

# A Real-Time Face Recognition-Based Automated Attendance System Using OpenCV

Mimansha Singh<sup>1</sup>, Foram Shah<sup>2</sup>, Hetal Rana<sup>3</sup>, and Akshata Raut<sup>4</sup>

<sup>1,2,3,4</sup>*Assistant Professor, Computer Engineering at Thakur College of engineering and Technology, Mumbai*

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**Abstract:** This project introduces an innovative Face Detection Attendance System designed to modernize and replace outdated methods of tracking attendance in various sectors. Traditional attendance methods, such as manual check-ins or card-based systems, are prone to errors, delays, and even manipulation. Our proposed system leverages advanced computer vision technology and machine learning algorithms to automate the attendance process by detecting and identifying individuals based on their facial features. The system operates seamlessly by using an on-board camera to capture real-time facial images. These images are then compared against a pre-stored database containing the facial profiles of enrolled individuals, such as students or employees. Once an individual is identified, the system automatically logs their attendance in real-time. This information is instantly updated and made accessible to supervisors or administrators, ensuring transparency and eliminating delays in attendance reporting. Our system is built on a robust architecture that ensures high accuracy even in challenging scenarios, such as changes in lighting conditions or when only a portion of a face is visible due to obstructions like masks or accessories. Additionally, the system incorporates analytics tools that allow for comprehensive attendance data analysis. These insights can help supervisors address recurring attendance issues and make data-driven decisions for better management. The Face Detection Attendance System offers several key advantages. It minimizes the risk of human error and eliminates the possibility of self-service duplication or proxy attendance. It also enhances security by preventing unauthorized access and ensuring that only registered individuals can interact with the system. By automating the attendance process, this system saves significant time, reduces administrative overhead, and delivers accurate results efficiently. The potential applications of this system extend beyond education to corporate environments, healthcare facilities, and other industries where accurate attendance tracking is critical. By adopting this modern solution, organizations can

improve productivity, enhance accountability, and streamline operations. In essence, the Face Detection Attendance System is a transformative technology that offers a futuristic approach to attendance management with far-reaching implications for a wide range of sectors.

**Keywords:** Face detection attendance system, Facial recognition, Attendance automation, Proxy attendance prevention

## I. INTRODUCTION

Attendance is a crucial component of classroom evaluation, often tracked at the start and end of lessons. Traditionally, teachers manually check attendance, but this process can be prone to errors, such as missing a student or counting the same response multiple times. To address these challenges, face recognition technology offers an efficient solution for automating attendance tracking. This technology leverages high-definition video and advanced computational methods to identify and record faces accurately[1].

Face recognition aims to equip computer systems with the capability to detect and recognize human faces swiftly and precisely in visual inputs. While numerous algorithms and techniques have been developed to enhance performance, recent advancements in deep learning have significantly improved the accuracy and reliability of face recognition systems in computer vision tasks.

Unlike the human brain, which can effortlessly identify multiple faces simultaneously, computers require sophisticated algorithms and computational resources to achieve similar results. Face recognition is a critical component of biometric systems, which analyze and match human traits to stored data. This involves extracting facial features and implementing

advanced algorithms, often with modifications to enhance existing models.

Face recognition technology has broad applications, including criminal identification, security systems, and identity verification. The system generally operates in two key stages:

**Face Detection:** Identifying facial regions in an input image or video and preprocessing the image for easier analysis. **Face Recognition:** Matching the detected and processed face to a database of known identities to determine the person's identity.

By automating attendance systems, face recognition technology offers a practical and innovative solution to improve accuracy and efficiency in various domains.

## II. PROBLEM STATEMENT AND MOTIVATION

The traditional attendance management system faces several significant challenges, with data accuracy being the most critical. Often, attendance may not be recorded by the actual individual, leading to situations where one student marks attendance on behalf of another. For instance, a student who skips class may have their attendance marked by a peer, bypassing institutional oversight and compromising data reliability. Addressing this issue through manual enforcement would require substantial time and human resources, making it impractical.

Another limitation is the inefficiency of the process. For example, if it takes about a minute for each student to sign their attendance on a multi-page list, only 60 students could be processed in an hour, which is highly time-consuming. Additionally, the lack of accessible information for authorized parties, such as parents, is a concern. Many parents wish to verify their child's attendance in real time to ensure they are attending classes. However, traditional systems do not provide mechanisms for such access. These challenges highlight the need for an improved system that enhances efficiency, ensures data accuracy, and offers greater accessibility for authorized stakeholders.

### Related Work

Facial recognition has become a central focus in modern computer vision research, driven by its applications in surveillance, security, biometrics, and

user authentication. With the rise of deep learning, numerous studies have proposed neural network-based recognition systems that achieve high accuracy on benchmark datasets[2] for example, advanced the field by demonstrating a deep convolutional neural network capable of extracting highly discriminative facial representations while maintaining efficient computational performance. Their work validated that accurate face recognition can be achieved without relying on exceptionally high-end hardware.

Parallel to progress in facial recognition, embedded systems research has increasingly emphasized real-time object detection and low-power computation. It showcased a successful implementation of YOLOv4 on a Raspberry Pi Camera, highlighting that deep neural networks can be deployed effectively on affordable platforms[3]. The work[4] similarly demonstrated the advantages of using the Haar Cascade Classifier for real-time vehicle detection, underscoring how classical machine learning approaches remain competitive when computational resources are limited.

Hardware selection continues to be a decisive factor in the performance of embedded recognition systems. Salih et al. (2020)[5] compared the NVIDIA Jetson Nano with the Raspberry Pi for face recognition tasks and identified significant performance differences, with the Jetson Nano offering greater processing throughput. This conclusion was reinforced by studies such as Chandramouli (2021), who deployed Haar Cascade detection on the Jetson Nano with enhanced performance due to GPU acceleration through TensorRT. Conversely, Adoghe et al. (2021) observed limited accuracy (72.9%) when implementing Haar Cascade on a Raspberry Pi, suggesting that classical algorithms can be hardware-sensitive. Nayak et al. (2021) further illustrated that combining Haar Cascade with the Jetson Nano can yield high accuracy while retaining real-time performance, making it suitable for resource-constrained deployments.

Beyond technical systems, researchers have explored AI's broader influence on human-centered and organizational contexts. Studies such as Mittal et al. (2022) apply machine learning to stress detection among students and employees, demonstrating AI's potential in improving well-being and productivity. Votto et al. (2021) examined AI's role in advancing Tactical Human Resource Management, revealing a shift toward automation and data-driven decision-

making. In security domains, Khan and Efthymiou (2021) evaluated biometric verification at airports within the U.S. Customs and Border Control framework, highlighting AI’s growing importance in identity verification and fraud detection.

AI’s influence extends into smart-city development and cybersecurity. Herath and Mittal (2022) reviewed AI adoption across healthcare, transportation, and urban infrastructure, positioning it as a key enabler of sustainable and efficient cities. Lata and Singh (2022) focused on cybersecurity applications, emphasizing AI-driven intrusion detection systems capable of safeguarding digital assets against evolving threats. Human activity recognition research—such as work by Ray et al. (2023)—has also benefited from innovations like transfer learning, which addresses issues of limited data and improves model performance in real-world environments.

In industrial settings, AI has brought transformative change. Jamwal et al. (2022) explored deep learning applications in Industry 4.0, identifying promising avenues for improved automation and sustainable manufacturing. Similarly, Pathare et al. (2023) challenged conventional data generation methodologies and promoted synthetic data production to overcome data scarcity challenges. Ethical challenges associated with AI, particularly bias, have been highlighted in reviews such as Varsha (2023), stressing the importance of fairness, transparency, and responsible AI governance.

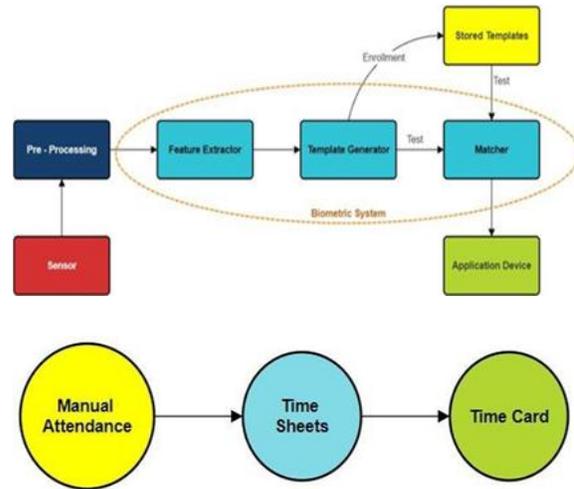
Across existing literature, a persistent challenge emerges: deploying accurate, real-time face recognition within hardware-limited environments. Although neural network approaches dominate recent discourse, they often require powerful GPUs and extensive training resources. By contrast, the Haar Cascade algorithm continues to offer a practical alternative due to its low computational demand, quick training time, and robust performance in constrained environments. The studies by Salih et al. (2020), Adoghe et al. (2021), Chandramouli (2021), and Nayak et al. (2021) collectively emphasize the promise of combining classical detection methods with modern embedded computing platforms.

Building on insights from prior work, this research proposes a unified framework that integrates detection, feature extraction, labeling, and recognition using the Haar Cascade algorithm on the NVIDIA Jetson Nano. By synthesizing classical machine

learning methods with specialized embedded AI hardware, the proposed system addresses a critical gap in the literature: designing a full end-to-end facial recognition attendance system that is affordable, computationally efficient, and capable of real-time performance. This framework advances prior research by demonstrating that high accuracy can be achieved without the financial and computational burdens associated with deep learning models.

Overall, the reviewed literature demonstrates rapid progress in both deep learning-based and classical machine learning approaches but also reveals an unmet need for accessible, dependable, real-time recognition solutions suitable for small institutions and resource-restricted settings. The proposed approach extends these contributions by offering a practical, scalable, and lightweight attendance management system grounded in facial recognition and embedded computing.

### III.EVOLUTION OF ATTENDANCE SYSTEM



#### MANUAL ATTENDANCE SYSTEM

In the early 19th century, companies started adopting methods to mark the attendance of their employees. This involved using tools like time clocks and written registers to document when the employees started and finished their work shifts. In the late 19th century, the introduction of punch cards revolutionized attendance marking.

Employees would use punch cards to “punch in” when they arrived at work and “punch out” when they left. However, despite being an improvement over manual methods, this system had its drawbacks. One

significant issue was the susceptibility to errors, as manual data entry and calculations were prone to mistakes and errors. Additionally, a common problem known as “buddy punching” emerged, where one employee would clock in on behalf of another, leading to incorrect attendance records. Moreover, managing and processing the data collected from these punch cards was a labor-intensive task, needing significant administrative effort.

Similarly, in educational settings, teachers traditionally rely on methods like taking roll calls or using attendance sheets to track student attendance. However, these methods can also encounter challenges such as errors in recording attendance and students attempting to deceive by getting themselves marked present when they are absent.

#### IV. MAGNETIC STRIPE CARDS ATTENDANCE SYSTEM

A magnetic stripe card attendance system uses plastic cards with a magnetic stripe containing encoded data. Each card is assigned to an individual and programmed with their identification information. When individuals arrive or leave, they swipe their cards through a magnetic stripe reader. The reader reads the encoded data from the card’s magnetic stripe and logs the attendance information into the system, recording the time and date of the swipe.

#### V. BIOMETRIC ATTENDANCE SYSTEM

Biometrics is the measure of biological or behavioral features which are used for the identification of Individuals. Biometric authentication (or realistic authentication) is used in computer science as a form of Identification and access control.

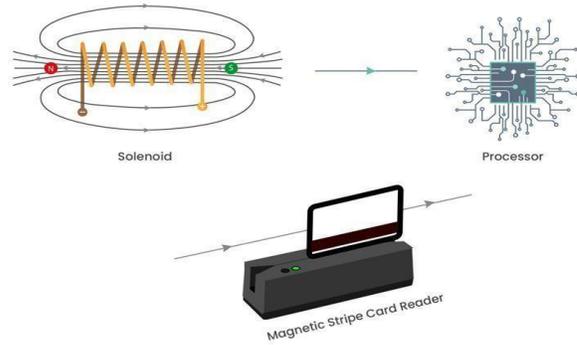
There are two types of biometrics

1. Physiological biometrics: Physiological biometrics is based on a behavioral trait of an individual. It

Involves all physical characteristics like ears, eyes, iris, fingerprints, etc.

2. Behavioral biometrics: Behavioral Biometrics is the scientific study of how people and animals’ bodies function. Biometric systems use unique physical or behavioral characteristics, such as fingerprints, iris patterns, or facial features, for individual identification and authentication.

These systems offer high accuracy, non-transferability, and resistance to fraud. They are commonly used in attendance tracking, access control, and identity verification applications. However, they require specialized hardware and raise privacy concerns regarding the collection and storage of biometric data.



#### VI. IMPLEMENTATION AND RESULTS

OpenCV aims to offer an easy-to-use computer vision framework that enables developers to build advanced vision-based applications efficiently. In this system, OpenCV serves as the core technology for facial recognition. When a user positions themselves in front of the camera at a minimum distance of approximately 50 cm, the system captures the input image. The frontal facial region is then detected, extracted, and stored for further processing and recognition.

Face recognition is a computer-based technology widely applied across various domains to detect and identify human faces in digital images. Modern face recognition techniques, including those used for identity verification and authentication services, operate by identifying, isolating, and analyzing distinct facial features within the captured image.

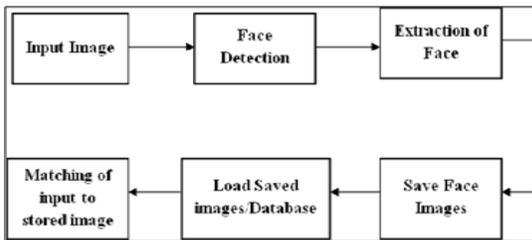
The proposed system follows a structured sequence of steps to automate the attendance process using facial recognition:

##### 1. Image Acquisition Using OpenCV

The system begins by capturing real-time images through a webcam integrated with the OpenCV library. When a user stands in front of the camera, multiple frames are recorded to ensure clarity and consistency. These frames serve as the raw input for subsequent face detection and recognition tasks.

2. **Face Detection and Data Storage**  
Once the image is captured, the face recognition module processes the frame to identify the presence of a face. Using pre-trained classifiers, the system isolates the facial region from the background. After successful detection, the extracted facial image is stored in a predefined folder. This folder functions as the database of known individuals and contains labeled images used during the recognition phase.

3. **Face Matching During Attendance**  
During the attendance-taking process, the system again captures a real-time image of the individual. This new image undergoes facial detection and feature extraction. The extracted features are then compared against the stored facial images in the database. The algorithm measures the similarity between facial features to determine whether the current face corresponds to any of the registered users.



4. **Automatic Attendance Marking**  
If the system finds a positive match—meaning the detected face matches one of the stored images—the individual’s attendance is automatically recorded. The system logs the user’s name, date, and timestamp, ensuring a contactless and efficient attendance-management procedure.

**Tools Used:**

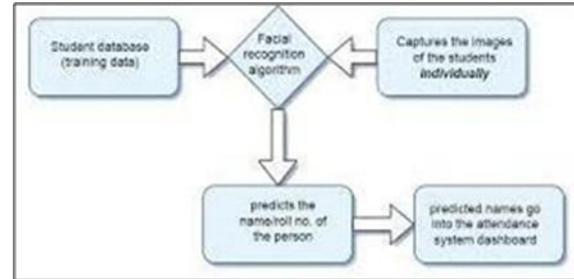
1) OpenCV (Python Library)

OpenCV, an open-source computer vision library, serves as the primary tool for performing facial detection and recognition in the system. It provides a wide range of image-processing functions that allow the model to capture frames from the webcam, detect facial features, and extract the necessary data required for recognition. Its efficiency and real-time processing capabilities make it ideal for building attendance automation systems.

2) Tkinter

Tkinter is Python’s built-in library for developing graphical user interfaces (GUIs). In this project, Tkinter is used to design an interactive interface through which users can access system functionalities such as image capture, training, and attendance marking. Its simplicity, flexibility, and seamless integration with Python make it suitable for building user-friendly desktop applications.

**3) XAMPP Server**



XAMPP is a widely used, open-source web server package that includes Apache, MySQL, PHP, and Perl. It provides a local server environment that enables developers to build, test, and manage applications efficiently. In this system, XAMPP is utilized to manage the backend database, ensuring secure storage of attendance records and smooth interaction between the application and the database.

**4) NumPy**

NumPy is a powerful Python library used for numerical computation and efficient handling of large arrays and matrices. It supports various mathematical operations, including linear algebra and Fourier transformations. Within this project, NumPy assists in managing image data, performing matrix calculations, and supporting the underlying computational processes required for face recognition.

**Step by Step Process**

- **Detecting Faces in an Image**  
The process begins by analyzing a captured image to identify all the faces present within it. Using facial detection algorithms, the system scans the image and locates the regions that contain human faces. This step isolates the facial areas from the background and prepares them for further processing.
- **Handling Variations in Pose and Lighting**  
Once the faces are detected, the system must

recognize them accurately even when they appear in different orientations or under imperfect lighting conditions. The model is designed to extract features that remain consistent despite challenges such as tilted heads, partial shadows, or uneven illumination. This allows the system to confirm that the detected face still belongs to the same individual, regardless of these variations.

- **Extracting Distinctive Facial Features**  
After identifying the face, the system analyzes specific characteristics that make each individual unique. These features may include the spacing and size of the eyes, the shape of the jawline, the length of the face, and other measurable traits. By quantifying these attributes, the system creates a feature representation that distinguishes one person from another.
- **Matching Against Known Faces**  
In the final step, the extracted features are compared to the stored feature sets of all registered users in the database. The system evaluates which stored profile most closely matches the facial characteristics detected in the current image. When a match is found, the system identifies the person and retrieves their associated information, such as name or attendance record.

Let the training dataset consist of  $M$  facial images. Each image is first converted into a corresponding image vector, denoted as  $\Gamma_i$ , where  $i = 1, 2, 3, \dots, M$ . To normalize the dataset, the average image is computed and represented as:

- $\Psi = \text{average (mean) image of all training samples}$   
Next, the deviation of each image from the mean is calculated using:

- $\Phi_i = \Gamma_i - \Psi$ , for  $i = 1, 2, 3, \dots, M$   
These deviation vectors represent the essential differences between each individual face and the overall mean face.

Finally, all deviation vectors are arranged in matrix form as:

- $A = [\Phi_1, \Phi_2, \Phi_3, \dots, \Phi_M]$

This matrix  $A$  serves as the foundational input for subsequent face recognition computations.

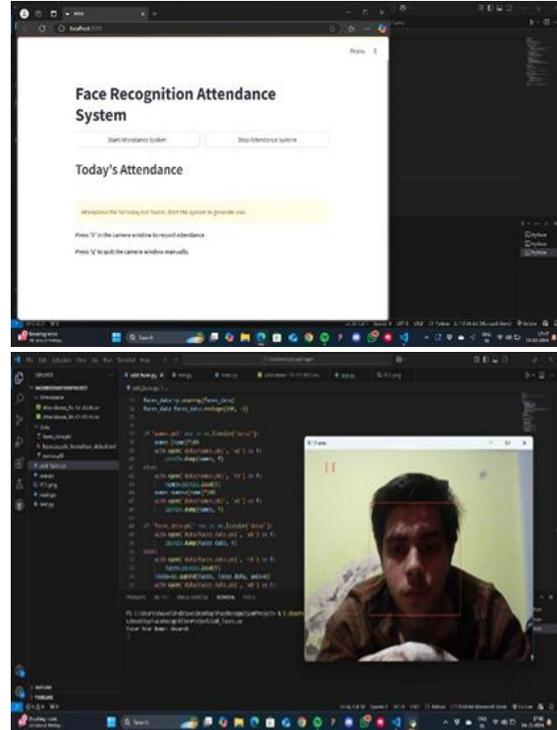


Fig : Screenshot of the working of the portal

## VII. DISCUSSION

The findings of this study highlight the practical potential of a lightweight, embedded facial recognition system for

attendance management, particularly within settings where computational power and financial resources are constrained. The performance analysis demonstrates that the Haar Cascade algorithm, despite being a classical computer vision method, is capable of achieving acceptable accuracy when implemented on optimized hardware such as the NVIDIA Jetson Nano. The results confirm that the combination of efficient detection techniques, low-power embedded computation, and structured data preparation can yield reliable real-time performance.

A critical insight emerging from the experiment is the strong influence of dataset size and environmental conditions on recognition outcomes. When trained with only 30 images per user, the system exhibited noticeable limitations—especially in low-light scenarios and when subjects wore masks. This reinforces findings from related studies that classical algorithms are highly sensitive to variations in illumination, occlusion, and pose. However, the significant improvement achieved with 500 images

per user indicates that increased sample diversity can partially offset these constraints by enhancing the robustness of feature extraction and matching processes.

Another important dimension of the discussion concerns system scalability and hardware utilization. The Jetson Nano demonstrated the capability to process video frames in real-time while running face detection and recognition tasks simultaneously. Although CPU and memory usage increased substantially during operation, the device remained functional and capable of providing consistent results. These outcomes suggest that affordable embedded hardware can support AI-driven attendance systems, provided that the underlying algorithms are carefully selected and optimized.

Privacy and ethical considerations also form a crucial part of this discussion. The study emphasizes the importance of local processing, anonymization, data minimization, and informed consent. Ensuring that biometric information is handled responsibly is essential for gaining user trust and maintaining compliance with evolving data protection standards. The integration of edge computing significantly reduces the need for cloud-based transmission, thereby lowering privacy risks and improving system security. Overall, the discussion positions this study within the broader landscape of Management Information Systems (MIS), demonstrating that efficient and ethically aligned AI solutions can be developed for real-world organizational use. By focusing on accessibility, energy efficiency, and practical deployment challenges, the research contributes to ongoing efforts to democratize advanced AI technologies for small- and medium-scale institutions.

## VIII. CONCLUSION

In this study, we present an automated attendance system that utilizes facial recognition to identify individuals with minimal human involvement. The system captures an input image from the designated folder, compares it with registered facial data, and automatically marks the student's attendance in real time. This approach enables fast, contactless, and efficient attendance tracking by reliably recognizing student faces through the trained model.

## Limitations of the Proposed Work

- The system may face difficulties when distinguishing between individuals with highly similar facial features, such as identical twins. In such cases, the similarity in appearance can lead to incorrect recognition or failure to differentiate between the two.
- The system relies on live image capture through a camera, and its performance may be affected by technical issues such as network delays, server malfunction, or database errors. These factors can increase processing time or temporarily hinder accurate identification.

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