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Adaptive Real-Time Federated AI Surveillance Framework for Intelligent Public Safety Monitoring

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ABSTRACT: Ensuring safety in densely populated and urban areas necessitates effective and intelligent monitoring systems that can identify unusual or hazardous activities in real time. Conventional surveillance systems rely heavily on human operators who manually review CCTV footage, often resulting in delayed reactions, missed incidents due to fatigue, and limited situational awareness. To overcome these challenges, this project introduces a real-time AI-based surveillance framework that utilizes advanced object detection algorithms, particularly the YOLO (You Only Look Once) model, to automatically recognize and locate public safety issues such as fights, child abductions, vandalism, graffiti, accidents, and public intoxication. The system continuously processes video feeds from CCTV cameras and identifies abnormal events by analyzing patterns, behaviors, and interactions within the scene. The model is trained on a substantial and diverse dataset covering different lighting conditions, crowd levels, and environmental settings to ensure robustness and adaptability in real-world environments. Upon detecting an abnormal event, the system triggers immediate alerts and sends them to relevant authorities, facilitating swift and informed action. Performance is evaluated using metrics such as precision, recall, F1-score, mean Average Precision (mAP), and frame-per-second (FPS) processing speed to ensure accuracy and real-time efficiency. By integrating AI-driven object detection with automated alert systems, the proposed framework offers a scalable, efficient, and intelligent solution for modern public safety surveillance, significantly improving urban security and reducing the burden on human operators.

KEYWORDS: YOLO (You Only Look Once), CCTV camera, F1-score, mean Average Precision (mAP), frame-per-second (FPS).

I. INTRODUCTION

In today's world, where cities are growing quickly, making sure people are safe has become a big problem. This is because more accidents, thefts, fights, vandalism, and other crimes or unusual activities are happening in busy places. Traditional security systems mostly depend on people watching many CCTV cameras at once, which takes a lot of time and can make mistakes. As more cameras and video data are being used, it's hard for people to monitor everything properly, especially in big areas. Therefore, there's a big need for a system that can automatically and smartly watch and check for safety in real time. AI and computer vision have changed security systems by letting them automatically see, understand, and recognize what people are doing in videos. Deep learning models, like YOLO (You Only Look Once), are very good at spotting and finding many objects at once in a video frame. This makes them useful for watching public areas in real time. These AI systems can not only find strange or dangerous activities, like fights, drunk people, or someone taking a child, but also tell the difference between normal and suspicious actions. This automation makes the system faster and more accurate at detecting threats, which reduces the need for people to watch everything themselves. The project called "Real-Time Surveillance of Public Safety Incidents Using AI Object Detection" aims to build a strong and flexible system that can look at live video and spot safety problems right away. The system is trained on a wide variety of video clips that show different lighting, crowd sizes, and other conditions, to make it work well in many situations. When the system finds something unusual, it sends an automatic alert to the right people so they can act quickly. By using AI, real-time processing, and fast alerts, this system helps manage public safety better, improves awareness of what's going on, and makes the city safer.

II. LITERATURE SURVEY

2.1 Recent Challenges and Opportunities In Video Summarization With Machine Learning Algorithms

P. Kadam et al. [1] look at the new challenges and chances of using machine learning for video summary. They talk about how the fast growth of video surveillance and multimedia data has made it important to find ways to summarize videos efficiently so that key info is kept while using less storage and computing power. They check different machine learning models, both supervised and unsupervised, to improve how well summaries match the real content. The study also shows the importance of understanding the context, keeping time order, and using multi-object detection to make useful summaries. The way they do this is by training AI models to automatically find and pick the most important parts of a video based on movement, objects, and scene shifts. The research points out how combining deep learning tools like CNNs and RNNs helps improve the quality of summaries, allowing systems to process real-time security data better and more efficiently.

2.2 Static Video Summarization with Multi-Objective Constrained Optimization

M. Dhanushree et al. [2] introduces a method for making summaries of videos using multi-objective constrained optimization. Their method focuses on picking the most important and representative frames from a video while making sure the content is varied and consistent in time. The system uses optimization algorithms to balance different goals like the summary being short, clear, and covering important parts. The way this is done is by first using deep convolutional networks to find features in each frame, and then solving an optimization problem to make the summary as relevant as possible while avoiding repetition. This approach is good for long security videos, where only key moments need to be kept for quick checking. By balancing different goals, the system ensures it keeps enough detail without being too long, making it useful for real-time incident analysis and storage in security systems.

2.3 Encoder–Decoder Architectures Based Video Summarization Using Key-Shot Selection Model

K. Yashwanth et al. [3] designed a video summarization framework using encoder-decoder models to pick key shots. The encoder-decoder model finds both the spatial and time aspects of a video, letting it spot and rebuild parts that show the main content. The encoder uses CNNs to get deep visual features, and the decoder gives back a time-based sequence to choose important shots. To make this work, the model is trained to reduce the difference between the original and summarized parts, making sure the selected shots have the most useful info. This approach cuts down on extra information and makes the summary better by focusing on changes in scenes and moving objects. It can be used in security systems to automatically pick key parts, making it easier to spot and check incidents in real time.

2.4 Property Constrained Video Summarization Via Regret Minimization

Y. Xu et al. [4] introduced a new way to summarize videos using regret minimization. The method helps choose the best parts of a video by balancing different qualities like variety, usefulness, and coverage, while also avoiding choices that could lead to poor results. They define rules or constraints that say what a good summary should look like, then use optimization techniques to make the best choices while keeping the cost of bad choices low. The method keeps changing its choices based on feedback, making it work well with different types of videos and situations. This approach is especially useful for smart security systems where finding and summarizing important events quickly is key. The regret minimization system makes it more reliable by ensuring summaries include all important safety events while ignoring unimportant parts efficiently.

2.5 Behavioral Profiling For Adaptive Video Summarization: From Generalization To Personalization

P. Kadam, et al., [5] focuses on behavioral profiling for adaptive video summarization, moving from general models to personalized methods. The method uses deep learning and behavioral analysis to create summaries that match specific user or system needs. This involves looking at past data to find out which activities or objects are most important for summaries. The model then learns to make adaptive summaries that highlight things like unusual movements, human interactions, or environmental changes as per user preferences. The system keeps improving its summarization process using feedback and reinforcement learning. In real-time surveillance, this approach helps security systems automatically focus on risky or suspicious activities, making the system more efficient, accurate, and faster, while also cutting down on unnecessary data processing.

2.6 Deep Learning-Based Anomaly Detection In Video Surveillance: A Survey

Duong, et al., [6] gives a detailed review of deep learning methods used for detecting anomalies in video surveillance.

They talk about different neural network structures like CNN, RNN, and autoencoders, and how effective they are in finding unusual activities. The authors examine the datasets and measurement tools used in anomaly detection studies. They also discuss challenges such as objects being hidden, different lighting conditions, and the need for fast detection. The paper highlights the use of unsupervised and semi-supervised methods to find new types of anomalies. It also talks about the role of extracting spatiotemporal features in improving the accuracy of models. The authors categorize techniques according to learning types and application areas. They also compare how different algorithms perform on standard datasets like UCSD and Avenue. The survey ends by pointing out areas that need more research, like scalability and understanding model decisions. It also suggests combining multiple data types and using edge AI for future surveillance systems.

III. METHODOLOGY

The proposed device provides a sophisticated actual-time AI-based surveillance solution aimed at detecting unusual public safety incidents with high accuracy and performance. It begins by using taking pictures continuous video streams from CCTV cameras deployed in various public places inclusive of streets, delivery hubs, and business regions. those video streams are then segmented into person frames to allow distinctive body-by means of-frame analysis. each frame undergoes a sequence of preprocessing steps, along with resizing to a fashionable decision, noise discount to do away with undesirable distortions, and brightness or evaluation adjustment to enhance visibility under one of a kind lights conditions. To train the machine correctly, a comprehensive dataset is created that consists of multiple categories of ordinary activities together with violence, theft, accidents, and suspicious actions. This dataset is manually categorized and annotated the usage of bounding packing containers to identify essential items and areas of interest. The YOLO (You most effective appearance once) algorithm is then hired for training, as it is able to acting object detection and class concurrently in a single skip, making it particularly suitable for actual-time applications.

After the schooling section, the model is deployed right into a stay environment wherein it constantly tactics incoming video frames. It detects objects in real time and highlights them with bounding packing containers together with self belief ratings to suggest prediction accuracy. past object detection, the machine incorporates behavior analysis by means of examining motion styles and interactions among objects over the years. This allows in distinguishing among regular daily activities and probably dangerous or unusual activities.

On every occasion the gadget identifies suspicious behavior that deviates from discovered styles, it classifies the occasion as odd. In such cases, an automated alert mechanism is induced instantly. Notifications are sent to applicable authorities or protection employees, presenting important info along with the type of incident, region, and time, enabling rapid reaction and intervention.

To make sure the reliability and robustness of the system, its performance is evaluated using general metrics which include precision, remember, F1-score, and imply average Precision (mAP). additionally, the device measures Frames consistent with 2nd (FPS) to confirm that it meets real-time processing necessities without massive delays.usual, this clever surveillance machine combines deep getting to know, real-time processing, and automated alerting to decorate public protection. It reduces the want for regular human tracking, minimizes response time to important incidents, and offers a scalable solution for contemporary smart metropolis environments.

IV. EXPERIMENTAL RESULTS

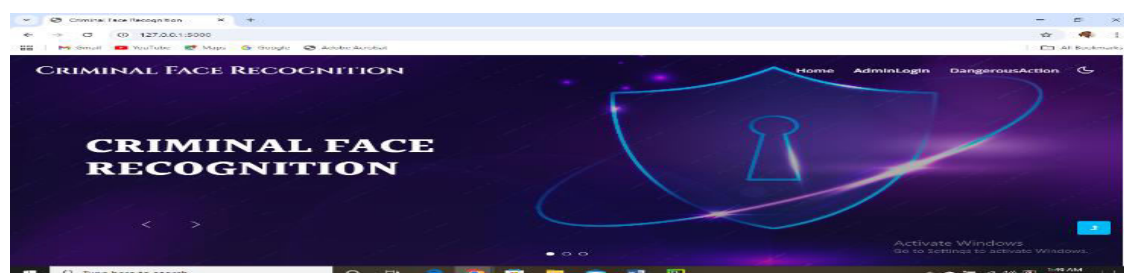


Figure (b). Home Page

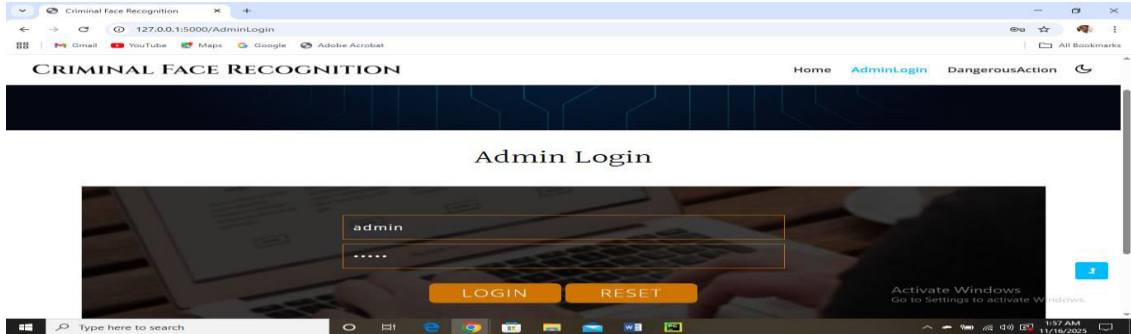


Figure (c). Admin Login

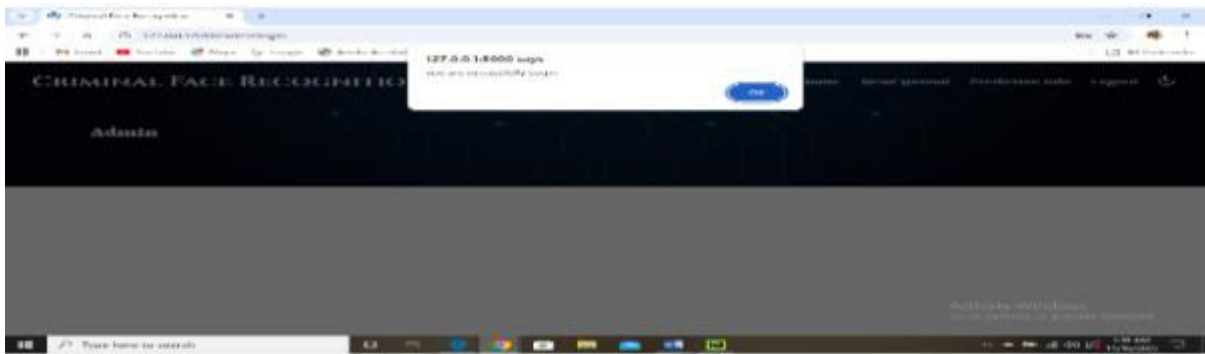


Figure (d). Login Page

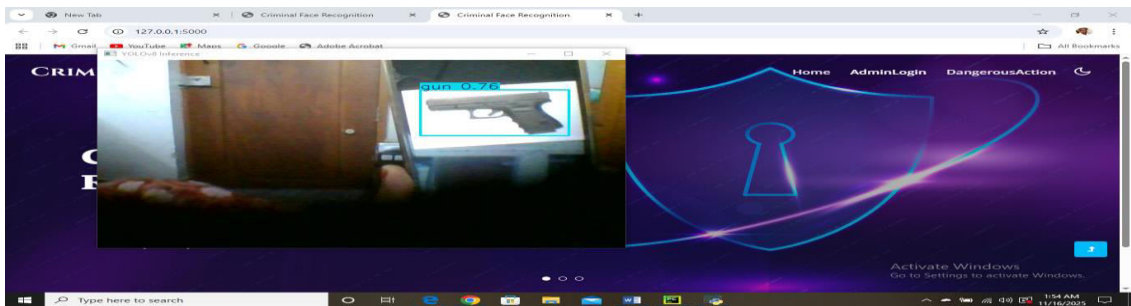


Figure (e). Dangerous action Gun image identify

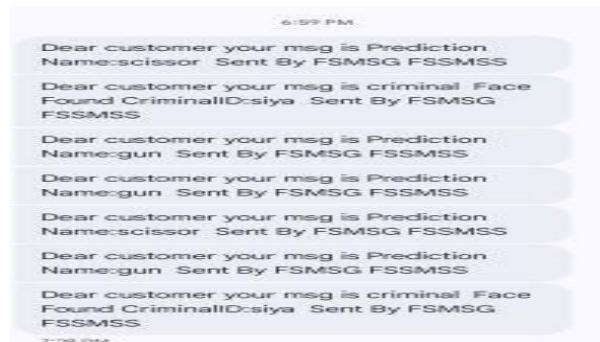
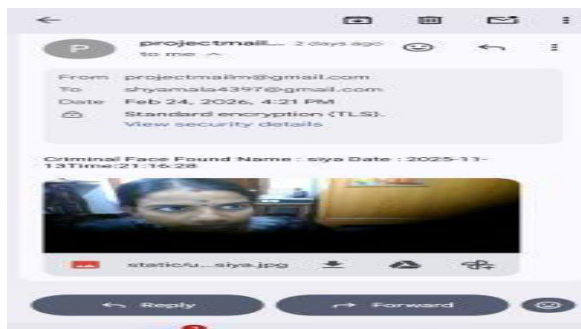


Figure (f). Alert Message with Criminal Face in Mail Notification Figure (g). Alert Message in SMS Notification

V. CONCLUSION

The project "ADAPTIVE REAL-TIME FEDERATED AI SURVEILLANCE FRAMEWORK FOR INTELLIGENT PUBLIC SAFETY MONITORING" offers a powerful and intelligent framework aimed at improving public safety through automation and artificial intelligence. By incorporating the YOLO deep learning model, the system efficiently detects and identifies abnormal human behaviors such as fighting, child abduction, vandalism, graffiti, and public intoxication in real time. The model's capability to process live video feeds from CCTV cameras enables instant threat identification, reducing reliance on manual monitoring and lowering the risk of human error.

Through ongoing training on a diverse dataset that encompasses various lighting conditions, environments, and crowd levels, the system attains high robustness, accuracy, and adaptability, ensuring dependable performance under real-world conditions. Additionally, the system features automated alert mechanisms that notify authorities instantly upon detecting unusual events, facilitating rapid response and informed decision-making. The system's architecture is scalable and designed for edge devices, enabling deployment across vast urban areas with minimal infrastructure needs. Overall, this project illustrates how AI-driven object detection can transform conventional surveillance into a smart, real-time, and responsive safety monitoring solution—significantly enhancing situational awareness, boosting public security, and laying the groundwork for safer, technology-based urban environments.

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