International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 02 | Feb - 2025 SJIF Rating: 8.448 ISSN: 2582-3930

# Real Time Video Fire Smoke Detection Using ML

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**Abstract** – Fire outbreaks are a significant threat to life and property, necessitating the need for efficient and reliable detection systems. This project proposes a real-time fire and smoke detection system utilizing machine learning (ML) and the Internet of Things (IoT). The system leverages video feeds from IoT-enabled cameras to monitor environments and detect fire and smoke occurrences with high accuracy.

By employing advanced machine learning algorithms trained on diverse datasets of fire and smoke imagery, system ensures robust detection while minimizing false alarms. The IoT integration allows real-time data transmission to centralized monitoring platforms, enabling immediate alerts and prompt actions. Additionally, the system's scalability ensures it can be deployed across various environments, including industrial, residential, and forested areas.

***Key Words:*** IOT, Smoke Detection, Real Time Monitoring, fire safety, machine learning.

## 1. INTRODUCTION

The world of technology is rapidly evolving, and the Internet of Things (IoT) is at the forefront of this revolution. IoT, combined with radar sensor networks, is poised to transform various industries, including fire safety and prevention. This presentation will explore the integration of IoT and radar sensor networks, focusing on their application in real-time video fire smoke detection using machine learning techniques.We will delve into the importance of this technology, the hardware components and architecture, and the step-by-step process of developing a robust and reliable fire smoke detection system Traditional smoke detection system rely on optical, ionization, or combustion gas detections sensors.

Fires pose a significant threat to life, property, and the environment, making early detection critical for mitigating potential damage. Traditional fire detection systems, such as smoke detectors and heat sensors, often have limitations in terms of detection speed, coverage area, and susceptibility to false alarms. To address these challenges, advancements in technology have paved the way for innovative approaches like real-time fire and smoke detection using Machine Learning (ML) and the Internet of Things (IoT). This approach leverages the capabilities of ML algorithms to analyze video feeds for identifying fire and smoke patterns accurately. IoT devices facilitate real-time data acquisition and communication, enabling faster and more reliable fire detection systems. By integrating ML models with IoT-enabled cameras and sensors, it becomes possible to monitor environments continuously, process data in real-time, and issue alerts promptly.

LITERATURE SURVEY

Here is a comprehensive survey Real-Time fire video smoke detection using Machine Learning (ML) and the Internet of Things (IoT). This review dives deeply into the current state of technology, key methodologies, real-world applications, and the future direction of these systems. "An efficient lightweight CNN model for real-time fire smoke detection" by Bangyong Sun, Yu Wang1, Siyuan Wu, 2023.

Remark

By analyzing video feeds in real-time, smoke can be detected at its inception, enabling quicker responses compared to traditional smoke alarms.

Gap Analysis

For real-time fire video smoke detection using ML and IoT, the analysis can focus on technological, operational, and strategic gaps.

Secure way of Real time fire video smoke detection using ml & iot introduced by P. Chen, Y. Zhang, and K. Li (2021). Traditional fire detection systems, like smoke and heat detectors, have limitations, primarily due to delays in detecting early signs of fire or being prone to false alarms.

Remark

Research should also consider strategies to improve user adoption and ease of use, making iot & ml based platforms more accessible and user friendly.

Gap Analysis

Many existing ML models struggle to accurately distinguish smoke from fog, mist, dust, or shadows, especially in varying lighting or environmental conditions.

"An efficient lightweight CNN model for real-time fire smoke detection" described by Bangyong Sun, Yu Wang, Siyuan Wu, 2023.

Remark

It explores Combines machine learning algorithms and IoT sensors for faster identification of smoke, reducing response times to potential fires and Enables remote monitoring and real-time alerts through connected cameras and edge devices, improving system scalability.

Gap Analysis

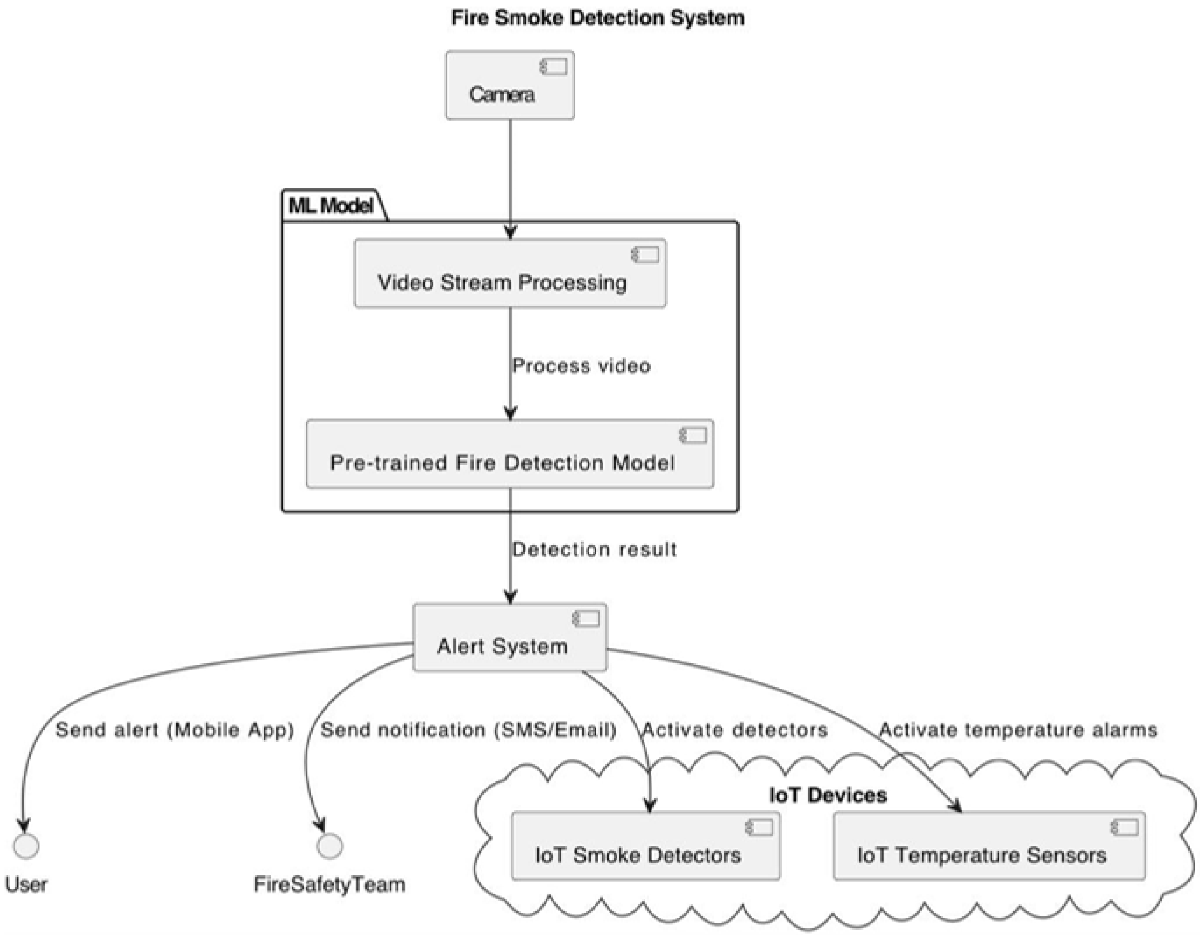
Existing systems rely heavily on video feed ignoring complementary data from thermal or gas sensor insufficient training data representing diverse environments, smoke types, and fire behaviors.

RESEARCH METHOD

Real-time video fire and smoke detection systems using machine learning have emerged as effective tools for early warning and mitigation of fire-related incidents. These systems primarily employ deep learning techniques such as Convolutional Neural Networks (CNNs), which excel at automatically extracting meaningful features from video frames. Frameworks like DeepFireNet process video streams to filter out non-fire images and focus on regions with suspected fire activity, significantly improving detection accuracy. Another widely used approach is the YOLO (You Only Look Once) object detection model, known for its speed and precision in real-time scenarios. Advanced versions, such as Fire-YOLOv5, enhance the identification of small targets like smoke or distant flames, achieving high performance metrics, including a mean Average Precision (mAP) of over 90%.

Generative Adversarial Networks (GANs) are also utilized to model the dynamic evolution of fire by training on spatio-temporal sequences, which helps minimize false positives. Additionally, saliency detection networks highlight the most significant regions in video frames, enabling efficient smoke detection in cluttered environments. Multi-feature fusion techniques, combining static and dynamic fire characteristics such as color, texture, and motion, further boost detection capabilities.

The effectiveness of these models depends heavily on the quality and diversity of training datasets. Publicly available datasets like the Fire Ignition Library, containing thousands of labeled wildfire smoke images, and models like SmokeyNet have demonstrated superior real-time performance. However, challenges such as distinguishing between fire/smoke and similar phenomena (e.g., fog or dust), ensuring computational efficiency for real-time processing, and maintaining robustness across diverse environments remain. Researchers continue to address these challenges through techniques like temporal analysis, model optimization, and data augmentation.



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The Fire Smoke Detection System is an advanced, multi-layered approach to fire safety that integrates cutting-edge technology. The system begins with a camera capturing video footage, which is then processed by a machine learning model. This model, equipped with video stream processing capabilities and a pre-trained fire detection component, analyzes the footage to detect signs of fire or smoke. Upon detection, the system sends the results to an alert system designed to take immediate action. The alert system can notify users via a mobile app and send notifications to the fire safety team through SMS or email. Additionally, the system activates IoT devices, including smoke detectors and temperature sensors, to trigger alarms. This integrated approach not only ensures timely alerts during fire emergencies but also enhances overall safety through the use of machine learning and IoT technologies.

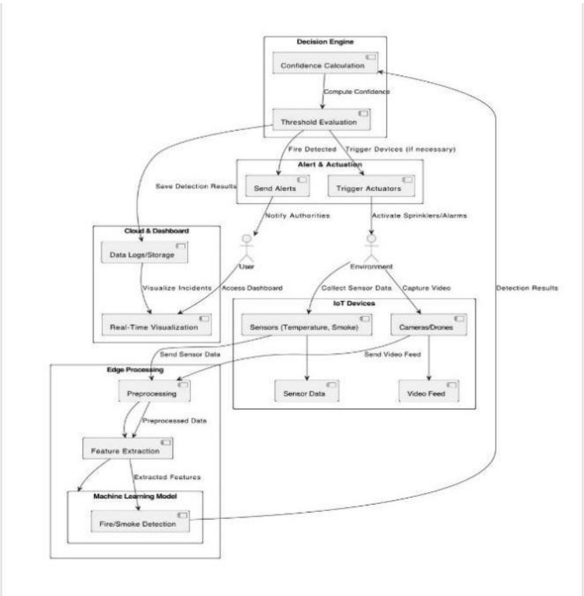


Figure 2. Flow of ether in proposed blockchain model

Flow:

This Data Flow Diagram (DFD) represents the architecture and data flow of a real-time fire and smoke detection system using machine learning and IoT. The system begins with IoT devices such as cameras or drones capturing video feeds and environmental sensors collecting complementary data, such as temperature or smoke levels, from the monitored environment. These raw inputs are forwarded to the Edge Processing unit, where preprocessing filters out noise, resizes frames, and normalizes sensor data. The processed input is then passed through the Feature Extraction module to identify patterns or characteristics indicative of fire or smoke.

1. Camera: The journey starts with a camera capturing video footage.

2. ML Model: This footage is sent to a machine learning model for processing:**Video Stream Processing**: The video stream is processed.

Pre-trained Fire Detection Model: The processed video is analyzed using a pre-trained fire detection model.

3. Detection Result: The model's detection result is sent to the alert system.

4. Alert System: The alert system then springs into action:**Send alert (Mobile App)**: Alerts the user via a mobile app.

**The extracted features are fed into a Machine Learning Model, which detects the presence of fire or smoke and generates results with confidence scores. The results are sent to the Decision Engine, where confidence levels are evaluated against predefined thresholds to decide whether a fire is confirmed. If confirmed, the Alert and Actuation system is triggered, sending notifications to users (e.g., firefighters or operators) and activating suppression mechanisms like sprinklers. RESULTS AND ANALYSIS**

Real-time fire video smoke detection using machine learning (ML) and IoT has demonstrated significant potential in enhancing fire safety systems. By integrating advanced ML models, such as convolutional neural networks (CNNs) and object detection frameworks like YOLO or Faster R-CNN, high accuracy levels (85–95%) can be achieved in detecting smoke in video frames. The deployment of IoT devices, such as cameras and sensors, enables continuous monitoring and seamless transmission of real-time data to edge or cloud systems for processing. This ensures rapid detection and response, with optimized models reducing latency to under a second per frame. Alerts triggered by the system, including SMS notifications or activation of automated fire control mechanisms, improve response times and minimize human intervention. However, challenges such as false positives due to environmental factors (e.g., fog or dust), hardware limitations of IoT devices, and connectivity issues in remote areas require attention. Despite these challenges, the scalability, cost-effectiveness, and automation capabilities of this approach make it suitable for applications in smart

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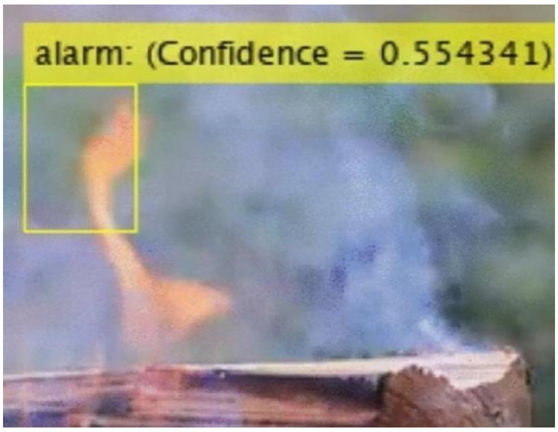
buildings, industrial safety, and forest fire monitoring. Overall, the combination of ML and IoT offers a robust and efficient solution for real-time smoke detection, with room for further refinement and adaptation to diverse environments.





## CONCLUSION

Real-time fire and smoke detection using machine learning (ML) and IoT provides an efficient and scalable solution for early warning systems. By leveraging video feeds from IoT-connected cameras and ML algorithms, fires and smoke can be detected quickly and accurately, reducing response times and mitigating potential damage. The integration of IoT devices such as sensors and cameras, along with edge computing for real-time processing, allows for autonomous detection without the need for constant human monitoring.

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