Module (Activation Mechanism)
  - Controls external alarms, sprinklers, or emergency systems based on fire detection.
- Alert System (Notification Module)
  - Sends SMS, email, or IoT alerts in case of fire detection.
  - Uses GSM, WiFi, or cloud-based notification services.
- Power Supply
  - Provides continuous power to the system (battery backup recommended).

**3. System Flow Diagram**

- Video Feed Capture: The camera continuously captures the monitored area.
- Frame Processing: The captured frames are analysed using OpenCV & AI.
- Fire Detection Algorithm: Detects flames based on colour, motion, and shape.
- Decision Making: If fire is detected, it triggers an alert.
- Alert Mechanism Activation:
  - Alarm System: Sounds a siren.
  - Notification System: Sends alerts via email/SMS.
  - Automated Response: Activates a sprinkler system (if integrated).
- Continuous Monitoring: The system keeps running in a loop for real-time detection.

**4. Block Diagram (Simplified Representation)**

Camera Module (Input)
↓
Processing Unit (OpenCV, AI)
↓
Fire Detection Algorithm
↓
---------------------------------------------------------

| Alarm System | SMS Alert System | Sprinkler Activation |
|---|---|---|

---------------------------------------------------------

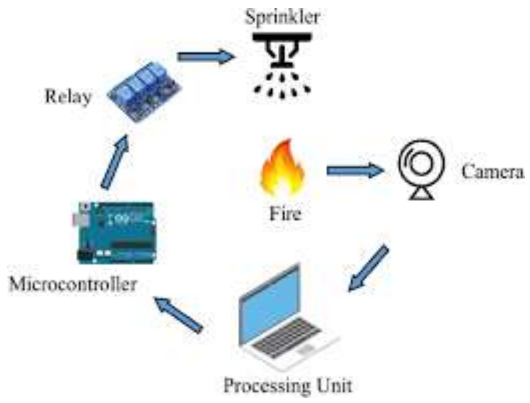


**Fig3. System Design**

## VI. SYSTEM OUTPUT / RESULTS

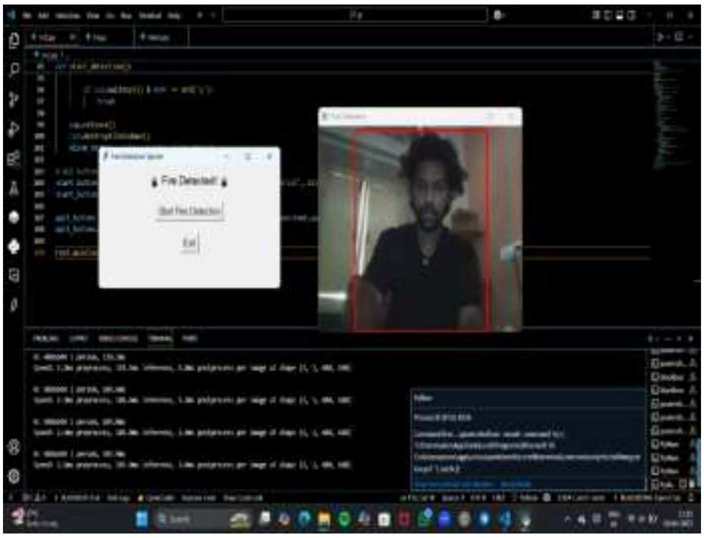

**Fig4. Live Video Capturing**

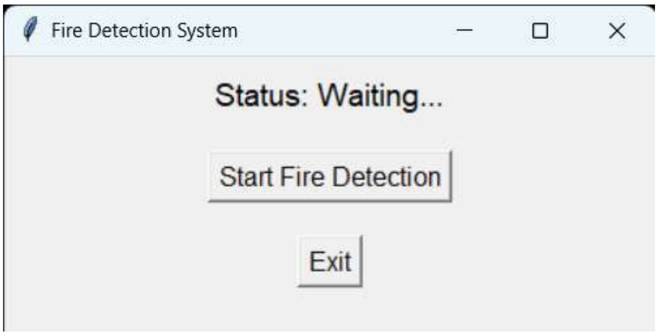


**Fig5. Status of Fire Detection**


**Fig6. Status of Fire Detection**

## VII. CONCLUSION

The Fire Detection and Alarming System using AI and Python provides an efficient, real-time solution for detecting fire using computer vision and deep learning. Unlike traditional smoke and heat detectors, this system leverages OpenCV and AI-based models to analyse video feeds from CCTV or laptop cameras, offering faster and more accurate fire detection. By detecting fire patterns based on colour, shape, and motion, the system ensures early warning and immediate response.

The integration of an alert system (alarms, SMS, and IoT notifications) enhances safety by ensuring that emergency responders are informed instantly. Additionally, the system can be scaled and customized to work in industrial, residential, and outdoor environments, making it a versatile fire prevention tool.

Despite its advantages, challenges such as false positives, environmental factors, and computational demands need further optimization. Future improvements can include thermal imaging, deep learning refinements, and IoT-based automation for better accuracy.

In conclusion, this AI-driven fire detection system is a cost-effective, scalable, and smart surveillance tool that can significantly reduce fire-related risks. With continued advancements in AI and IoT, this technology has the potential to become a critical component of modern fire safety systems.

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