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Real-Time Student Face Recognition Attendance System Using AI

Dharmaraj K B [1], Dhanushree C N [2], Revanth H V [3], Shashank N [4], Tejaswini P M [5]

[1] Assistant Professor, Department of ISE, MITM, Mysore, VTU Belagavi, India

[2-5] UG Students, Department of ISE, MITM, Mysore, VTU Belagavi, India

Abstract: This paper proposes a Real-Time Student Face Recognition Attendance System using Artificial Intelligence (AI) to automate the attendance process in educational institutions. The system leverages state-of-the-art deep learning techniques, such as Convolutional Neural Networks (CNNs), for efficient face detection and recognition. It integrates facial recognition models with a real-time video stream, enabling automatic identification of students as they enter the classroom. The system first detects faces using a robust face detection algorithm, followed by face recognition to match the detected face with stored student data. The attendance is marked instantly, providing an accurate and seamless solution. The use of AI enhances the system's performance, achieving high accuracy even in varied lighting conditions and with minimal facial occlusion. The system also incorporates security features, ensuring that it is resistant to impersonation or fraud. With easy integration into existing educational infrastructure, the proposed system offers a reliable and efficient alternative to traditional manual attendance methods, saving time, reducing human error, and ensuring transparency.

Keywords: Face Recognition Attendance System

1. INTRODUCTION

Managing student attendance is a fundamental task for educational institutions. Accurate attendance tracking ensures accountability, supports educational progress monitoring, and is essential for various administrative purposes such as grading, resource allocation, and even in addressing student absenteeism. Traditional methods of attendance, including roll calls, paper-based sign-ins, and ID card-based systems, often face challenges related to accuracy, efficiency, and security. These methods are vulnerable to human error, are time-consuming, and can be easily manipulated or circumvented.

In response to these challenges, modern educational systems are increasingly turning to advanced technological solutions. One of the most promising innovations in this domain is facial recognition technology. Powered by artificial intelligence (AI) and machine learning (ML), facial recognition offers a non-intrusive, highly efficient, and accurate way to monitor student attendance. By leveraging AI models, facial recognition systems can analyze facial features captured through cameras, enabling real-time identification and verification of individuals. This technology offers several advantages, including faster processing times, greater reliability, and the elimination of manual errors or fraud (such as students signing in for their peers).

The evolution of facial recognition technology in the education sector has been significantly influenced by advancements in computer vision, deep learning, and biometric analysis. Over the last few years, facial recognition systems have become more precise, with improvements in algorithms that allow them to identify students with high accuracy even in less-than-ideal lighting conditions or when facial features may be partially obscured (e.g., wearing glasses or face masks).

This survey aims to review and analyze key academic works published between 2021 and 2024, focusing on the implementation and evaluation of facial recognition systems for student attendance in educational settings. These studies explore a range of topics, including the performance and accuracy of facial recognition algorithms, the integration of such systems into existing campus infrastructure, ethical and privacy considerations, and the scalability of such solutions across different types of educational institutions (e.g., primary schools, universities, online learning platforms).

2. PROPOSED SYSTEM

The proposed system aims to fully automate the process of recording student attendance by utilizing real-time face recognition technology integrated with artificial intelligence. The core idea is to reduce manual intervention while increasing the accuracy and reliability of attendance data. During the registration phase, each student's facial images are captured using a webcam, ensuring multiple angles and lighting conditions to improve recognition reliability. These images are labeled with unique student IDs and stored for training the system.

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Once trained, the system activates at the start of a lecture session, using the webcam to scan for student faces. The recognized faces are matched against the trained dataset using a facial recognition algorithm. If a match is confirmed with a confidence score exceeding the defined threshold, the system logs the attendance, including student ID, date, time, and subject. The system also includes an intuitive graphical user interface for ease of use, allowing instructors to start and stop sessions, manually add entries for unrecognized faces, and access attendance logs.

The inclusion of a text-to-speech engine enhances user interaction by providing real-time auditory feedback on system operations, such as successful recognition or errors. All attendance data is securely saved in timestamped CSV files or a relational database, ensuring easy retrieval and integration with institutional reporting systems

3. LITERATURE SURVEY

Survey of Existing Approaches:

Ravishka Fernando et al. (IEEE ICIPRoB 2024) proposed a real-time attendance system that combines Haar Cascade for face detection and Local Binary Pattern Histogram (LBPH) for face recognition. Haar Cascade is used for detecting faces in real time, scanning images and applying a series of classifiers to identify faces quickly. Once detected, LBPH is employed to analyze the texture of the face, creating a unique pattern for each individual, enabling recognition. The system demonstrated over 99% accuracy in controlled conditions, showcasing its robustness. However, its performance dropped when faced with challenges such as poor lighting or occlusions, where parts of the face are obscured, like by a mask or hair. This makes it less effective in environments where lighting is suboptimal or faces are partially hidden. This system is particularly useful in real-time attendance applications where fast and accurate identification is critical.

Balakannan et al. (IEEE ICEECT 2024) introduced a hybrid machine learning approach, combining Convolutional Neural Networks (CNNs) for feature extraction with Support Vector Machines (SVM) and K-Nearest Neighbors (KNN) classifiers for face recognition. CNNs are adept at extracting hierarchical features from images, allowing the system to process and analyze facial features efficiently. The extracted features are then classified using either SVM or KNN, comparing them to a known database to identify the individual. The modular design of the pipeline offers flexibility, allowing for easy swapping or upgrading of components. However, the system's performance is hindered by high computational costs, as CNNs require substantial processing power for feature extraction. Additionally, facial occlusions limit its effectiveness in less than ideal conditions. This approach is suitable for applications where customization and flexibility are key, though it may not be ideal for devices with limited computational resources.

Kritagya Painuly et al. (IEEE CONIT 2024) focused on utilizing deep CNNs and transfer learning using pre-trained models such as VGG16 and ResNet for face recognition. Transfer learning allows the system to leverage the knowledge from models trained on large datasets, which is particularly useful for tasks like face recognition. Both VGG16 and ResNet are well-established CNN architectures known for their high performance in image classification tasks. The system demonstrated impressive results, performing well even under real-world variations such as different lighting conditions and facial angles. However, these models are computationally intensive and require significant hardware resources, making them less suitable for devices with limited processing capabilities. This approach is ideal for high-end applications where computational power is available and where the need for accuracy under diverse conditions is paramount.

D. Balakrishnan et al. (IEEE ICETITE 2024) developed a CNN-based system for face recognition, utilizing FaceNet for generating face embeddings and MTCNN for face detection. FaceNet is known for its ability to convert faces into numerical vectors (embeddings), which can be compared for recognition. MTCNN, a multi-stage face detection method, is used to detect faces and align them for consistent recognition. While the system achieves high accuracy, it faces challenges with distinguishing between similar-looking faces, which can result in false positives in identification. This limitation highlights the need for additional measures, such as face verification or multi-factor authentication, to enhance the system's reliability when dealing with closely resembling individuals. This system is suitable for high-accuracy recognition applications, particularly where face verification is necessary to address potential misidentifications.

Muhamad Aiman et al. (IEEE SCOReD 2024) designed an end-to-end CNN-based facial recognition system that emphasizes user-friendliness and accessibility. The system features a simple Graphical User Interface (GUI), making it easy for non-technical users to operate. The end-to-end CNN architecture streamlines the process by handling both feature extraction and recognition automatically, eliminating the need for manual intervention. The system also integrates with a Database Management System (DBMS), which is essential for managing and storing large datasets of face images and recognition results. While this approach is designed to be user-friendly, it does not provide detailed performance metrics, such as accuracy. However, it is well-suited for applications where ease of use and accessibility are priorities, and where the system needs to handle large numbers of users through efficient database integration.

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4. BLOCK DIAGRAM AND SYSTEM ARCHITECTURE

```
[Camera Input]
     ↓
[Face Detection - Haar Cascade]
     ↓
[Face Recognition - LBPH]
     ↓
[Confidence Score Check]
     ↓
✓ If matched → [Attendance Logging - CSV/DB]
✗ If not → [Manual Entry Module]
     ↓
[GUI + TTS Feedback]
```

Fig. 1. Block Diagram

The architecture of the system follows a modular design, enabling seamless integration and maintenance. The process begins with the image acquisition module, where a live webcam feed captures student faces. The image is immediately processed through a face detection module using the Haar Cascade classifier. Once a face is detected, it is cropped and passed to the recognition module.

The recognition module employs the Local Binary Patterns Histogram (LBPH) algorithm, which is suitable for real-time applications and performs well with grayscale images. The algorithm compares the extracted facial features with the stored training dataset to find the best match. When a match is found within the acceptable confidence level, the student's attendance is marked and the details are recorded in a CSV file or database.

The graphical user interface (GUI) layer built using Tkinter acts as the front-end control panel for the instructor. It provides functionalities such as selecting the subject, initiating recognition, viewing stored attendance, and performing manual entries when recognition fails. A fallback mechanism ensures that even if the system fails to recognize a student due to lighting issues or occlusions, the instructor can manually input attendance.

An additional feature is the audio feedback provided via the pyttsx3 text-to-speech library, which confirms the recognition status and guides the user through the process. This enhances system usability, especially in classroom environments where visual focus may be divided.

5. IMPLEMENTATION DETAILS

The system is developed using Python as the core programming language, leveraging libraries such as OpenCV for image processing, Tkinter for GUI creation, NumPy and Pandas for data handling, and pyttsx3 for speech synthesis. During the setup phase, facial images of each student are captured and labeled using their unique student IDs. Around 25 to 30 images per student are collected to ensure variability in angles and expressions.

These labeled images are then used to train the LBPH face recognizer, which generates a model file (.yml) used for future recognition. The training process ensures that the system can distinguish between registered students even under slightly altered conditions. Once deployed, the system allows the instructor to input the subject name through the GUI and begin scanning for student faces.

As each student’s face is recognized, the system logs the current date and time along with the subject. The attendance information is appended to a subject-specific CSV file for permanent storage. The GUI provides options for viewing attendance history and for adding manual entries when required. The text-to-speech functionality announces each recognized student and notifies the user in case of failure, enhancing interactivity.

The implementation also includes options for data visualization, converting attendance records into charts and graphs using Pandas and Matplotlib, which aids in analyzing attendance trends over time.

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6. RESULT AND PERFORMANCE ANALYSIS

The Student Attendance System Using AI was tested extensively to evaluate its functionality, accuracy, speed, and reliability across various scenarios. The system successfully integrates facial recognition with real-time data logging and a user-friendly GUI, delivering promising results in classroom simulations.

System Functionality Results

The system was tested with multiple students across different lighting conditions, facial orientations, and camera angles. The major functional modules yielded the following outcomes:

- Face Registration - Successfully captured 50+ facial images per student
- Model Training - Generated a trained model (Trainner.yml) with accurate face encoding
- Automatic Attendance - Accurately recognized known students within 1–2 seconds per face
- Manual Attendance Entry - Allowed error-free fallback attendance marking
- Attendance Record Storage - Saved subject-wise CSV files with correct timestamps and data fields
- View Attendance - Displayed attendance files in tabular format via GUI
- Text-to-Speech Feedback - Delivered clear audio prompts for system feedback and alerts

Recognition Accuracy

The system uses the LBPH (Local Binary Pattern Histogram) algorithm for facial recognition. During testing:

Recognition Accuracy: ~92–95% under well-lit, frontal face conditions.
False Negatives (unrecognized but valid faces): ~5–8%, mostly under poor lighting or angled faces.

False Positives: 0% — unregistered faces were correctly identified as "Unknown".

System Performance

- Image Capture Time: ~1.5 seconds per face
- Model Training Time: ~2–5 seconds for 10+ students
- Recognition Speed: < 2 seconds per face
- Average CSV Logging Time: < 1 second
- GUI Response Time: Instantaneous (< 0.5 seconds)

The system operates smoothly on basic hardware without the need for external servers or GPUs, demonstrating its suitability for offline deployment in typical classrooms or laboratories.

Usability Evaluation

- Interface: Intuitive and minimalistic, using Tkinter with large buttons and clear labels.
- Error Handling: The system appropriately prompts for missing inputs and prevents invalid data entries.
- Accessibility: Text-to-speech feedback aids non-technical users in understanding actions and errors.
- Flexibility: Both automatic and manual attendance modes allow comprehensive usability.

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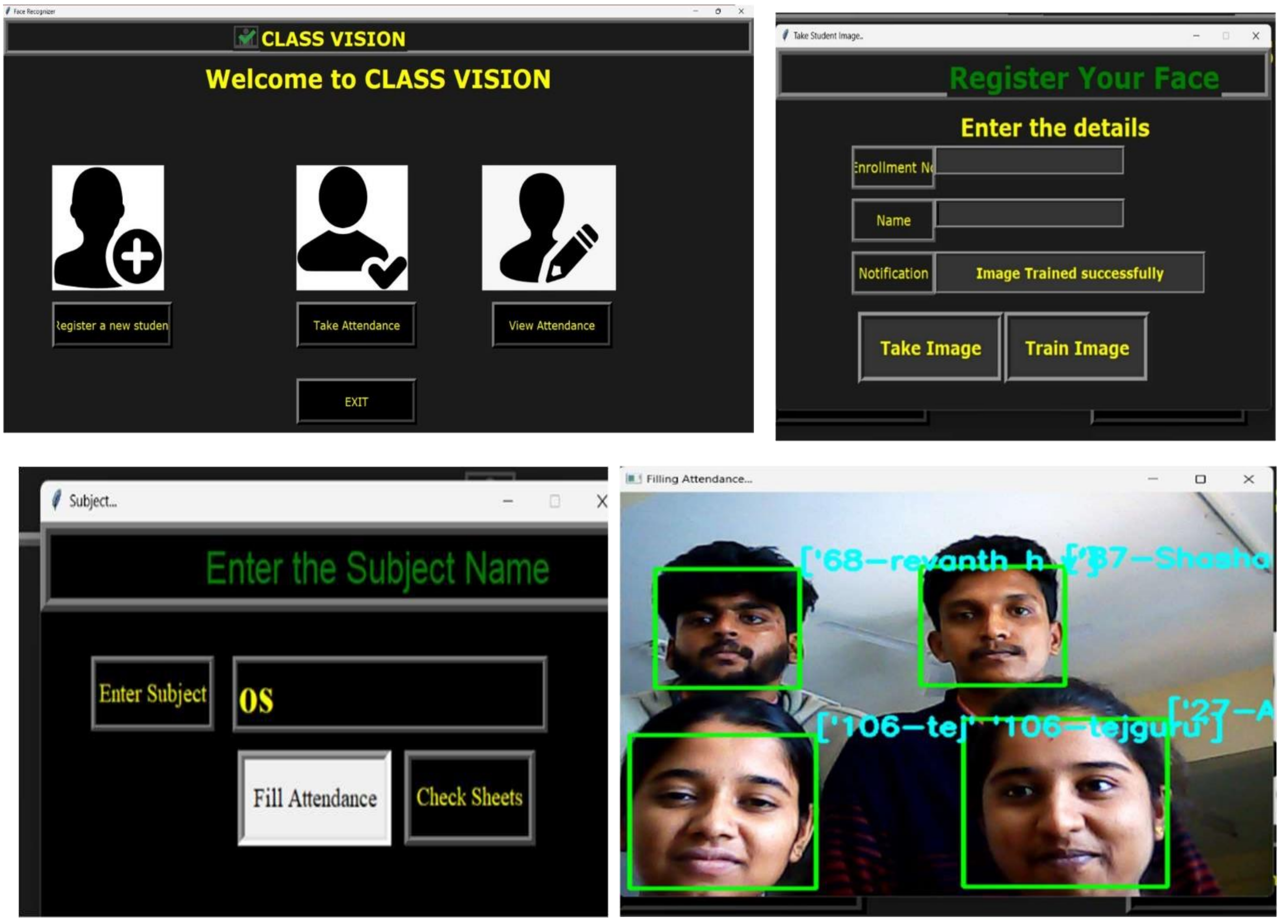

Fig 1. Student Registration and Attendence

Attendance of os

Enrollment	Name	2025-05-08	2025-05-09	Attendance
13	['pari']	1.0	0.0	50%
27	['Anu']	0.0	1.0	50%
45	['dhanuuuuuu']	0.0	1.0	50%

Fig 2. Result

7. CONCLUSION

The Student Attendance System Using AI successfully addresses the limitations of traditional attendance-taking methods by introducing a fast, secure, and automated solution powered by facial recognition technology. By utilizing Python, OpenCV, and Tkinter, the system combines real-time face detection and recognition with an intuitive graphical user interface, ensuring both high performance and ease of use.

Throughout the development and testing phases, the system demonstrated accurate student identification, reliable attendance logging, and responsive user interactions. Features such as manual attendance entry and text-to-speech feedback further enhance the system's usability, making it suitable even for non-technical users. The use of the LBPH (Local Binary Pattern Histogram) algorithm provided a lightweight and effective approach to real-time face recognition, achieving high accuracy without requiring extensive computational resources.

This project has proven that integrating artificial intelligence into everyday educational processes can significantly reduce manual effort, prevent errors, and improve operational efficiency. The modular design of the system allows for easy maintenance and future scalability. Overall, the project fulfills its core objectives and represents a meaningful step toward digitizing and automating routine classroom management tasks.

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