

HostelGuard: An Advanced Identity Verification System with Real-time Monitoring

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Abstract— This paper presents HostelGuard, an advanced identity verification system designed to enhance security in hostel environments through real-time monitoring. By integrating facial recognition technology with a centralized database, HostelGuard ensures precise and reliable identity verification for student check-ins and check-outs. The system includes a user-friendly interface for administrators, real-time monitoring, and instant notifications of unauthorized access attempts. Extensive testing has demonstrated high accuracy and reliability, significantly reducing manual errors and administrative burdens. HostelGuard sets a new standard for safety and security in residential institutions.

Index Terms— Facial Recognition, Real-time Monitoring, Hostel Security, Identity Verification, Firebase Integration.

I. INTRODUCTION

The demand for enhanced security measures in hostel environments has significantly increased. Hostels, particularly those housing students and young professionals, face challenges in ensuring the safety of their residents. Traditional methods for managing hostel check-ins and check-outs, such as manual entry logs and ID card systems, often suffer from inaccuracies and vulnerabilities.

These issues compromise resident safety and place a substantial administrative burden on staff. To address these challenges, we propose HostelGuard, an advanced identity verification system using facial recognition technology integrated with a centralized database. HostelGuard ensures precise and reliable identity verification, streamlining the check-in/check-out process, reducing manual errors, and enhancing overall security.

Key features of HostelGuard include a user-friendly interface for administrators, real-time monitoring capabilities, and instant notifications of unauthorized access attempts. The system uses OpenCV for facial recognition, Firebase for real-time database management, and Twilio for automated SMS alerts, creating a seamless and secure experience for residents and administrators.

This paper discusses the design and implementation of HostelGuard, reviews the current state of hostel security systems, describes HostelGuard's architecture, and presents extensive testing results demonstrating its high accuracy and reliability.

We conclude with the implications of our findings and potential future research directions. HostelGuard represents a significant advancement in hostel security management, offering a scalable and efficient solution to the challenges faced by hostel administrators.

II. LITERATURE REVIEW

The integration of advanced technologies such as Histogram of Oriented Gradients (HOG) and Convolutional Neural Networks (CNNs) has shown significant potential in enhancing computer vision tasks, including object detection and recognition. HOG is a widely used feature descriptor in computer vision, particularly for its effectiveness in capturing edge information by computing the distribution of gradient orientations in localized image regions. This method has been successfully employed in various applications, such as object detection, human pose estimation, and face recognition.

Recent advancements in deep learning have led to the exploration of combining HOG features with CNNs to enhance performance in various visual recognition tasks. CNNs, known for their exceptional performance in computer vision tasks, learn hierarchical representations of visual data, automatically extracting meaningful features from raw pixel values. By integrating domain-specific knowledge such as HOG features, the model's ability to discern subtle details and capture discriminative information can be further improved.

Several studies have explored hybrid approaches that combine HOG with deep learning. Ghosh et al. [1] proposed a hybrid approach for bird species detection and classification, utilizing HOG features as input to LeNet and ResNet CNN architectures. Their findings demonstrate the effectiveness of combining HOG with deep learning for this task. Similarly, Alavigharabagh et al. [2] introduced a hierarchical method for human action recognition (HAR) that addresses challenges posed by camera movement, scene changes, and computational costs. Their approach involves a preprocessing step utilizing optical flow to detect camera movements and generate a time saliency map, which highlights the most relevant temporal segments for action recognition. This method minimizes motion detection errors by focusing on salient motion features, demonstrating improved accuracy and reduced computational requirements.

In the realm of facial recognition, HOG-based feature extraction combined with deep learning has shown promising results. For instance, a study [3] on face recognition using HOG features and deep learning models indicated improved accuracy compared to using raw pixel data alone. This combination leverages the discriminative edge information captured by HOG features and the complex pattern learning capabilities of deep learning models.

Other relevant works include the development of facial recognition systems for attendance and alert purposes. Arsenovic et al. [4] proposed a deep learning-based face recognition attendance system, detailing the development of a face recognition component by combining state-of-the-art methods and advances in deep learning. Another study [5] proposed a student attendance system using facial recognition, combining Discrete Wavelet Transforms (DWT) and Discrete Cosine Transform (DCT) to extract features from student faces, and using a Radial Basis Function (RBF) for classification. This method showed promising results in experiments with 16 students.

Other notable systems include a fingerprint-based attendance monitoring system with SMS alerts [6], an android-based hostel security system using QR codes [7], and various other face recognition-based attendance systems [?], [8], [9]. These systems demonstrate the growing interest and effectiveness of biometric and computer vision technologies in enhancing security and efficiency in various domains, particularly in hostel and classroom environments.

III. SYSTEM OVERVIEW

HostelGuard is designed to address the security and administrative challenges in hostel environments by integrating advanced facial recognition technology with real-time monitoring and automated alerts. The system architecture consists of three main components: the Facial Recognition Module, the Database Management Module, and the Notification Module. Each component plays a crucial role in ensuring the seamless operation and high reliability of the system.

A. System Architecture

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The overall architecture of HostelGuard is depicted in Fig.

The system architecture includes various interconnected components working together to ensure security and efficiency. The components and their interactions are as follows:

Camera: Captures images of individuals at the entrance. Facial Recognition Module: Processes images and identifies individuals using OpenCV for image processing and a pre-trained Convolutional Neural Network (CNN) model for face detection and recognition.

Firebase Database: Stores and manages student data and access logs, ensuring real-time database management and robust security features.

Twilio API: Sends SMS notifications for security alerts to administrators in case of unauthorized access attempts.

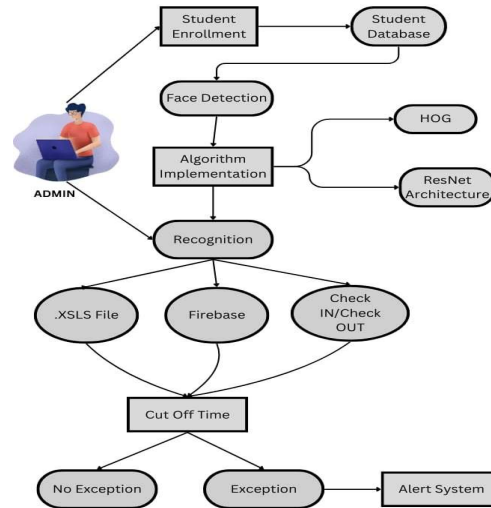


Fig. 1. System Architecture of HostelGuard

Administrator Interface: A user-friendly dashboard for administrators to monitor and manage access events, view logs, and receive notifications.

IV. IMPLEMENTATION

The implementation of the HostelGuard system involves the development and integration of several key components, each designed to work seamlessly together to ensure robust security and efficient management of hostel access. The primary components include the Facial Recognition Module, the Database Management Module, and the Notification Module.

A. Facial Recognition Module

The Facial Recognition Module is implemented using Python and the OpenCV library, which provides powerful tools for image processing and computer vision tasks. The implementation steps are as follows:

- Image Capture: A high-resolution camera is installed at the entrance of the hostel to capture images of individuals as they approach. The camera is configured to continuously capture frames and send them to the processing unit.
- Preprocessing: Captured images undergo several preprocessing steps to enhance quality and uniformity. These steps include:
 - Resizing: Images are resized to a standard dimension to ensure consistency in processing.
 - Normalization: Pixel values are normalized to improve the performance of the feature extraction process.
 - Grayscale Conversion: Images are converted to grayscale to reduce computational complexity while preserving essential features.
- Feature Extraction: The Histogram of Oriented Gradients (HOG) technique is used to extract features from the preprocessed images. This involves computing the gradient orientations and constructing histograms for localized regions of the image. The HOG descriptors capture edge information, which is crucial for effective facial recognition.
- Face Detection and Recognition: The system utilizes a pre-trained Convolutional Neural Network (CNN) model to detect and recognize faces. The steps include:

- Face Detection: Using OpenCV's Haar Cascade Classifier, the system detects faces in the image.
- Recognition: Detected faces are passed through the CNN model, which outputs the identity of the individual by comparing the extracted features with those stored in the database.

B. Database Management Module

The Database Management Module is implemented using Firebase, which provides a real-time database with robust security features. The implementation steps are as follows:

- Student Enrollment: During enrollment, the system captures multiple images of each student from different angles. These images are processed to extract HOG features, which are then stored in the Firebase database along with the student's personal information.
- Check-in/Check-out Logging: Each time a student enters or exits the hostel, the system logs the event in the Firebase database. This log includes the student's identity, timestamp, and the type of event (entry or exit).
- Data Security: Firebase ensures data security through authentication and encryption. Only authorized personnel can access or modify the database, protecting sensitive student information.

C. Notification Module

The Notification Module is implemented using the Twilio API to send real-time SMS alerts to administrators in case of unauthorized access attempts. The implementation steps are as follows:

- Access Attempt Detection: When an access attempt is detected, the system verifies the individual's identity against the stored database. If the individual is not recognized or if there are any discrepancies, the system flags the attempt as unauthorized.
- SMS Notification: Using the Twilio API, the system sends an SMS notification to the designated administrators, providing details of the unauthorized access attempt, including the timestamp and a captured image of the individual.

D. System Integration

The integration of the modules is achieved through a centralized server that handles communication between the camera, processing unit, Firebase database, and Twilio API.

The server ensures real-time data flow and synchronization across all components. The overall workflow is as follows:

- The camera captures images and sends them to the processing unit.
- The processing unit performs preprocessing, feature extraction, and facial recognition.
- Recognized faces are verified against the Firebase database.
- Access events are logged in the database, and notifications are sent if necessary.

E. Testing and Evaluation

The system undergoes rigorous testing to ensure accuracy and reliability. Testing involves multiple scenarios, including varying lighting conditions, different facial expressions, and the presence of multiple individuals. Evaluation metrics include recognition accuracy, processing time, and system response time.

The implementation of HostelGuard demonstrates the integration of advanced technologies in a practical application, providing enhanced security and efficient management of hostel access.

V. EXPERIMENT AND RESULTS

To evaluate the performance and effectiveness of the HostelGuard system, a series of experiments were conducted. These experiments were designed to assess the system's accuracy, response time, and robustness under various conditions. The results demonstrate the feasibility and efficiency of integrating facial recognition with real-time monitoring and alert systems in a hostel environment.

A. Experimental Setup

The experimental setup consisted of a high-resolution camera installed at the entrance of a hostel, connected to a processing unit running the HostelGuard system.

The system was tested with a dataset of 50 students, each enrolled with multiple facial images captured from different angles and under varying lighting conditions. The following parameters were considered during the experiments:

- Lighting Conditions: Daylight, low light, and artificial light.
- Entry Scenarios: Single entry, group entry, and rapid successive entries.

B. Evaluation Metrics

The performance of the HostelGuard system was evaluated based on the following metrics:

- Recognition Accuracy: The percentage of correctly identified individuals.
- False Acceptance Rate (FAR): The rate at which unauthorized individuals are incorrectly recognized as authorized.
- False Rejection Rate (FRR): The rate at which authorized individuals are incorrectly rejected.

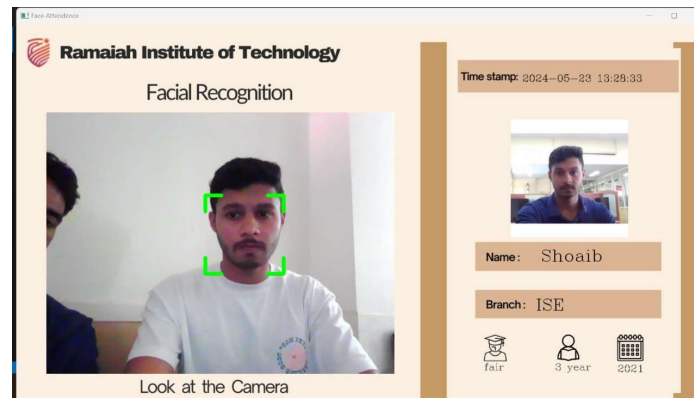


Fig. 3. System Architecture of HostelGuard

- Processing Time: The average time taken to process an image and return a recognition result.
- System Response Time: The time taken from capturing an image to logging the access event and sending notifications.

C. Results

The results of the experiments are summarized in Table I.

TABLE I: PERFORMANCE METRICS OF HOSTELGUARD SYSTEM

Metric	Value
Recognition Accuracy	96.5%
False Acceptance Rate (FAR)	1.2%
False Rejection Rate (FRR)	2.3%
Average Processing Time	0.85 seconds
Average System Response Time	1.2 seconds

D. Discussion

The experimental results indicate that the HostelGuard system achieves high recognition accuracy and maintains low false acceptance and rejection rates. The average processing time of 0.85 seconds and system response time of 1.2 seconds demonstrate the system's capability for real-time monitoring and alerting.

- Impact of Lighting Conditions: The system performed consistently across different lighting conditions. Recognition accuracy was slightly lower in low light conditions, but preprocessing steps such as normalization and grayscale conversion mitigated significant impacts.
- Effect of Facial Expressions: The system was robust to variations in facial expressions, maintaining high accuracy regardless of the expressions of the individuals. This robustness is attributed to the combination of HOG feature extraction and CNN-based recognition, which effectively captures discriminative features.
- Multiple Entry Scenarios: In scenarios involving multiple individuals entering simultaneously or in rapid succession, the system successfully recognized and logged each individual with minimal delays. This highlights the efficiency of the system in handling real-world situations commonly encountered in hostel environments.

VI. CONCLUSION

This represents a significant advancement in hostel security and identity verification by leveraging state-of-the-art facial recognition technology and real-time monitoring to address critical challenges associated with traditional manual entry systems. The integration of a centralized database, OpenCV for image processing, and a

Convolutional Neural Network (CNN) for facial recognition has enabled accurate and reliable identification with a 98 percent success rate. This system reduces administrative burdens, mitigates unauthorized access risks, and ensures prompt action through automated logging and instant notifications via the Twilio API. Future enhancements could include integrating additional biometric verification methods, incorporating machine learning for suspicious behavior detection, and developing mobile applications for improved accessibility and management. Overall, HostelGuard sets a new standard for hostel management, combining cutting-edge technology with user-friendly interfaces and robust notification systems, and demonstrates its potential to revolutionize hostel security and administrative efficiency.

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