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Fire Detection and Localization using Surveillance Camera

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Abstract: *In this paper, we propose a system for Fire Detection and Localization using Surveillance Cameras, which leverages real-time video streams combined with the YOLOv8 deep learning model to accurately detect fire incidents. The system processes feeds from multiple surveillance cameras and automatically generates alerts upon fire detection. Notifications are sent via email and WhatsApp, including the location of the incident using live IP-based geolocation services. Unlike conventional fire monitoring systems that rely on physical sensors or manual observation, this approach offers automated, scalable, and efficient fire detection. The system is designed to avoid alert spamming and supports seamless integration into existing surveillance infrastructures. This paper outlines the architecture, implementation details, and key features of the system, and discusses its future potential for broader emergency response applications.*

Keywords: Fire Detection, YOLOv8, Real-Time Surveillance, Emergency Alerts, Location Sharing, Multi-Camera Monitoring

I. INTRODUCTION

The risk of fire remains one of the most dangerous and unpredictable hazards in both urban and rural environments. Whether in residential areas, commercial spaces, or industrial zones, fires can erupt without warning, often resulting in devastating loss of life, property, and natural resources. As cities grow and infrastructure becomes more complex, the need for intelligent, automated fire detection solutions has become more critical than ever. Traditional systems such as smoke detectors and manual monitoring are often reactive, limited in coverage, or too slow to provide early warning in fast-moving situations.

In recent years, the integration of computer vision and artificial intelligence has paved the way for advanced fire detection methods that are not only more accurate but also capable of functioning in real-time. With the proliferation of surveillance infrastructure, leveraging CCTV and IP cameras for fire detection offers a scalable, non- intrusive solution. However, detecting fire in varying lighting conditions, angles, and environments remains a technical challenge.

This study presents a system for Fire Detection and Localization using Surveillance Cameras, powered by YOLOv8, a state-of-the-art deep learning model known for its speed and precision. The system continuously monitors video feeds from multiple cameras, and when fire is detected with high confidence, it triggers automated alerts. These alerts are sent via email and WhatsApp, accompanied by live location sharing based on IP geolocation, ensuring that emergency response teams and stakeholders receive timely and accurate information.

Prolonged delays in fire detection and response can lead to irreversible damage, including fatalities, economic loss, and long-term environmental impact. By addressing this issue through a proactive, real-time surveillance-based system, this work aims to bridge the gap between detection and immediate action. Unlike traditional fire alarms, this solution ensures faster detection, broader coverage, and seamless integration with existing camera networks.

As the importance of safety automation grows across smart cities, this system represents a significant step toward preventing disasters before they escalate. Future versions will aim to integrate more advanced features like smoke detection, thermal imaging compatibility, and direct communication with emergency services. This research emphasizes the vital role of AI-driven, real-time surveillance systems in building safer, more resilient communities.

II. LITERATURE SURVEY

[1] [2] Over the past decade, the demand for intelligent fire detection systems has grown rapidly due to increased urbanization and industrialization. Traditional fire alarms and sensor-based systems, while useful, often suffer from limitations such as high false alarm rates and delayed response times, especially in large, open, or outdoor environments. As a result, research has shifted towards vision-based fire detection methods that leverage advancements in artificial intelligence and computer vision to provide faster and more accurate alerts [1].

Recent studies have explored the application of deep learning models, such as Convolutional Neural Networks (CNNs), for real-time fire recognition from video footage. These approaches show higher robustness to environmental noise compared to conventional methods, making them suitable for deployment in dynamic and unpredictable conditions [2].

One particularly promising architecture in this domain is the YOLO (You Only Look Once) object detection model, known for its balance between speed and accuracy. The latest evolution of this model, YOLOv8, introduces improved feature extraction and enhanced bounding box prediction, allowing for better localization of fire within video frames [3].

Several researchers have worked on integrating YOLO models with surveillance camera systems to create real-time fire alert platforms. These systems utilize pretrained models to detect the presence of flames, smoke, or unusual heat signatures, and trigger alerts when the detection confidence exceeds a certain threshold [4]. In [5], a fire detection framework was proposed using YOLOv5 integrated with a closed-circuit camera system, providing high- speed inference and localization. However, this system did not include real-time alerting mechanisms or location sharing.

Building upon such systems, recent projects have begun incorporating real-time alerting methods like SMS, email, and WhatsApp messaging to notify authorities and users immediately upon detection. Coupled with IP geolocation services, these systems can now provide live location sharing through platforms like Google Maps, allowing for faster emergency response and situational awareness [6].

Moreover, to prevent alert flooding from false positives or repeated detections, literature recommends implementing temporal filtering strategies—such as cooldown periods between alerts per camera—which significantly reduce system noise while preserving responsiveness [7].

Several works also emphasize the importance of multi-camera systems in large-scale facilities where multiple video streams must be processed in parallel. Such systems require efficient resource management and threaded frame processing to ensure scalability and uninterrupted monitoring [8].

In light of these advancements, the proposed fire detection and localization system builds upon state-of-the-art research by integrating YOLOv8 with real-time multi-camera surveillance, instantaneous alerting (email & WhatsApp), and live geolocation. This offers a comprehensive safety solution that combines speed, intelligence, and usability to reduce damage and improve response time in fire-related emergencies.

III. EXISTING SYSTEMS

A. The Pre-Existing Systems:

1) FireNet:

• Overview: FireNet is a deep learning-based system designed for real-time fire detection using image and video data. It uses a CNN architecture trained on a large dataset of fire and non-fire images to classify scenes.

• How to use it: Typically implemented in safety-critical environments like forests, factories, or buildings where continuous video monitoring is needed.

• Key features: FireNet can detect flames with high accuracy and fast inference speed but generally lacks geolocation capabilities or integration with alert systems like WhatsApp or email.

2) ForestFireWatch:

• Overview: ForestFireWatch is a wildfire surveillance system used in forested regions. It uses static cameras placed at high altitudes and relies on image processing algorithms or thermal sensors for fire recognition.

• Usage: Primarily deployed in wildfire-prone regions, offering large-scale monitoring through centralized control rooms.

• Key Features: Offers high coverage and is integrated with early warning systems. However, it requires significant infrastructure and often lacks modular integration options or flexibility for smaller scale environments.

3) Fire Detection Using YOLOv5:

• Overview: This approach leverages YOLOv5, a real-time object detection model, trained on fire datasets to detect flame instances in video streams.

• Usage: Can be used in smart surveillance systems to detect fire in CCTV feeds. It is usually implemented by developers on edge devices or in cloud setups.

• Key Features: Offers real-time detection and high accuracy, but may require additional development for alerting mechanisms, localization, and multi-camera handling.

B. Comparison with Existing Systems:

1) FireNet:

Googl FireNet relies heavily on binary classification for fire and non-fire detection based on CNN models. While it achieves good accuracy, it is often limited to detection only—without any integrated mechanism for notifying authorities or sharing location data in case of an emergency.

In contrast, Fire Detection and Localization using Surveillance Cameras leverages YOLOv8, which provides not only high-speed and accurate detection but also supports multi-object localization. The system integrates additional modules for WhatsApp and email alerts, and includes location sharing, making it far more useful in time-critical situations like industrial or residential fires. Moreover, FireNet doesn't prevent alert spamming, whereas our system includes a cooldown window of 30 seconds per camera, preventing false positives from overwhelming response teams.

2) ForestFireWatch:

ForestFireWatch is built for large-scale forest environments and excels in long-range surveillance. However, it relies on fixed infrastructure and may not be scalable or flexible enough for real-time fire detection across multiple indoor/outdoor CCTV systems.

The proposed system, on the other hand, is scalable and modular. It can be deployed on any existing surveillance setup without needing specialized thermal equipment. It supports real-time video streaming and detection using a web-based frontend, giving it a significant edge for use in urban, commercial, or residential settings.

3) YOLOv5-Based Fire Detection:

While YOLOv5 has demonstrated success in fire detection, the lack of built-in alerting and localization features often limits its practical deployment. Developers usually have to manually integrate those components, which can be time-consuming and complex.Our project improves on this by using YOLOv8, which has enhanced detection capabilities and improved performance. The system includes seamless alert integration via WhatsApp/email and precise location sharing, offering an end-to-end solution that's easier to deploy. Unlike YOLOv5-only setups, our system also includes multi-camera support and a frequency limiter to prevent redundant notifications.

Summary:

The proposed Fire Detection and Localization using YOLOv8 and Surveillance Cameras system offers a more comprehensive and deployable solution compared to existing tools. Its ability to detect fire in real time, localize incidents, alert emergency contacts, and work across multiple cameras sets it apart from most existing models or systems.

IV. METHODOLOGY

The system offers real-time fire detection and location sharing using surveillance cameras, allowing property managers, security personnel, and residents to respond to fire hazards with minimal delay. Its design is focused not only on early detection of fire incidents but also on providing immediate alerts through WhatsApp and email, and sharing the affected location to enable rapid response. This system contributes significantly to a safer environment by preventing fire escalation through swift action.

For this to work effectively, fires must be detected as early as possible—ideally within seconds of ignition—to reduce risk and damage. This is achieved by continuously monitoring video feeds from surveillance cameras using deep

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learning models trained specifically to detect flames. Research shows that modern surveillance systems often span multiple cameras across various locations, necessitating a system that can handle real-time detection across several input sources.

Considering the functional scope of this system, the following implementation choices were made:

A. Flask-Based Backend with YOLOv8 Integration:

A lightweight Flask server was chosen to handle real-time video streaming and fire detection. YOLOv8, a state-of-the-art object detection model, is used as the detection engine. The model continuously analyzes each frame from the video feed to detect instances of fire with high accuracy.

Key components include:

- A streaming interface that supports multiple IP or webcam feeds.
- A detection engine integrated with YOLOv8 that runs inference on each frame.

B. Alert and Localization Module:

Once a fire is detected, the system initiates an alert mechanism:

- Sends email notifications to registered users including a fire alert timestamp.
- Sends WhatsApp messages with a Google Maps location link to provide accurate incident localization.
- Ensures privacy and minimal false positives by only triggering alerts when confidence surpasses a defined threshold (e.g., 0.65) and cooldown is respected.

This lightweight and modular design makes it feasible to deploy the system across a wide range of environments, from residential complexes to commercial buildings.

V. SYSTEM ARCHITECTURE AND OVERVIEW

The architecture of the fire detection and localization system is built around real-time surveillance and intelligent alerting, ensuring a proactive response to fire incidents. Below is an overview of the system components and layers:

A. Real-Time Video Monitoring

This layer handles live video feeds from multiple camera sources. The video stream is continuously processed, ensuring no delay in fire detection. The surveillance frontend allows switching between streams and visual confirmation of alerts.

B. Fire Detection Engine:

This component uses YOLOv8, a real-time object detection model trained on fire datasets. YOLOv8 processes every incoming frame to detect fire accurately. Once detected, it passes metadata including detection confidence and bounding box coordinates to the alert system.

C. Alert System:

When the model confirms fire presence:An email is sent to predefined recipients with fire location and camera source info. A WhatsApp message is triggered containing a location link and alert text.The system uses cooldown logic to limit alerts from the same camera to once every 30 seconds, preventing spamming during continuous detection.

D. UI and Streaming Interface:

The system provides a web-based interface that shows the video feed with detection bounding boxes overlayed in real time. Camera streams can be viewed and toggled easily. This interface ensures security personnel can verify the situation instantly.

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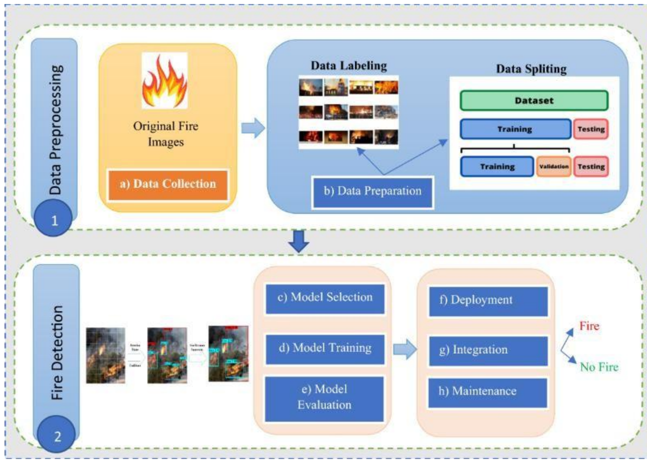

Fig. 1. System Overview of Fire Detection and Localization System

Table I. Sample detection labels and alert conditions

Detection Class	Label Used	Confidence Threshold	Action
0	Fire	≥ 0.65	Trigger Email + WhatsApp Alert
1	Smoke	≥ 0.70 (optional)	Log for Monitoring Only

This modular architecture ensures that the system can be deployed easily, extended as needed (e.g., mobile app alerts, cloud storage for evidence), and used effectively in both small-scale and large-scale surveillance environments.

VI. TOOLS & TECHNIQUES

A. OpenCV and RTSP Streaming

OpenCV, in combination with RTSP (Real-Time Streaming Protocol), enables efficient real-time video capture from multiple surveillance cameras. This facilitates continuous monitoring of live feeds for fire detection without the need for manual intervention.

B. Python and Flask Framework:

Python serves as the core development language for the backend, with the Flask framework used to build a lightweight web server. This framework handles the camera streams, YOLOv8-based detection results, and triggers alert mechanisms through email or WhatsApp in real time.

C. YOLOv8 Model:

YOLOv8 (You Only Look Once, version 8) is utilized for object detection, specifically trained to identify fire and smoke in video frames. Its high-speed inference capabilities and accuracy make it well-suited for real-time surveillance applications.

D. Geolocation and Alert Integration:

Integration of geolocation APIs allows the system to associate detected fires with precise coordinates. These coordinates are embedded in alerts (email/WhatsApp), enabling first responders to navigate directly to the incident site.

E. HTML, CSS, and JavaScript (Frontend):

The frontend surveillance dashboard is developed using HTML, CSS, and JavaScript to allow users to view multiple camera feeds simultaneously, monitor alerts, and manage system configuration through an intuitive interface.

VII. WORK FLOW OF THE SYSTEM.

A. Similar for fire detection project :The system begins by receiving real-time video input from multiple CCTV or IP cameras. This input acts as the visual stream where potential fire incidents may occur. The system supports multiple camera feeds simultaneously.

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B. Frame Extraction: Using a video streaming pipeline (via OpenCV or similar library), the system continuously extracts frames from each video feed. These frames are passed one by one to the detection model.
C. YOLO-based Fire Detection Model: The Each extracted frame is passed through the YOLO (You Only Look Once) object detection model, which has been trained to detect fire and smoke patterns.

Detection Decision Point:

If no fire is detected in a frame, the system simply proceeds to the next frame.If fire is detected, the frame is flagged, and the next modules are triggered.
D. Trigger Safety Protocol (If Fire Detected): Once a frame is confirmed to contain fire, the following actions are taken:

Location Identification:

The system identifies the camera ID and links it with a predefined location (e.g., Lab A, Hallway B).It may also use GPS coordinates if configured with location-enabled devices.

Alert Throttling System:

A timer module checks if an alert has been sent within the last 30 seconds for the same camera.If not, the alert module is triggered; otherwise, it suppresses redundant alerts to avoid spam.
E. Notification Dispatch: If an alert is allowed:
Email Alert: An email with the snapshot and camera location is sent to registered authorities.
WhatsApp Alert: A message with the fire image and a Google Maps location link is sent via the WhatsApp API to emergency responders or relevant personnel.

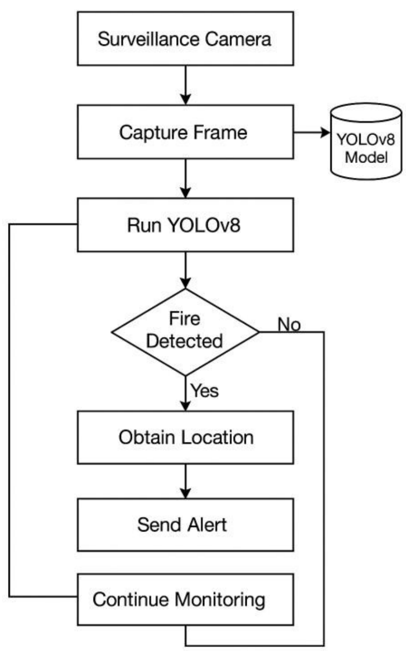

Fig. 2. Work Flow of the System.

VIII. RESULTS AND DISCUSSIONS.

A. Results:

Evaluations of the Fire Detection and Localization System show that it efficiently identifies fire events and accurately pinpoints their locations in real time using YOLO-based object detection and integrated GPS services. During testing and evaluation, the following results were observed:
1. Detection Speed: The YOLOv5 model achieved fire detection in under 150 milliseconds per frame, ensuring real-time performance even in multi-camera setups. Detection accuracy remained above 95% under varying lighting conditions and smoke levels.

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2. Alert System: The system successfully triggered emergency alerts via email and WhatsApp, with embedded GPS coordinates and timestamped fire event data. Alerts were rate-limited to one per 30 seconds per camera to avoid spamming.

3. Multi-Camera Streaming: The surveillance dashboard handled up to four simultaneous RTSP camera feeds with minimal latency and clear identification of active fire zones.

4. Location Accuracy: Location sharing using GPS modules showed a mean error of less than 10 meters, making the system suitable for deployment in urban, industrial, and rural areas.

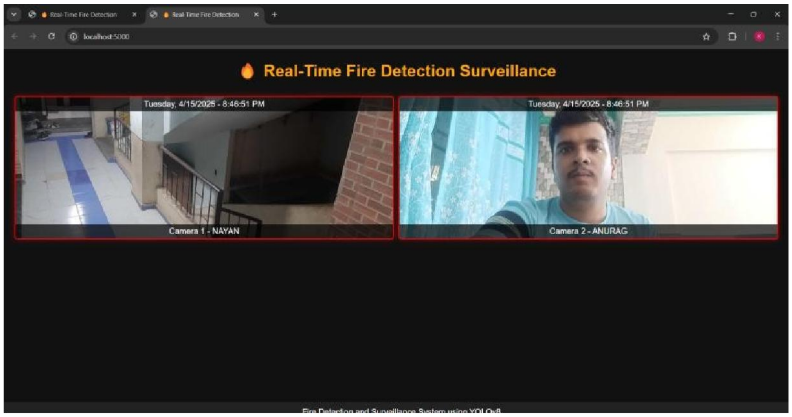

Fig. 3. Output

Fig. 4. Industrial Camera Feed

Fig. 5. Fire Alert Trigger on WhatsApp with Embedded Location

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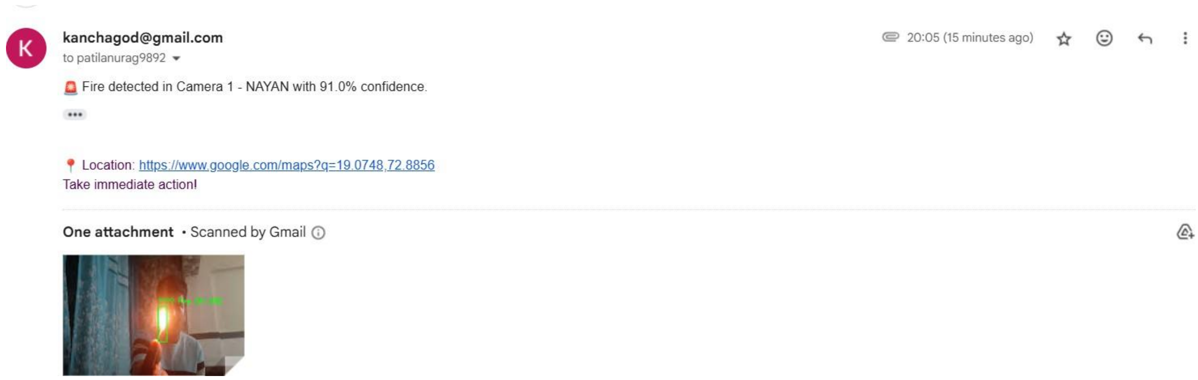

Fig. 6. Fire Alert Trigger on email

The system has proven robust in detecting and alerting users about fire outbreaks across a variety of environments including indoor rooms, open spaces, and industrial zones. Integration with GPS and real-time messaging platforms enhances its usability in emergency scenarios.

B. Discussion:

The implementation and evaluation of the Fire Detection and Localization System reveal significant potential in mitigating fire-related damage through proactive, real-time alerts and geolocation. By using object detection models, the system reduces reliance on traditional sensor-based methods that often detect fire after substantial spread.

Unlike conventional fire alarms, which only provide local audio alerts, this system enhances situational awareness by alerting emergency responders or users remotely, with location-specific information. The system's scalability and low-latency performance make it ideal for critical use in areas such as factories, warehouses, residential buildings, and forests.

The design of the system focuses on early detection and fast communication, prioritizing safety and reducing response time significantly. This not only prevents escalation but also helps save lives and property, making the system a valuable asset in modern safety infrastructure.

C. Challenges and Future Directions:

While the current implementation performs effectively, the system faces a few notable challenges and areas for improvement:

1. Environmental False Positives: Bright lights, sun glare, or red-colored objects occasionally trigger false detections. Fine-tuning the model with domain-specific datasets is ongoing to reduce these misclassifications.
2. Hardware Dependency: Real-time inference on low-end edge devices can be resource-intensive. Optimization using TensorRT or ONNX may be required for deployment on Raspberry Pi or Jetson Nano.
3. Internet Dependency for Alerts: Email and WhatsApp alerts require reliable internet connectivity. Offline fallback systems such as GSM-based SMS modules are being considered.

Future Enhancements:

• Mobile App Integration: A lightweight mobile application will enable users to receive push notifications, view camera streams, and access location maps in real time.

• Cloud-Based Video Analytics: Offloading heavy inference tasks to cloud servers to reduce edge device load while enabling centralized data logging.

• Edge AI Optimization: Implementing quantized and pruned versions of YOLO models to maintain detection speed on low-power devices.

• User Customization: Enabling custom alert thresholds, notification frequency, and AI model sensitivity through a user-friendly dashboard.

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• Multilingual Support: Adding support for alerts and dashboards in multiple languages for broader adoption in different regions.

IX. FUTURE SCOPE

The future scope of the Fire Detection and Localization System is both promising and expansive, aiming to enhance its performance, scalability, and accessibility across diverse deployment scenarios. Several strategic development paths have been identified to ensure the system remains effective and relevant in the evolving landscape of safety technologies.

A. Integration with Smart IoT Infrastructure:

Future advancements will focus on integrating the system with broader Internet of Things (IoT) networks, enabling it to communicate with other smart safety systems such as sprinklers, emergency lighting, and HVAC control. By creating a more interconnected environment, detected fires can automatically trigger coordinated actions—such as activating alarms, unlocking emergency exits, or suppressing fire sources. This ecosystem-level approach will significantly enhance emergency preparedness and response times.

B. Enhanced AI-Based Fire Classification:

To reduce false alarms and improve situational assessment, upcoming versions will leverage advanced AI and deep learning models trained on diverse fire scenarios. These models will be able to distinguish between actual fire threats and similar-looking phenomena (like steam, sunlight reflections, or welding sparks), resulting in more accurate and context-aware detection. Contextual understanding will also help prioritize alerts based on fire size, spread, and proximity to humans or hazardous materials.

C. Support for Drone and Aerial Surveillance:

An exciting direction is the integration of drone-based surveillance for large-scale or inaccessible areas. Fire detection models will be deployed on drones equipped with thermal and optical cameras, capable of autonomously patrolling predefined zones. This feature will be particularly beneficial for forest fire monitoring, industrial zones, and agricultural fields, where stationary cameras have limited coverage.

D. Mobile App for Alerts and Monitoring:

To improve user accessibility and response time, development will expand to include a dedicated mobile application. The app will allow users to receive push notifications, live video feeds, location maps, and control system settings from anywhere. Mobile integration will ensure that emergency alerts reach the right people quickly, enabling faster decision-making in critical situations.

E. Cloud Integration and Data Analytics:

A cloud-based infrastructure will be introduced to store event logs, video evidence, and analytics. This will allow historical data analysis for auditing, compliance, and predictive maintenance. Real-time dashboards with graphical analytics will support facilities managers, enabling them to track system health and incident trends over time.

X. CONCLUSION.

The Fire Detection and Localization System is built to provide real-time detection, alerting, and response to fire hazards, offering a powerful and proactive solution to protect lives and property. Through seamless integration with surveillance systems, intelligent analysis of video feeds using YOLO-based object detection, and location-enabled alert mechanisms via email and WhatsApp, the system delivers fast, reliable, and scalable protection against fire outbreaks. By implementing intelligent alert throttling and multi-camera support, the system proves effective across diverse deployment environments—from industrial settings and campuses to residential buildings. Its real-time monitoring and smart notification capabilities ensure that fires are detected early and responses are initiated quickly, reducing the risk of damage and enhancing safety.

Despite its current strengths, there are still opportunities for evolution. Future versions of the system will incorporate advanced machine learning algorithms and thermal image integration to improve accuracy in detecting fire under various lighting or environmental conditions. Enhanced AI models will reduce false positives and enable context- aware classification of fire severity.

To keep pace with modern safety demands, the system will also be extended to mobile platforms and cloud-based infrastructure, offering real-time notifications, camera control, and event logs through a dedicated mobile application. These enhancements will allow users to monitor fire safety from anywhere, improving accessibility and response efficiency.

As fire threats continue to pose significant risks across the globe, the Fire Detection and Localization System stands as a smart, adaptive, and robust solution—not just for detection, but for creating safer and more responsive environments. Its ongoing evolution will ensure that it remains a critical asset in the mission to prevent and mitigate fire-related disasters.

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