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Real-Time Crowd Surveillance for Detecting Weapons and Locating Missing Individuals

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Abstract: *Public safety in densely populated areas such as railway stations, airports, and malls demands an intelligent and automated surveillance system capable of real-time threat detection. The proposed system employs Convolutional Neural Networks (CNNs) as the core deep learning architecture for both weapon detection and missing-person identification. Live video streams from IoT-enabled cameras are analyzed at the edge using a CNN-based detection model that identifies and classifies dangerous objects like guns or knives with high precision. The same CNN framework is utilized for facial detection and recognition, where face embeddings are generated and compared using a CNN-based similarity model to locate missing individuals across multiple camera views in real time.This fully CNN-driven system eliminates dependence on manual monitoring and enables faster, more reliable decision-making in critical situations. The integration of edge computing ensures low-latency processing, allowing instant alerts to be sent to security personnel upon detecting threats or missing persons. By combining object detection and face recognition within a unified CNN architecture, the proposed model enhances the accuracy, scalability, and efficiency of surveillance systems. Ultimately, this CNN-based framework represents a step toward building smart, secure, and responsive environments that strengthen public safety and trust in modern urban infrastructures.*

Keywords: CNN, Computer Vision, Deep Learning, Object Detection, Face Recognition, IoT Surveillance, Edge Computing, Public Safety, Real-Time Monitoring

I. INTRODUCTION

Public safety in highly populated environments such as shopping malls, airports, railway stations, and educational institutions has become one of the most critical challenges of the modern era. Increasing incidents of violence, weapon-related crimes, and missing-person cases have exposed the limitations of conventional surveillance systems. These traditional systems depend heavily on manual monitoring, which often leads to delayed response, human fatigue, and oversight in recognizing potential threats. To overcome these limitations, the integration of Artificial Intelligence (AI) and Computer Vision has become a promising solution for developing smart, automated, and responsive surveillance mechanisms. The proposed system introduces an intelligent, real-time surveillance model that utilizes the laptop's built-in camera as the primary video input device. This makes the system cost-effective and easy to deploy in small-scale or prototype environments such as schools, offices, and public facilities. The system continuously captures video frames and processes them using a Convolutional Neural Network (CNN), which efficiently detects and classifies suspicious objects like guns, knives, or other weapons. CNNs are particularly effective for this task because of their ability to learn spatial hierarchies and extract critical visual features from complex scenes. Once the CNN-based model identifies a weapon or any potential threat in the camera's live feed, the system instantly triggers an audio alert through the laptop's buzzer. This real-time feedback mechanism ensures immediate awareness and helps in preventing possible incidents before they escalate. The buzzer acts as a warning signal for both security personnel and nearby individuals, ensuring rapid response and enhanced situational awareness. The system can be extended to send alert notifications via email, SMS, or security dashboard integration for large-scale deployment. In addition to weapon detection, the proposed framework can be expanded to detect and track missing or unauthorized persons using CNN-based face recognition. The CNN extracts face embeddings and compares them with stored profiles to verify identities or locate individuals across video frames. This dual functionality of the system — threat detection and human recognition makes it a versatile tool for real-world safety applications. The entire process is designed to work in real time using edge computing principles, minimizing latency and maximizing response efficiency. Since all processing occurs locally on the laptop, the system maintains data privacy and reduces dependency on cloud computing. This local processing also ensures that alerts are generated instantly without the need for an internet connection, making it reliable even in offline scenarios. The proposed CNN-based laptop surveillance system represents an innovative and practical approach to enhancing public safety. By combining computer vision, deep learning, and real-time alert mechanisms, it provides an intelligent, automated solution for modern security challenges. The integration of a simple laptop camera and buzzer transforms an ordinary device into a powerful, AI-enabled security assistant capable of safeguarding human lives through timely detection and action.

II. LITERATURE REVIEW

1) Aniruddha Dey (2016) proposed a contour-based procedure for face detection and tracking from video sequences. The study introduced a novel method utilizing edge-based contour extraction combined with motion analysis to enhance detection accuracy in dynamic scenes. The approach significantly improved tracking stability even under varying illumination and partial occlusion, making it useful for real-time face detection in video surveillance.

2) Andreas Ess et al. (2008) developed a mobile vision system for robust multi-person tracking. Their framework combined stereo vision with object detection and probabilistic tracking, enabling accurate localization and motion estimation of multiple individuals in real-world environments. The system demonstrated robustness to occlusion and crowd density, forming a foundation for intelligent surveillance and autonomous navigation.

3) Rolf H. Baxter et al. (2015) introduced an adaptive motion model for person tracking using instantaneous head-pose features. By integrating head-pose estimation into a particle filter-based tracking system, the proposed method improved prediction accuracy in crowded or dynamic environments. The adaptive model enhanced the ability to track individuals through abrupt motion and viewpoint changes.

4) He Guohui and Wang Wanying (2015) presented an algorithm for fatigue driving detection through face localization. The method relied on facial feature extraction using image processing and pattern recognition to identify signs of driver fatigue, such as eye closure and yawning. This research contributed to intelligent transportation systems by offering real-time, camera-based safety monitoring solutions.

5) K. V. Arya and Abhinav Adarsh (2015) proposed an efficient face detection and recognition method for surveillance applications. The system used a combination of feature-based extraction and classification techniques to achieve high recognition accuracy under varying lighting and pose conditions. The research demonstrated the potential of face recognition for automated security and access control.

6) Pranti Dutta and Dr. Nachamai M explored face detection from video files with different formats. Their work emphasized the importance of preprocessing and format compatibility in achieving consistent detection results. The proposed framework effectively handled various video codecs and resolutions, enhancing the adaptability of face detection algorithms in multimedia surveillance systems.

7) Lihe Zhang et al. (2016) proposed a sparse hashing tracking method for efficient object tracking in videos. The approach utilized sparse representation and hashing-based feature compression to maintain real- time tracking with reduced computational load. The model showed superior performance in handling occlusions and background clutter, improving tracking accuracy in dynamic environments.

8) Dennis Mitzel et al. presented a multi-person tracking system using sparse detection and continuous segmentation. Their model fused detection responses with motion segmentation for consistent identity maintenance of multiple

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targets. This integration improved robustness in complex crowd scenes, ensuring reliable person tracking over long sequences.

9) Francesco Comaschi et al. developed a robust online face tracking-by-detection framework. The system integrated continuous face detection with an adaptive re-identification mechanism to track faces across frames. The online design allowed for real-time operation and recovery from detection failures, significantly improving face tracking reliability in unconstrained environments.

10) Xiaoming Liu and Tsuhan Chen proposed a video- based face recognition method using adaptive Hidden Markov Models (HMMs). Their approach modeled temporal variations in facial expressions and poses across video frames, enabling improved recognition performance. The adaptive HMM framework contributed to robust face verification in real-world video surveillance scenarios.

11) Sanskar Pawar et al. (2021) presented a system for finding missing persons using artificial intelligence. The research utilized image processing and deep learning techniques to identify individuals from surveillance footage by comparing facial features against stored images. This AI-driven approach provided an efficient solution for large-scale public safety applications.

12) Bharath Darshan Balar et al. (2019) designed an efficient face recognition system for identifying lost people. The system employed feature extraction and CNN-based classification to detect and recognize missing individuals in real time. The model demonstrated effective accuracy under varied lighting and facial orientations, supporting its applicability in police and rescue operations.

13) Ms. Neha Ahirrao and Prof. Namrata D. Ghuse (2022) reviewed various image processing techniques for identifying missing persons and criminals. Their study analyzed existing algorithms and emphasized the integration of deep learning and facial recognition for enhanced identification accuracy. The review concluded that CNN-based approaches outperform traditional methods in both speed and reliability for surveillance-based recognition tasks.

III. OBJECTIVES

1) To design a real-time surveillance system capable of processing live video streams from multiple cameras.
2) To implement deep learning-based object detection models for identifying weapons such as guns, knives, or other harmful objects.
3) To develop a person re-identification (Re-ID) module for tracking and locating missing individuals across different camera feeds.
4) To integrate IoT-enabled communication for real-time alert generation and data sharing with security authorities.
5) To employ edge computing for faster on-site video analysis and reduced latency in detection and response.
6) To create an intuitive dashboard for monitoring, alert visualization, and system management by security personnel.
7) To ensure data privacy, system reliability, and scalability for deployment in public spaces such as malls, stations, and campuses.

IV. METHODOLOGY

The methodology of the proposed system involves a real- time surveillance approach using CNN (Convolutional Neural Network) for object detection and classification through a laptop camera. The live video feed is continuously captured and processed frame by frame, where the CNN model analyzes each frame to identify potential threats such as weapons. Preprocessing techniques like resizing, normalization, and noise removal are applied to enhance image quality and improve detection accuracy. Once the CNN detects a weapon, an automated response mechanism activates the laptop's buzzer, alerting security personnel instantly. The system operates on an edge computing framework, enabling local data processing for faster decision-making without relying heavily on cloud services. This integrated methodology ensures real-time, accurate, and efficient surveillance capable of enhancing public safety in high-risk or densely populated environments.

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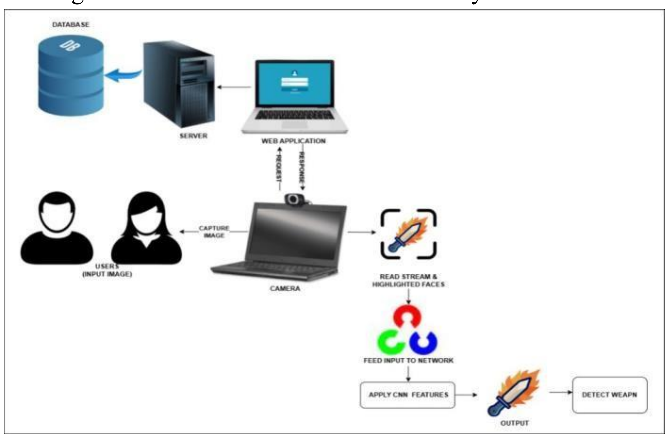
V. SYSTEM ARCHITECTURE

The architectural design of the Real-Time Crowd Surveillance for Detecting Weapons and Locating Missing Individuals system follows a modular, layered architecture that integrates IoT-based video acquisition, AI-driven analytics, and cloud-enabled data management. The system architecture consists of four main layers: Data Acquisition Layer, Processing Layer, Application Layer, and User Interface Layer. In the Data Acquisition Layer, live video streams are captured from CCTV or IP cameras using IoT- enabled connections. The Processing Layer utilizes CNN for real-time weapon detection and FaceNet for facial recognition, performing frame-by-frame analysis to identify threats or missing persons. These models run on high- performance GPUs or edge devices for low-latency inference. The Application Layer manages data storage, alert generation, and communication between modules through APIs, while ensuring security using encryption protocols. Finally, the User Interface Layer provides a centralized dashboard for administrators and security operators to monitor live feeds, receive alerts, and review detection reports. This layered and scalable design enables efficient real-time surveillance, high system reliability, and ease of maintenance while supporting future upgrades or integration with external law enforcement systems.



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