Criminal Face Detection Using Facial Recognition

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Abstract - This paper presents a comprehensive criminal face detection and identification system built using traditional face recognition techniques rather than deep learning or convolutional neural networks (CNNs). The solution is designed for real-time law enforcement assistance, secure access verification, and controlled surveillance environments. The system employs OpenCV's Haar Cascade Classifier for efficient and lightweight face detection, while facial feature extraction and recognition rely on dlib's Histogram of Oriented Gradients (HOG)-based model and 128-dimensional face encodings. The system maintains all identity records inside a local credential database, and facial images are stored securely in a structured local file system, ensuring privacy and data protection without cloud dependency. The proposed approach demonstrates reliable identification accuracy in controlled environments, fast inference speed, and low hardware requirements, making it suitable for organizations with limited computational resources. Experimental evaluations confirm the model's capability to consistently detect and recognize faces under stable lighting conditions and frontal orientations.

Keywords: Face recognition, Haar Cascade, HOG, dlib encodings, OpenCV, Criminal identification, Local database, Local file storage.

I. INTRODUCTION

Facial recognition systems have evolved into integral tools in security, law enforcement, and identity verification applications. Although deep learning-based methods have gained significant popularity in recent years, traditional face recognition techniques continue to offer substantial advantages, particularly in low-resource environments. Many institutions require systems that are fast, lightweight, interpretable, and not dependent on powerful GPU infrastructure. Additionally, privacy concerns and data governance policies often discourage cloud-based or neural-network-driven recognition models.

The proposed system—Criminal Face Detection Using Facial Recognition—utilizes classical computer vision techniques to deliver reliable real-time face detection and recognition. OpenCV's Haar Cascade algorithm performs the detection phase, while facial recognition is accomplished using dlib's Histogram of Oriented Gradients (HOG) and 128-dimensional encoding approach. This combination allows the system to extract unique facial descriptors without requiring any deep-learning-based training.

Our system further integrates a locally managed credential database to store criminal records and identity details. Facial images used for recognition are preserved in a hierarchical local directory structure, ensuring strong privacy control and eliminating the need for external servers. A user-friendly interface built using Python's Tkinter framework allows officers and users to interact seamlessly with the application.

This paper provides a complete overview of the system's architecture, components, implementation flow, experimental evaluation, and limitations. Furthermore, the paper highlights the importance of traditional techniques in environments where computational resources are constrained and local data policies must be strictly followed.

II. LITERATURE REVIEW / RELATED WORK

Several studies have explored the evolution of face detection and recognition methodologies over the last few decades. Before the recent rise of deep learning, traditional algorithms such as Eigenfaces using Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and Local Binary Patterns Histograms (LBPH) were dominant in research and deployment environments.

The Haar Cascade Classifier introduced by Viola and Jones remains one of the most widely implemented algorithms due to its high-speed detection capabilities and suitability for real-time applications. It relies on Haar-like features and Adaboost classifiers trained to differentiate between facial and non-facial regions.

Similarly, the Histogram of Oriented Gradients (HOG) descriptor gained prominence for its robustness in capturing gradient-based structure of faces. The dlib library combines HOG-based feature extraction with a linear SVM classifier, and later maps detected faces into 128D facial embeddings. These embeddings allow accurate face comparisons using simple Euclidean distance calculations.

LBPH-based models also continue to be used in many low-resource environments due to their resilience to lighting changes and minimal hardware dependency.

Traditional approaches have proven extremely valuable in projects where:

- Real-time performance is mandatory
- Local offline processing is required
- No specialized GPU hardware is available
- Privacy restrictions prevent cloud model use

This project builds upon these traditional techniques to ensure efficiency, privacy, and local control of data.

III. PROPOSED SYSTEM / METHODOLOGY

The proposed system follows a structured workflow using classical face detection and recognition techniques.

A. System Components

1. Face Detection: Implemented using OpenCV Haar Cascade classifiers.
2. Feature Extraction: Carried out using dlib's HOG-based 128D encodings.
3. Face Recognition: Achieved by comparing encoding vectors using Euclidean distance.
4. Local Credential Database: Used for storing user identity information (name, ID, contact details, etc.).
5. Local File System Storage: Facial images of individuals are stored as image files for future matching.
6. User Interface: Built using Tkinter for ease of use.

B. Workflow

1. Capture or upload an image.
2. Detect the face using Haar Cascades.
3. Generate facial encodings using HOG-based dlib encoding.
4. Match the encoding with existing encodings stored in the local filesystem.
5. Retrieve user identity from the local database if a match is found.
6. Display results with identification confidence.

IV. SYSTEM IMPLEMENTATION

The system is implemented using Python and the following libraries:

- OpenCV for Haar-based face detection
- dlib for HOG-based encoding generation
- face_recognition API as a wrapper for simplifying recognition steps
- Tkinter for graphical user interface
- SQLite / local DB for credential storage

Images are stored in a structured local directory where each folder corresponds to an individual's identity.

V. RESULTS AND DISCUSSION

The system was tested under multiple conditions to evaluate its performance using traditional facial recognition.

A. Experimental Setup

- Laptop with 8GB RAM
- Standard USB webcam
- Python 3.11
- OpenCV and dlib libraries installed

B. Performance Metrics

- Accuracy: 85–90% under controlled lighting
- Recognition Speed: ~0.5 to 1 second
- False Positives: Low when faces are clear and frontal

Traditional HOG-based recognition works best in:

- Good lighting
- Frontal or slightly angled faces
- Clean backgrounds

Challenges arise with occlusions, masks, low lighting, and side-face images.

V. CONCLUSION

This study demonstrates that classical face recognition approaches remain effective for real-time criminal identification without deep learning. Haar Cascades and dlib HOG encodings provide reliable performance while requiring minimal computation. Storing credential data in a local database and images in a secure file system enhances data privacy.

Future improvements may include integrating LBPH or lightweight neural models if resources permit.

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