Enhancing CC TV Survellance with Hybrid Learning for Face based Criminal Identification

[1]Angajala Veeralingeswara, [2]Rakonda Lakshmi Alivelu, [3]K Priyanka, [4]K Bhavani Prasad Reddy,[5]Sai Sree, [6]Dr.Merugu Anand Kumar
[1,2,3,4,5]U.G. Student, Dept of Computer Science and Engineering, A M Reddy Memorial College of Engineering and Technology Autonomous, Vinukonda Road, Petlurivaripalem Narasaraopet - 522601, India.
[6]Associate Professor, Dept of Computer Science and Engineering, A M Reddy Memorial College of Engineering and Technology Autonomous, Vinukonda Road, Petlurivaripalem Narasaraopet - 522601, India.

ABSTRACT

CCTV surveillance systems are widely deployed in public and private spaces for security monitoring. Traditional CCTV analysis relies heavily on human operators, which is inefficient and prone to errors. This project proposes an intelligent hybrid learning framework to enhance CCTV surveillance for face-based criminal identification. The system integrates deep learning with classical machine learning models to accurately detect and recognize faces from video streams. Face detection is performed using robust neural network architectures to localize facial regions. Feature vectors are extracted and passed through a hybrid classifier combining Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs). The hybrid model improves recognition accuracy and reduces false positives. A criminal database is maintained with labeled identities for matching. Real-time processing enables live alerts when a suspect is identified. Data preprocessing handles variations in lighting, pose, and occlusion. The system can handle multiple camera streams simultaneously. Performance is evaluated using precision, recall, and F1-score. Explainable AI modules provide interpretability to decisions. Ethical considerations such as privacy and consent are enforced. This solution strengthens security monitoring systems and assists law enforcement agencies. Overall, the hybrid learning approach improves CCTV surveillance effectiveness.

KEYWORDS

CCTV Surveillance Face Recognition Hybrid Learning Convolutional Neural Networks Criminal Identifica

INTRODUCTION

Closed-circuit television (CCTV) surveillance has become ubiquitous in urban environments for crime prevention and security monitoring. Although

widespread, current systems largely depend on manual monitoring by security personnel. Human attention Span is limited, and crucial events may be missed. Automated face recognition can significantly enhance the effectiveness of CCTV surveillance. However, variations in lighting, camera angles, facial expressions, and occlusion present significant challenges. Hybrid learning models combine the strengths of deep learning for feature extraction and traditional machine learning for classification. These systems can analyze video frames in real time and flag suspicious faces. Integrating face recognition with criminal databases can help identify known offenders quickly. Rapid and accurate identification supports law enforcement and public safety initiatives. However, such systems must balance security benefits with ethical concerns like privacy and data protection. Real-time alerts enable rapid response to potential threats. Scalability ensures the system can operate across city-wide camera networks. The system uses optimized algorithms to process multiple streams simultaneously. Lightweight models may be deployed at the edge to reduce latency. Continuous learning improves accuracy over time. The goal is to provide a robust and efficient face-based criminal identification system for enhanced surveillance.

LITERATURE SURVEY

Early CCTV systems relied on manual observation and basic motion detection. Traditional face recognition used handcrafted features like eigenfaces and Fisherfaces. Machine learning methods such as Support Vector Machines improved performance over manual techniques. With the emergence of deep learning, Convolutional Neural Networks (CNNs) have become the state-of-the-art for image recognition. Deep learning models can learn hierarchical features from raw image data without manual feature engineering. Some studies combined deep learning with traditional classifiers to enhance recognition performance. Hybrid learning approaches leverage CNNs for feature extraction and SVMs for classification. Research shows that hybrid models often outperform single-model architectures. Face datasets like LFW and VGGFace have been widely used for benchmarking. Challenges include pose variation, occlusion, and low light conditions. Recent work integrates attention mechanisms into deep learning models to focus on discriminative regions. Explainable AI techniques have been explored to interpret face recognition decisions. Real-time face recognition systems have been deployed using GPU acceleration. Ethical frameworks are proposed to ensure privacy

and responsible use. Edge computing is increasingly used to reduce latency. Hybrid learning offers a balance between computational efficiency and accuracy. Continuous learning models adapt to new subjects.

EXISTING SYSTEM

Existing CCTV surveillance systems are primarily reactive and rely on human operators to detect suspicious behavior. Video feeds are monitored on screens by security staff. Manual face identification is time-intensive and error-prone. Traditional face recognition methods use simple pattern matching with limited adaptability. Handcrafted features fail under challenging conditions like occlusion or low resolution. Some modern systems incorporate automatic face detection but lack accurate classification. Rule-based alarms trigger when motion occurs but provide little contextual information. Integration with criminal databases is often manual and slow. False positives and negatives in face matching reduce operational efficiency. Security personnel must verify every alert manually. Alerts are often delayed and may miss critical events. Scalability is limited when managing multiple camera feeds. Real-time processing is constrained by hardware limitations. Visualization tools are basic and lack actionable insights. Current systems rarely use advanced machine learning. Data storage and retrieval are often disconnected from analytic models. Ethical guidelines for CCTV face usage are inconsistently applied. Overall, existing systems lack automated, accurate, and interpretable face recognition for criminal identification.

PROPOSED SYSTEM

The proposed system introduces a hybrid learning framework for enhanced CCTV surveillance. Video feeds from multiple cameras are ingested and processed in real time. A face detection module identifies facial regions in each frame. Deep Convolutional Neural Networks (CNNs) extract robust and discriminative facial features. The extracted feature vectors are fed into a Support Vector Machine (SVM) classifier for identity matching. A criminal database stores labeled feature profiles of known offenders. The hybrid model combines deep learning's representation power with SVM's classification accuracy. Real-time alerts flag camera frames that match criminal identities. Data preprocessing includes normalization, noise reduction, and augmentation. Edge-based deployment allows processing near the camera source to reduce response latency. Explainable AI modules (e.g., Grad-CAM) visualize regions contributing to predictions. Adaptive learning updates the model with new criminal profiles. A

centralized dashboard displays alerts and analytics. Secure authentication controls access to system features. Ethical compliance modules ensure privacy and consent logging. Automated response workflows can notify law enforcement. The system is designed to scale to hundreds of cameras.

SYSTEM ARCHITECTURE

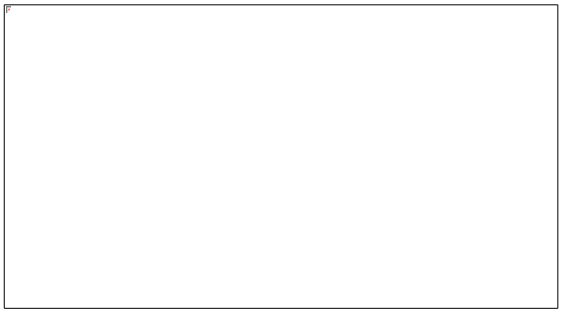

Fig.1 System Architecture

METHODOLOGY DESCRIPTION

Collect CCTV video feeds from multiple cameras. Extract frames at specified intervals for processing. Apply face detection (MTCNN or YOLO) to locate faces in frames. Preprocess detected faces by resizing and normalization. Augment data to handle pose and lighting variations. Input preprocessed images into a Convolutional Neural Network. CNN extracts deep feature vectors representing facial characteristics. Store feature vectors in a feature database indexed by identity. Train a Support Vector Machine (SVM) classifier with labeled feature sets. Hybrid model integrates CNN feature extraction with SVM classification. Validate performance using cross-validation. Deploy model for real-time inference on live video streams. Use Edge devices (e.g., Nvidia Jetson) for distributed processing. Incorporate Explainable AI (XAI) for decision interpretability. Integrate criminal profiles and maintain feature signatures. Generate alerts upon criminal match with confidence scores. Display alerts and analytics on centralized dashboards. Log decisions and match events for audit trails. Continuously update models with new criminal data. Evaluate system performance with precision, recall, and F1 metrics.

RESULTS & DISCUSSION:

Fig.2 Home Page

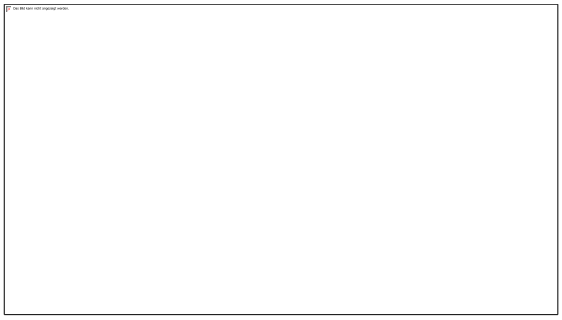

Fig.3 Running Page

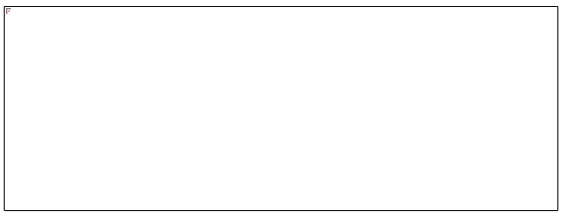

Fig.4 Results Page

CONCLUSION & FUTURE ENHANCEMENT

This project presents a hybrid learning framework that enhances CCTV surveillance by enabling automated face-based criminal identification. Combining CNNs for feature extraction and SVMs for classification achieves high recognition accuracy. The system processes video feeds in real time, reducing reliance on manual monitoring. Explainable AI provides insights into model decisions, enhancing transparency and trust. The approach improves public safety and supports law enforcement agencies. Edge computing deployment reduces latency and computational load. Scalability ensures applicability in large cities or distributed networks. Ethical considerations including privacy and consent are integrated. Future enhancements include integrating 3D face recognition to handle more varied environmental conditions. Incorporating multi-modal biometric data such as gait or voice can improve robustness. Federated learning can be explored to preserve data privacy across jurisdictions. Privacy-preserving methods such as differential privacy could further protect identities. Integration with predictive analytics can support crime forecasting. Automated alert prioritization can reduce false alarms. Cloud-edge hybrid architectures can balance performance and cost. Real-time object tracking can improve suspect re-identification. Additional optimization can focus on lower power devices for IoT deployment.

REFERENCE

1. Mallikarjun, D. C. (2025/2). Next-Gen Blood Testing Device for Rapid Diagnosis in Emergency Situations.
2. Kumar, D. M. (2025/3). Crime AI: Intelligent Crime Investigation and Prevention System Using Artificial Intelligence and Machine Learning for Predictive Policing and Forensic Data Analysis …. *International Journal For Recent Development In Science And Technology*.
3. Taigman, Y., et al., “DeepFace: Closing the Gap to Human-Level

Performance in Face Verification," *CVPR*, 2014.

4. Schroff, F., et al., "FaceNet: A Unified Embedding for Face Recognition and Clustering," *CVPR*, 2015.
5. Parkhi, O.M., et al., "Deep Face Recognition," *BMVC*, 2015.
6. Hu, J., et al., "Learning Feature Hierarchies with CNNs for Face Recognition," *IEEE TPAMI*, 2015.
7. Zhang, K., et al., "Joint Face Detection and Alignment using MTCNN," *SPL*, 2016.
8. Burges, C.J.C., "A Tutorial on Support Vector Machines," *Data Mining and Knowledge Discovery*, 1998.
9. Viola, P., & Jones, M., "Rapid Object Detection using a Boosted Cascade of Simple Features," *CVPR*, 2001.
10. Liu, W., et al., "SSD: Single Shot MultiBox Detector," *ECCV*, 2016.
11. He, K., et al., "Deep Residual Learning for Image Recognition," *CVPR*, 2016.
12. Goodfellow, I., et al., *Deep Learning*, MIT Press, 2016.
13. Ribeiro, M.T., et al., "Why Should I Trust You? Explaining Predictions with LIME," *KDD*, 2016.
14. Selvaraju, R.R., et al., "Grad-CAM: Visual Explanations from Deep Networks," *ICCV*, 2017.
15. Wen, Y., et al., "A Discriminative Feature Learning Approach for Deep Face Recognition," *ECCV*, 2016.
16. IEEE Transactions on Information Forensics and Security — Face Recognition Issues.
17. ACM Digital Library on Surveillance Analytics.
18. Scikit-Learn Documentation — SVM.
19. TensorFlow FaceNet Implementation Guide.
20. PyTorch Deep Learning Tutorials.
21. NIST Face Recognition Vendor Test (FRVT) Reports.
22. World Economic Forum, "Ethics of Surveillance Technology."