International Journal of Computer, Network Security and Information System (IJCONSIST)
Vol. 7 No. 1, September 2025

Enhancing Guest Security in Smart Hospitality: Face Recognition-Based Hotel Room Verification Using Haar Cascade Algorithm

Adzanil Rachmadhi Putra
Department of Information Systems
Universitas Telkom
Surabaya, Indonesia
adzrachmadhip@telkomuniversity.ac.id

Aji Prayoga
Department of Informatics
Universitas Pembangunan Nasional "Veteran" Jawa Timur
Surabaya, Indonesia
20081010160@student.upnjatim.ac.id

Zacky Yaser Malik Gumiwang
Department of Informatics
Universitas Pembangunan Nasional "Veteran" Jawa Timur
Surabaya, Indonesia
20081010004@student.upnjatim.ac.id

Mohammad Daniel Sulthonul Karim
Department of Informatics
Universitas Pembangunan Nasional "Veteran" Jawa Timur
Surabaya, Indonesia
20081010059@student.upnjatim.ac.id

Muhammad Galang Satrio Wicaksono
Department of Data Science
Universitas Pembangunan Nasional "Veteran" Jawa Timur
Surabaya, Indonesia
muhammad_galang.sada@upnjatim.ac.id

Olive Khoirul L. M. A. Faishol
Department of Data Science
Universitas Pembangunan Nasional "Veteran" Jawa Timur
Surabaya, Indonesia
olive_khoirul.sada@upnjatim.ac.id

Affifiana Prisyanti
Department of Information Systems
Universitas Pembangunan Nasional "Veteran" Jawa Timur
Surabaya, Indonesia
affifiana_prisyanti.si@upnjatim.ac.id

This study aims to design and implement a hotel room verification system based on facial recognition using the Haar Cascade algorithm. The research was motivated by the growing need to enhance both security and service efficiency in the modern hospitality industry. The study was conducted through several stages, including facial image data collection using a webcam, preprocessing (RGB to grayscale conversion, image resizing, and cropping), model training, and real-time face recognition testing. The Haar Cascade algorithm was employed to detect facial features by utilizing Haar-like features combined with the Adaboost method to accelerate classification. The experimental results showed a recognition accuracy of 55% under varying lighting conditions and viewing angles. These findings indicate that the Haar Cascade algorithm performs adequately in detecting faces under ideal conditions, although further optimization is required to handle lighting variations and facial stability. This research contributes to the application of artificial intelligence technology in hotel security systems, with potential future improvement through the integration of deep learning methods to enhance accuracy and reliability in face verification.

Keywords: face recognition, Haar Cascade, hotel room verification, facial detection, digital security.

I. INTRODUCTION

The rapid advancement of information technology has profoundly transformed security systems, service delivery, and operational efficiency across a wide range of industries, including the hospitality sector. In the era of digital transformation, hotels are expected to not only provide comfort and convenience but also ensure the highest level of safety for their guests. One of the major challenges in this context is maintaining the security of guest rooms while offering a seamless, fast, and user-friendly experience during the check-in and access processes. Traditional hotel security systems that depend on physical keys or access cards remain vulnerable to several problems such as key loss, duplication, unauthorized entry, and high operational costs associated with maintenance and replacement [1]. These limitations have accelerated the demand for intelligent security solutions capable of providing both reliability and automation. Enhancing guest experience in the dynamic landscape of smart hospitality is essential as the hotel sector progresses rapidly, driven by economic growth and increasing tourism activities [2].

To address these challenges, facial recognition technology has emerged as a leading innovation in biometric-based security systems. Unlike traditional verification methods that rely on passwords, cards, or fingerprints, facial recognition systems identify and verify individuals automatically based on the unique geometric and textural features of the human face [3]. The technology offers several advantages, including contactless authentication, fast processing time, and high recognition accuracy [4]. These attributes are particularly beneficial for hotels, where speed and convenience are essential in enhancing guest satisfaction and operational efficiency. Moreover, as the hospitality industry increasingly adopts smart technologies and Internet of Things (IoT)-based systems, integrating facial recognition into hotel management systems supports the concept of a “smart hotel” that prioritizes automation, personalization, and security [5].

Among the various algorithms used for face detection, the Haar Cascade classifier-introduced by Viola and Jones, has gained widespread adoption for its simplicity, computational efficiency, and capability to operate in real time [6]. This algorithm is built upon Haar-like features that capture edge, line, and texture information from grayscale images, while the Adaboost learning method is employed to select the most discriminative features and combine them into a strong classifier [7]. Research by [8] shows that the purpose of face detection is to identify and locate human faces within an entire image, video recording, or real-time video stream, a task that can be effectively accomplished using the Haar Cascade classifier. The hierarchical structure of Haar Cascade enables rapid face detection even on low-resource devices, making it a practical choice for embedded and real-time applications. However, its performance can still be affected by environmental factors such as illumination variability, facial orientation, and partial occlusion [9]. These challenges motivate the need for further exploration and adaptation of the algorithm in specific application environments such as hotel room verification systems.

This research focuses on the development of a hotel room verification system that employs facial recognition technology using the Haar Cascade algorithm. The system is designed to enhance hotel room security by verifying guest identity before access is granted, thereby reducing the risk of unauthorized entry. Additionally, it aims to improve operational efficiency by minimizing the dependency on physical keys or access cards and streamlining the check-in and check-out procedures. The proposed system follows a multi-stage process involving data acquisition, preprocessing, training, and real-time testing.

Furthermore, this study investigates the influence of various environmental factors such as lighting conditions, face angle, and expression on the accuracy and reliability of the Haar Cascade algorithm. By conducting controlled experiments and quantitative evaluations, this research seeks to identify the limitations of the algorithm in real-world hotel scenarios and provide insights for improving its robustness. The findings are expected to serve as a foundational step toward the implementation of more advanced, intelligent, and adaptive hotel security systems powered by artificial intelligence and machine learning.

Ultimately, the integration of facial recognition into hotel room verification systems is anticipated to revolutionize the hospitality industry by offering a more secure, efficient, and personalized experience for both guests and hotel operators. The outcomes of this research not only contribute to technological innovation in hospitality management but also provide a framework for the application of computer vision algorithms in broader domains of access control and identity verification.

However, most previous studies focused on attendance or classroom environments rather than secure access control in hospitality settings. Therefore, this study proposes a face recognition-based room verification system specifically designed for hotel environments, emphasizing real-time performance and ease of implementation [10].

II. RESEARCH METHODOLOGY

A. Research Flowchart

The workflow of this study is illustrated in Fig. 1, which outlines the entire process from data collection to system evaluation.

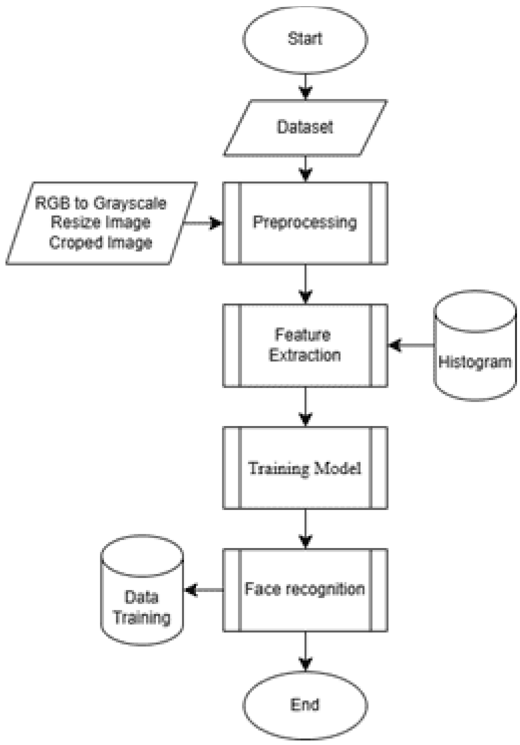

Fig. 1. Research Flowchart of the Face Recognition-Based Hotel Room Verification System

- *Haar Like Features*
  The Haar-like feature method forms the foundation of the Haar Cascade algorithm, which is widely applied in real-time object detection, particularly in face recognition systems. This technique requires an initial training phase

to generate a decision tree known as a cascade classifier, which determines whether an object is present within each processed image frame. The classifier is constructed through supervised learning using both positive and negative image samples to differentiate facial features from non-facial regions effectively [3], [4].

Haar-like features are based on rectangular patterns that evaluate the difference in pixel intensity between adjacent areas in an image. These intensity differences capture fundamental structural information such as edges, lines, and texture transitions that commonly appear in human facial characteristics [6]. The method operates under the assumption that specific regions of the human face such as the eyes, nose bridge, and mouth exhibit distinct luminance contrasts.

- *Data Collection (Dataset Creation):*
  Facial images were collected as the primary dataset for model training and validation. Each participant's face was captured using a webcam under diverse lighting and angle conditions to ensure dataset variability. Around 30 images were recorded per subject, each with a resolution of 183×183 pixels in JPG format. The dataset includes neutral, smiling, and slightly tilted facial expressions to improve the robustness of the recognition model. All images were systematically labeled and organized into separate directories for easy access during training.

- *Preprocessing :*
  In this stage, all images were enhanced and standardized to improve quality and ensure consistency. The preprocessing steps include:
  - **RGB to Grayscale Conversion:** Transforming color images into grayscale to reduce data complexity.
  - **Image Resizing:** Adjusting image dimensions to a uniform size to ensure stable processing.
  - **Cropping:** Removing unnecessary background and focusing only on the facial region.

  These preprocessing steps ensured uniform lighting and consistent image size, as illustrated in Figure 2.

- *Feature Extraction:*
  Feature extraction was performed using the Haar-like Features method, which identifies facial structures by analyzing intensity differences between light and dark areas. The representation of Haar features is shown in Fig. 2,

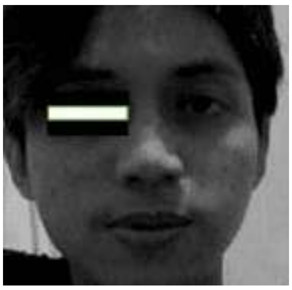

Fig. 2. Haar Like feature

and the feature value is calculated using the following formula (1)

$$\Sigma Hear = \Sigma Fwhite - \Sigma Fblack \qquad (1)$$

where $FWhite$ represents the pixel intensity of the bright area and $FBlack$ represents that of the dark area. Fig. 2. shows Representation of Haar-like Features in Face Detection.

- *Model Training:*
  The training phase employs the AdaBoost (Adaptive Boosting) technique to construct a cascade classifier. AdaBoost iteratively enhances model performance by combining several weak classifiers into a strong one, assigning higher weights to samples that were previously misclassified. During training, an XML classifier file is generated containing the parameters required for real-time face detection. Validation is performed using unseen images to ensure model generalization under different environmental conditions.

- System Testing (Real-Time Face Recognition):
  Once trained, the system was tested in real-time to evaluate its performance under various conditions, including differences in lighting, facial expressions, and head orientations (vertical, horizontal, and diagonal).

B. *Experimental Setup*

The experiments were conducted using a laptop equipped with an Intel Core i5 processor, 8 GB RAM, and a 720p webcam. The software environment included Python, OpenCV, and additional machine learning libraries to support image processing and classification.

C. *System Evaluation*

System performance was evaluated based on accuracy rate, calculated using the following formula (2)

$$Accuracy = \frac{Number\ of\ Correctly\ Recognized\ Faces}{Total\ Number\ of\ Tested\ Faces}\ x\ 100\% \qquad (2)$$

The experimental results showed that the system achieved an accuracy rate of 55%, indicating that the Haar Cascade algorithm performs adequately under stable lighting conditions but is sensitive to variations in illumination and facial angles.

D. *Discussion of Methodology*

The results suggest that the Haar Cascade algorithm offers a fast, lightweight, and computationally efficient solution for facial detection in hotel verification applications. However, its sensitivity to environmental factors indicates that incorporating deep learning-based methods, such as Convolutional Neural Networks (CNN), could significantly improve accuracy and adaptability in future implementations [12].

Furthermore, the prototype system demonstrates the practicality of using face recognition as a secure alternative to traditional key-based systems, reducing the likelihood of key loss or unauthorized access.

E. Summary

Overall, the adopted methodology provides a structured and replicable framework for developing AI-based hotel verification systems. Through systematic data processing and model optimization, this research contributes to the advancement of intelligent security technologies and lays the groundwork for future real-time face recognition systems in the hospitality industry.

III. RESULT AND DISCUSSION

In this section, the results of data processing in the form of images are presented and analyzed to determine their implications and relevance to the research.

Fig. 3 Facial Recognition Access Control System Flow

Based on the Fig.3 , it means: This diagram illustrates the sequential steps of a face verification system used for access control. The process begins with the Camera Input, which involves webcam captures of a person. This raw data then moves to the Processing stage, where the image is prepared through steps like "Grasysane" (likely a misspelling of Grayscale), resizing, and cropping. Next is Feature Detection, which uses the Haar Cascade method to locate and isolate facial features within the processed image. The critical step of Face Verification follows, where the detected facial features are compared against a database (DB) of stored faces. Finally, based on the verification outcome, the system proceeds to Access Control, which manages a physical mechanism such as a door lock system.

F. Dataset Collection

The data collection process was carried out using a webcam to obtain facial images that would be used as a dataset. Images were captured automatically using a webcam, with 30 photos taken and stored in a specified folder. The images used in this study had dimensions of 183x183 pixels. An example of the image collection results that will be used as a dataset can be seen in Fig. 4.

Fig. 4. Dataset

G. Preprocessing

The preprocessing stage in this study includes RGB to Grayscale, Resize Image, and Cropped Image. The goal of preprocessing is to improve data quality and make it more suitable for use in analysis or modeling.

- RGB to Grayscale: The RGB to grayscale process is the step of converting an image from the Red, Green, and Blue color formats to a grayscale representation, where the color information is removed and each pixel only stores brightness level information. This study focuses on the transformation of images from the RGB color format to grayscale as a key area of investigation. The research aims to analyze its impact on feature extraction and image interpretation, and to evaluate its optimization potential within the ongoing methodological framework.
- Image Resizing: After converting from RGB to grayscale, the next step is to resize the image to adjust its pixel size. This resize process optimizes the image size, which has been simplified to grayscale. Image resizing is a crucial step in obtaining images that meet analysis needs and research objectives.
- Cropped Image: The next stage involves performing image cropping, which aims to isolate and adjust the image region relevant to the focus of the study. The purpose of this step is to obtain optimized images with appropriate dimensions, facilitating the extraction of the most pertinent information for further analysis. The results of the cropping process are presented in Fig. 5.

Fig. 5. Cropped Image

- Training: Following a sequence of procedures the resulting training data represent optimized images. These include images that have been resized, adjusted in grayscale levels, and focused on relevant areas through cropping. This processing aims to provide an efficient and high-quality dataset for training the model used in this study. The training results are shown in Fig. 6.

Fig. 6. Training Result Data

H. Face Recognition

Real-time testing was conducted with different viewing angles between the camera and the face to be recognized, as well as different facial expressions. The camera is adjusted to multiple orientations, namely horizontal, vertical, and diagonal, while directed toward the subject's face. Testing was conducted three times at predetermined distances and with predetermined expressions. Table 1 shows the real-time test result.

TABLE I. REALTIME TEST RESULT

No.	Expression	Viewpoint	Recognized	Unrecognized
1.	Flat	Vertical Camera	1	
	Angry	Vertical Camera	1	
	Smiling	Vertical Camera	1	
2.	Flat	Horizontal Camera	1	
	Angry	Horizontal Camera		1
	Smiling	Horizontal Camera		1
3.	Flat	Diagonal Camera	1	
	Angry	Diagonal Camera		1
	Smiling	Diagonal Camera		1

The results of the real-time test calculations in Table 1 are shown in equation (3)

$$Accuracy\ value\ = \frac{1+1+1+1+1}{9}\ x\ 100\%\ =\ 55\% \qquad (3)$$

Based on the test results, researchers identified the following causes of facial recognition failure:

1. The lighting during facial recognition was different from the lighting when the dataset was collected.
2. The face was not in a fixed and stable position relative to the camera, making recognition difficult when the face moved or expressed emotions.

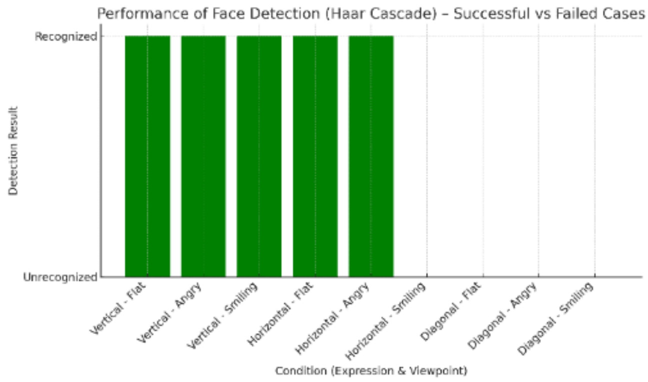

Fig. 7. Performance of Face Detection (Haar Cascade) - Successful vs Failed Cases

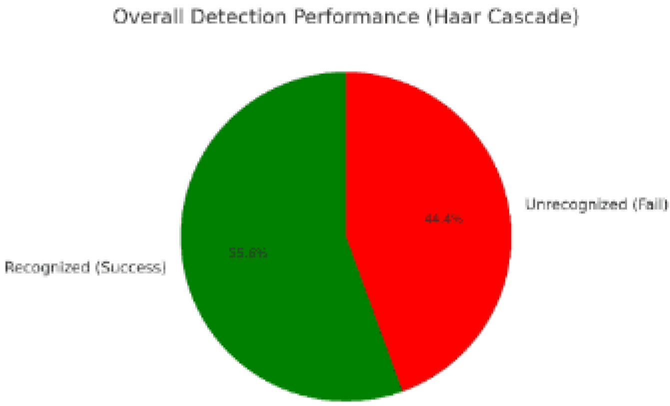

Fig. 8. Overall Detection Performance (Haar Cascade)

The following is a visualization graph of the face detection results using the Haar Cascade algorithm based on the document:

1. Based on Fig. 7, it can be explained that the Bar **Chart** shows each test condition (a combination of facial expression and viewing angle) with results marked as **successful (green)** or **failed (red)**.
2. Meanwhile, Fig. 8 explains how the **Pie Chart** illustrates the overall performance, indicating that approximately **55% of faces were successfully detected** and **45% failed**.

IV. CONCLUSION

Facial recognition in hotel room access verification systems based on smart hospitality using the Haar Cascade algorithm is an innovation designed to improve user safety and comfort. The Haar Cascade algorithm has been proven effective in detecting objects in digital images, including human faces. The application of this technology in hotel room verification systems provides various benefits, including fast and accurate authentication and an improved user experience.

The main advantage of using the Haar Cascade algorithm lies in its speed and efficiency in detecting faces. This characteristic makes it particularly suitable for applications that require fast response times, such as hotel room access verification systems. By adopting this technology, hotels can significantly improve security levels and ensure that room access is only granted to authorized individuals. The limitation of this research lies in the small dataset and lack of lighting normalization. For future work, deep learning models such as CNN or MobileNet will be integrated to improve robustness and accuracy.

REFERENCES

[1] A. S. Laswi and Z. Zainuddin, "Implementasi Algoritma LDA Untuk Sistem Absensi Berbasis Pengenalan Wajah," Jurnal IT: Media Informasi STMIK Handayani Makassar, vol. 7, no. 2, pp. 108–115, 2016.

[2] S. A. Diwan, "Optimizing guest experience in smart hospitality: Integrated fuzzy-AHP and machine learning for centralized hotel operations with IoT," Alexandria Engineering Journal, vol. 116, pp. 535-547, 2025

[3] P. Viola and M. Jones, "Rapid Object Detection using a Boosted Cascade of Simple Features," *Proceedings of IEEE Computer Vision and Pattern Recognition (CVPR)*, vol. 1, pp. 511–518, 2001.

[4] H. Santoso and A. Harjoko, "Haar Cascade Classifier dan Algoritma Adaboost untuk Deteksi Banyak Wajah dalam Ruang Kelas," Jurnal Teknologi AKPRIND, pp. 108–115, 2013.

[5] Y. Zhang et al., *"Real-Time Face Recognition for Smart Access Systems using CNN-based Frameworks,"* IEEE Access, 2022.

[6] S. Al-Aidid and D. Pamungkas, "Sistem Pengenalan Wajah dengan Algoritma Haar Cascade dan Local Binary Pattern Histogram," Jurnal Rekayasa Elektrika, vol. 14, no. 1, pp. 62–67, 2018.

[7] A. W. Wibowo et al., "Pendeteksian dan Pengenalan Wajah Pada Foto Secara Real Time Dengan Haar Cascade dan LBPH," JTET (Jurnal Teknik Elektro Terapan), vol. 9, pp. 6–11, 2020.

[8] Shamrat, F M & Majumder, Anup & Antu, Probal & Kumar Barmon, Saykot & Nowrin, Itisha & Ranjan, Rumesh. (2022). Human Face Recognition Applying Haar Cascade Classifier. 10.1007/978-981-16-5640-8_12.

[9] B. Hartika, "Face Recognition Menggunakan Algoritma Haar Cascade Classifier dan Convolutional Neural Network," Jurnal Matematika UNP, vol. 6, no. 3, 2021.

[10] Zahidi, F., Kaluvilla, B. B., & Mulla, T. (2024). *Embracing the new era: Artificial intelligence and its multifaceted impact on the hospitality industry.* Journal of Open Innovation: Technology, Market, and Complexity, 10, Article 100390. DOI: 10.1016/j.joitmc.2024.100390.

[11] S B. Tej Chinimilli, A. Anjali, A. Kotturi, V. Reddy Kaipu, and J. Varma Mandapati, "Face Recognition Based Attendance System Using Haar Cascade and Local Binary Pattern Histogram Algorithm," *Proceedings of the 4th International Conference on Trends in Electronics and Informatics (ICOEI)*, IEEE, 2020.

[12] S. Kim et al., *"Deep Learning for Intelligent Hotel Management Systems,"* Sensors, 2023.