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Real-time Face Recognition Using FaceNet and Haar Cascade for Door Monitoring

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Abstract
The demand for intelligent security systems has surged, leading to innovative solutions in access control and monitoring. This paper introduces a comprehensive Door Monitoring System integrating the Haar Cascade algorithm and the FaceNet model to enhance the accuracy and efficiency of door access control using camera. The Haar Cascade algorithm excels in real-time face detection, identifying faces within monitored areas with precision even under varying lighting conditions and diverse facial orientations. Complementing this, the FaceNet model employs deep learning techniques for accurate face recognition. The system offers a non-intrusive and efficient solution for access control by alerting users with images of unknown individuals, captured and stored securely. The integration of Haar Cascade and FaceNet yields a reliable and robust smart door monitoring system suitable for residential, commercial, and institutional areas.

Keywords: Monitoring System, Face Recognition, FaceNet, Haar Cascade, door access control.

1. Introduction

Security concerns have become paramount in contemporary society, prompting the emergence of door monitoring systems as indispensable tools for safeguarding various environments, ranging from residential complexes to commercial establishments. The rise of criminal activities such as trespassing and theft underscores the necessity of effective surveillance systems to ensure the security and safety of individuals. By integrating advanced technologies such as video surveillance and facial recognition, modern door monitoring systems offer superior solutions for addressing evolving security challenges. Real-time monitoring and precise identification of individuals are fundamental aspects of door monitoring systems, enhancing security for households and ensuring residents' safety and peace of mind. The integration of sophisticated technologies, including pre-trained classifiers like Haar Cascade and FaceNet, further elevates the effectiveness of surveillance, enhancing monitoring capabilities for improved security outcomes.

2. Related Work

In this section, we review related studies and research paper recommendations for face recognition and door security systems:

Nongmeikapam Thoiba Singh et al. (2023) proposed a surveillance system utilizing computer vision and the Haar Cascade algorithm with OpenCV for real-time monitoring and identification. Multiple cameras at checkpoints capture images, enabling face detection, feature extraction, and comparison with an authorized database to enhance campus security.

Daniel Anando Wangean et al. (2023) developed a door lock security system utilizing the Haar Cascade algorithm and OpenCV LBPH Face Recognizer for smart locking of doors based on face recognition. The system offers secure and efficient access control with enhanced room access limitations, suitable for attendance and surveillance systems in various organizations.

Chinduru Anilkumar et al. (2023) explored the use of OpenCV for face recognition and developed a smart attendance system leveraging OpenCV for accurate face recognition based on the 'labelled faces in the wild' dataset. This system offers efficient attendance management through a user-friendly Flask web application.

Avadhoot Autade et al. (2023) proposed an automated attendance system employing VGG-16 and FaceNet for real-time face recognition. The system achieved a 75% accuracy rate, providing an automated solution for heightened efficiency and security in various settings. This system utilizes a Convolutional Neural Network (CNN) method with FaceNet to deliver an efficient facial recognition system.

3. Proposed Work

The proposed monitoring system is designed to operate in real-time, capable of detecting and alerting users about any suspicious individuals as soon as they are detected. By promptly alerting users and capturing images of unknown individuals, potential threats can be averted effectively. The system integrates FaceNet and the Haar Cascade algorithm for door access control, aiming to alert users about unidentified individuals, thereby enhancing security and safety in residential and commercial areas requiring control over door access. The monitoring system for door access control by recognition of faces encompasses the following steps:

3.1 Data Collection

The process commences with the acquisition of face images via a camera, employing Haar Cascade for initial face detection to ensure accurate capture. These images facilitate dataset creation, vital for training the FaceNet model effectively. Leveraging Haar Cascade ensures precise identification of facial features, laying a robust foundation for subsequent recognition tasks. This collection process yields a diverse dataset, enhancing the model's ability to generalize and recognize faces accurately. The collected data is then used to train the FaceNet model.

3.2 Training

The FaceNet model undergoes rigorous training, utilizing collected face images from the dataset. Essential modules such as OpenCV and Keras are seamlessly integrated to facilitate model development. Haar Cascade continues to play a pivotal role during training, refining the model's ability to detect and recognize faces accurately.

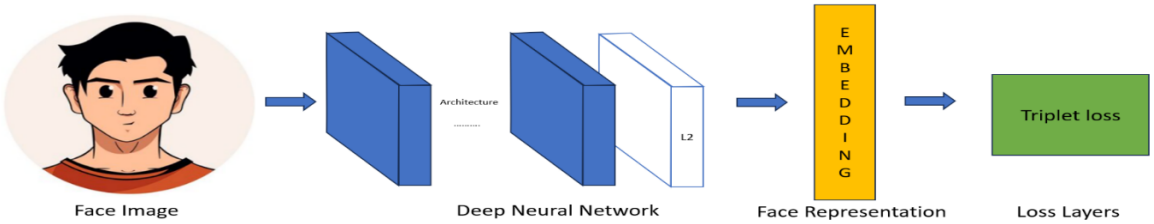

Figure 1: Working of the FaceNet model for training

Features from the face images are extracted using FaceNet with the help of a deep neural network that uses multiple convolutional and pooling layers for feature extraction. L2 distance, also known as Euclidean distance, is found for the face images represented as vectors in a feature space. Smaller L2 distances between embeddings suggest similar faces, whereas larger distances indicate dissimilar faces. The embeddings of a face is finally obtained from the neural network. Triplet loss is a loss function that helps in training the model with the embeddings that are similar for faces of the same person and dissimilar for faces of different people. The goal of the training process is to minimize the triplet loss. The trained dataset can then be used for real-time door monitoring.

3.3 Real-Time Monitoring

Continuous monitoring of live video feeds is facilitated, with the trained FaceNet model deployed for real-time face recognition. Integration of Haar Cascade ensures efficient face detection, enhancing recognition accuracy even in diverse environments. The monitoring process is done using a camera, which is fixed on a door for access control. Real-time feedback provides timely response and decision making, ensuring effective utilization of the recognition system. Detection and recognition of faces is done while monitoring on a designated area through a door using camera. Monitoring is done in real-time where faces are recognized using the trained models.

3.4 Unrecognized Face Capture

Faces detected in the video feed undergo recognition using Haar Cascade and the trained FaceNet model. The system leverages Haar Cascade for initial face detection in the video feed, then utilizes the FaceNet model to identify faces. Unrecognized faces trigger image capture, which are securely stored on a designated location or a web server, ensuring a comprehensive record of unidentified faces. This approach to face capture enhances the system's capability to address emerging security challenges in various areas..

3.5 Alert and Web Access

A notification system alerts registered users upon detecting unrecognized faces, enhancing situational awareness. Furthermore, a dedicated web server provides convenient access to view captured images of unidentified individuals. By showcasing these faces on a dedicated website, users can engage in the identification process, further enhancing security and surveillance. Providing users with timely alerts, users can effectively respond to security incidents. Below figure illustrates the working of the proposed system, highlighting its comprehensive approach to door access control and monitoring.

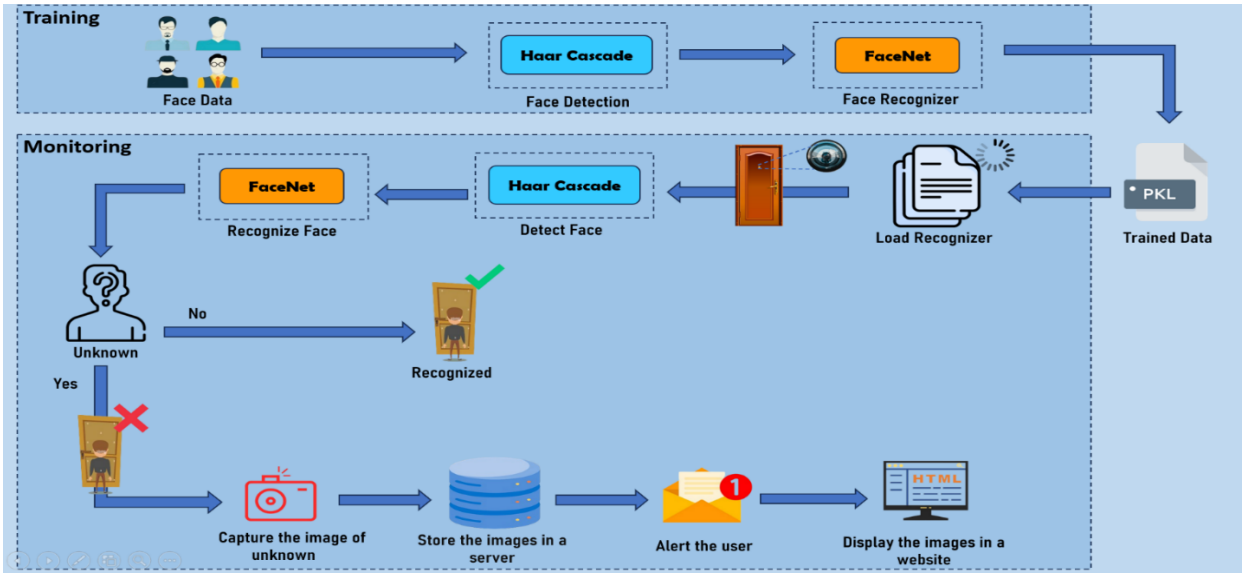

Figure 2: System Architecture

4. Results and Discussion

The system demonstrated real-time recognition and monitoring capabilities for accurate identification of known and unknown individuals. Several key considerations were taken into account during testing:

4.1 System Requirements

The system was implemented and tested on a PC running Windows 11 and Python 3.8.10. Pretrained models for FaceNet and Haar Cascade were utilized to ensure compatibility and optimize performance. These system configurations were selected to achieve the desired level of performance for the monitoring system.

4.2 Controlled Environment

Testing and evaluation of the monitoring system were conducted in a controlled environment with adequate lighting conditions for optimal face recognition. While this controlled environment provided an ideal testing environment, it's essential to acknowledge the potential impact of external variables such as diminished lighting conditions on system performance. Recognizing these factors is crucial for a comprehensive assessment and understanding of the system's capabilities and limitations.

4.3 Output Screenshots

These screenshots provide insights into the system's functionality and its effectiveness in real-world scenarios.

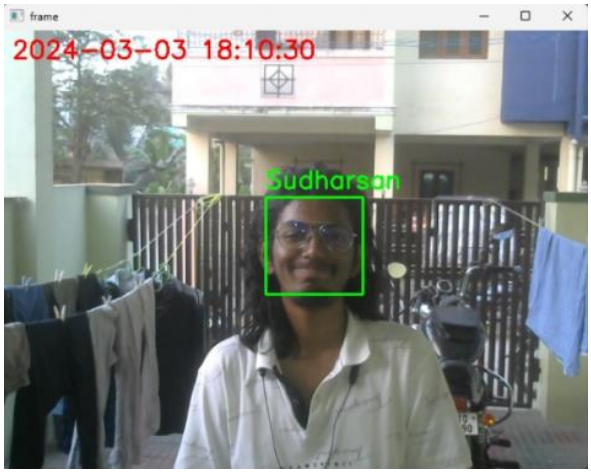

Figure 3: Recognition of a known face while detection

Figure 4: Recognition of unknown face while detection

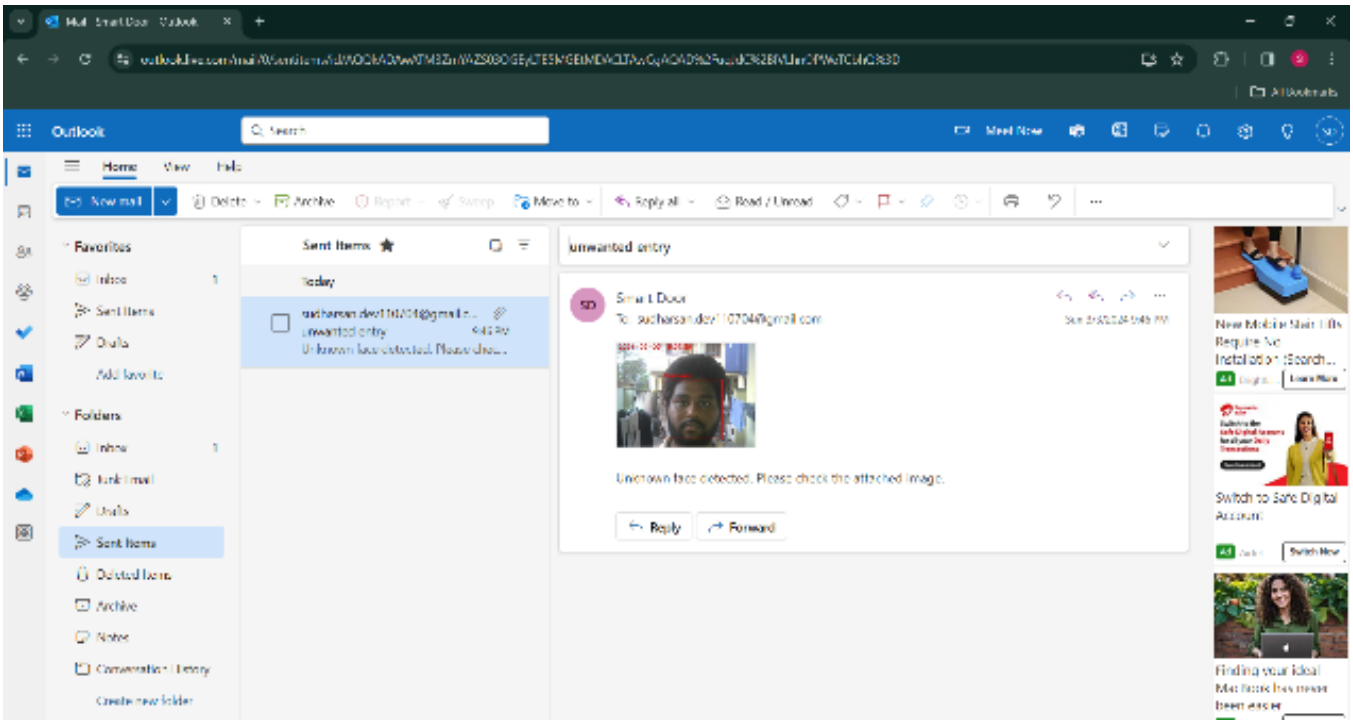

Figure 5: Mail sent to the user

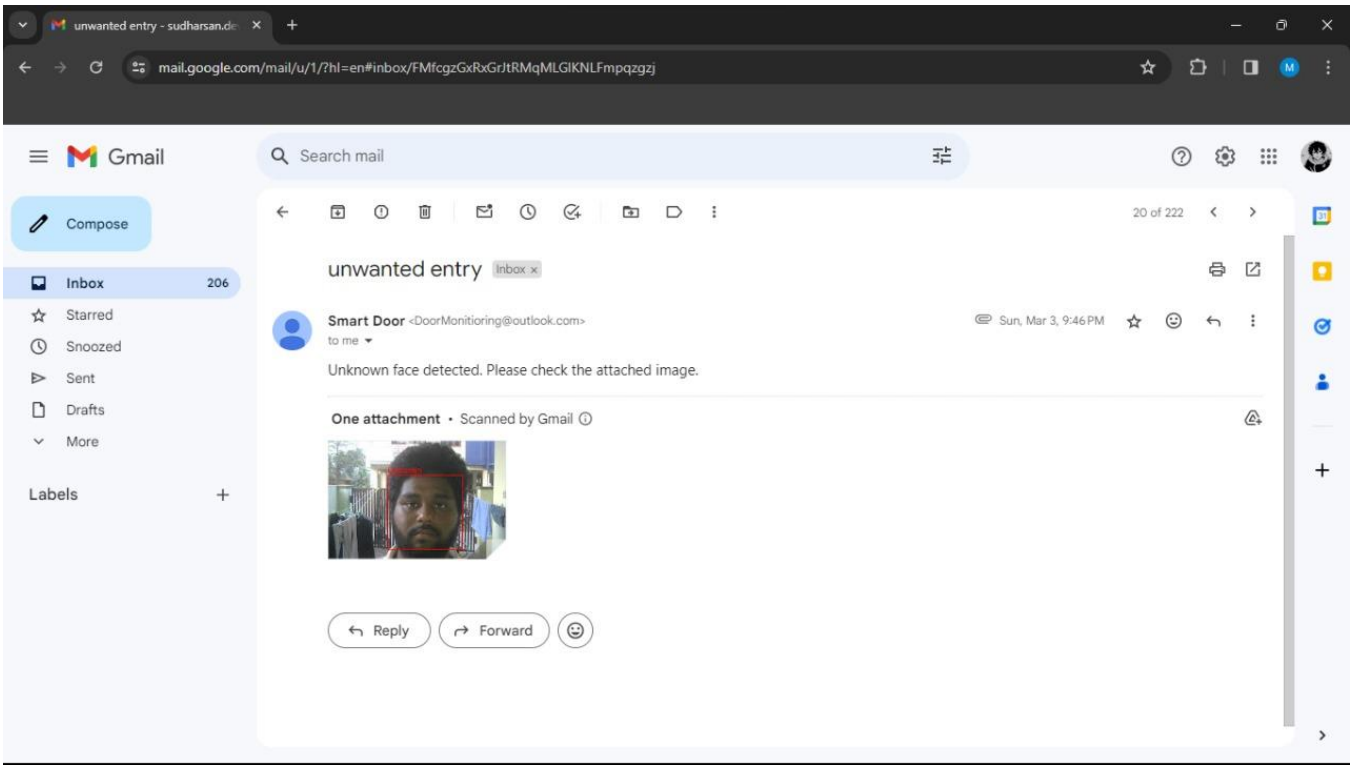

Figure 6: Alert mail received by the user

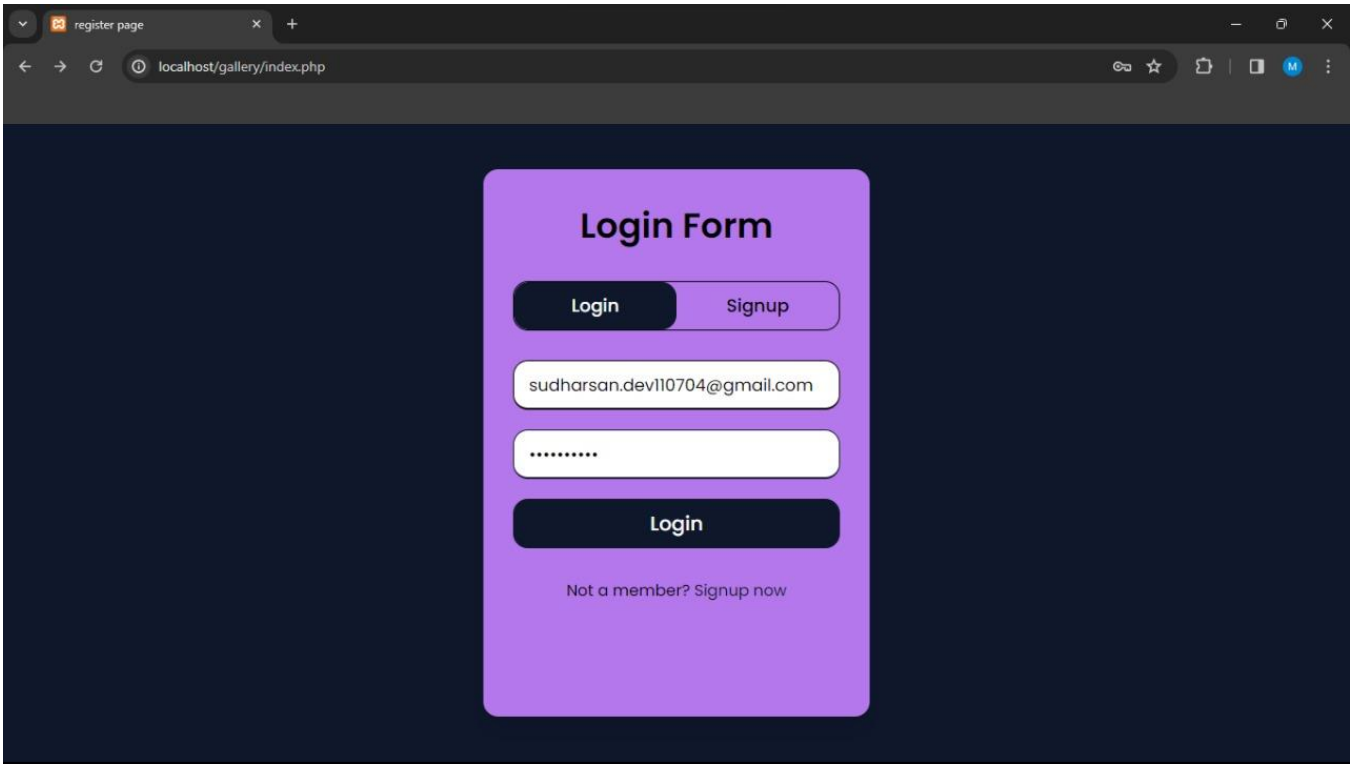

Figure 7: Website login page that can only be accessed by the user

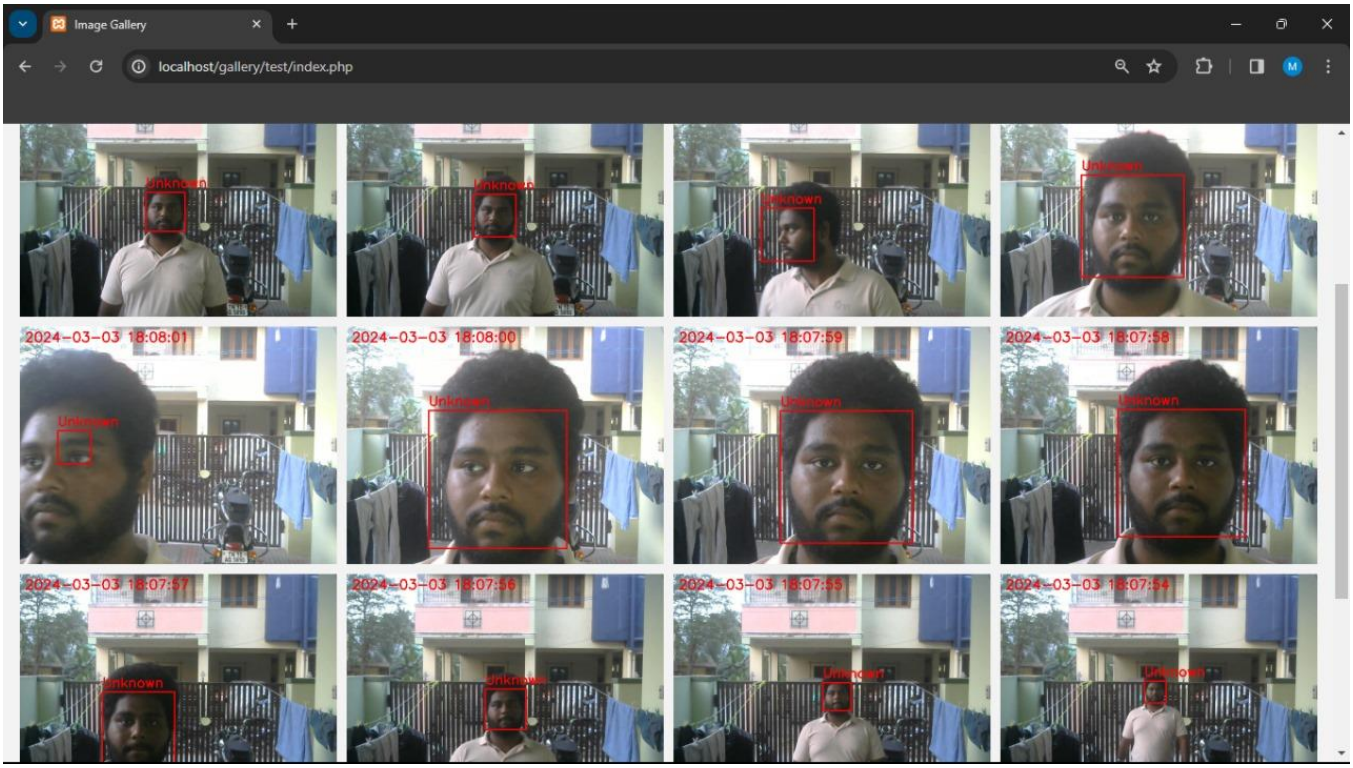

Figure 8: Faces of the unknown are showcased in the website

Conclusion

In conclusion, the proposed real-time face recognition system utilizing FaceNet and Haar Cascade algorithms offers a robust solution for door access control and monitoring. By providing users with timely

alerts and comprehensive monitoring capabilities, the system empowers them to manage and respond to security incidents effectively. The integration of advanced technologies enables precise identification of individuals, enhancing security and safety in residential and commercial environments. Future enhancements and optimizations can further extend the system's capabilities for use in various surveillance systems, adapting to different lighting conditions and emerging security challenges.

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