Smart Attendance: Automated Facial Recognition System

[1]Nilam Honmane, [2]Pranav Kadbane, [3]Sujal Hande, [4]Srushti Goyal, [5]Amit Jadhav
[1]Assistant Professor, [2345]Student
[12345]Information Technology,
[12345]Zeal College of Engineering and Research, Pune, India
[1]nilam.honmane@zealeducation.com , [2]pranavkadbane@gmail.com, [3]handesujal28@gmail.com, [4]srushtigoyal1308@gmail.com, [5]amitjadhav132003@gmail.com

Abstract:

Automating the process of attendance management is essential for enhancing efficiency and accuracy in educational and professional settings. Traditional methods such as manual roll calls, RFID-based tracking, or fingerprint scanning often introduce delays and are prone to errors and misuse, including proxy attendance. This paper presents the design and implementation of a facial recognition-based attendance system that provides a contactless, reliable, and automated solution. Utilizing computer vision and machine learning, the system captures real-time facial images, identifies individuals through face encoding, and records attendance without manual intervention. The application is built using Python, OpenCV, and the face recognition library powered by dlib's face recognition model. Experimental results demonstrate high recognition accuracy under standard lighting and environmental conditions. The system's modular design enables easy deployment in environments such as classrooms, corporate offices, and secure facilities. This paper explores the system's architecture, core functionalities, implementation methodology, encountered challenges, and potential areas for future enhancement.

Keywords: Face Recognition, Attendance Automation, Computer Vision, Machine Learning, Convolutional Neural Network, Real-Time Processing, OpenCV, LBPH, Haar Cascade.

Introduction:

Attendance tracking is a fundamental administrative activity in educational institutions and workplaces. Traditionally, attendance is recorded manually through roll calls or by using methods such as RFID cards and fingerprint scanners. While these approaches have served their purpose for decades, they present several challenges. Manual roll calls are time-consuming, especially in large classrooms or organizations, and are prone to errors such as incorrect marking, proxy attendance, or negligence. Similarly, fingerprint and RFID-based systems, though more automated, involve physical contact and are vulnerable to misuse such as card sharing or system tampering.

With the advancement of biometric technologies and artificial intelligence (AI), facial recognition has emerged as a powerful tool for identity verification. It provides a contactless, fast, and secure way to identify individuals by analysing their facial features. Unlike other biometrics, facial recognition does not require the user to touch any device or carry an external object like a card or badge, making it highly suitable for post-pandemic scenarios where hygiene and non-contact solutions are essential.

This paper proposes a facial recognition-based attendance system that automates the attendance process by identifying faces in real-time using a webcam and recording the presence of individuals in a structured database. The system uses machine learning algorithms and computer vision techniques implemented through Python, OpenCV, and the face recognition library. It eliminates the need for physical input devices, minimizes human errors, and ensures accuracy in identity verification.

The primary objective of this project is to create a reliable and efficient attendance tracking solution that can be deployed in classrooms, offices, and secure premises. The system is designed to be scalable, with provisions for dataset expansion, multi-user detection, and real-time logging. Moreover, it aims to contribute to the growing domain of intelligent automation systems that blend AI with real-world applications.

This paper provides a detailed description of the system's architecture, methodology, and implementation process. It also discusses the results obtained, the challenges faced during development, and possible directions for future enhancements.

Literature Review:

1. Facial Recognition-Based Attendance System (2024)

This paper presents an automated attendance management system powered by facial recognition. Utilizing Haar classifiers and Local Binary Pattern Histograms (LBPH), it ensures precise face detection and recognition, enabling a contactless attendance-tracking method. Developed with Python, OpenCV, and SQL, the system captures and processes facial images in real time to mark attendance. Results highlight its efficiency and high accuracy in identifying faces, enhancing both security and convenience. However, factors like camera quality, lighting conditions, and facial obstructions pose challenges, emphasizing the need for further improvements to enhance real-world applicability.

2. Smart Attendance System Using Face Recognition: A Machine Learning Approach (2024)

This paper presents an automated attendance system that leverages facial recognition and machine learning techniques. It utilizes Local Binary Pattern Histogram (LBPH) and Haar cascade algorithms for accurate face detection and recognition. A student image database is created, allowing the system to perform real-time identification and automatically mark attendance. The authors emphasize its potential to improve efficiency in educational institutions. However, challenges like lighting variations, face occlusions (e.g., glasses or hats), and dependence on high-quality images are acknowledged. Despite these limitations, the system greatly enhances attendance management by minimizing manual effort and errors.

3. A Survey on Face Recognition Based Attendance System (2024)

This paper explores various facial recognition techniques used in automated attendance systems. It employs Haar Cascade and Histogram of Oriented Gradients (HOG) algorithms for real-time face detection and recognition. These methods significantly enhance attendance accuracy and efficiency by minimizing manual effort. However, the paper also identifies challenges such as sensitivity to lighting conditions, facial obstructions, and the need for large datasets to ensure reliable performance. Further refinements are required to address real-world complexities like changing lighting, facial expressions, and orientations, ensuring the robustness of facial recognition-based attendance systems across diverse environments.

System Design and Architecture:

The proposed system is a real-time facial recognition-based attendance management system developed using Python, Streamlit for the frontend interface, and OpenCV for computer vision capabilities. It integrates user authentication, student registration, face detection and recognition, and attendance logging — all within a single, interactive web application.

1. Overview

The system consists of the following functional components:

1. User Authentication System
2. Student Registration and Image Capture
3. Face Training and Recognition Engine
4. Attendance Recording System
5. Attendance Viewing Interface

Each module is integrated through a web-based interface using Streamlit, ensuring simplicity and accessibility for both administrative users and operators.

2. User Authentication System

The system begins with a secure login/signup mechanism. New users can register through a signup form that stores their credentials (username and password) in a SQLite database. Returning users authenticate via login, and session states are managed through Streamlit's session state to control access to the main application features.

This ensures that only authorized personnel can access attendance functionalities like capturing or viewing attendance data.

3. Student Registration and Image Capture

In the "New User" section of the app, students are registered by capturing their face using a webcam. The face image is saved locally in a directory (/images) with the filename matching the student's name. This serves as the base dataset for training the face recognizer. The face capture process uses OpenCV's webcam input and allows manual control to capture or cancel via keyboard commands ('s' to save, 'q' to quit). This ensures clean, intended image acquisition.

4. Face Training and Recognition Engine

The system employs OpenCV's LBPH (Local Binary Patterns Histograms) face recognizer for facial identification. This recognizer is well-suited for real-time applications due to its speed and tolerance to lighting changes.

Training Process:

- Each saved image is read in grayscale mode.
- OpenCV's Haar Cascade is used to detect the face within the image.
- Detected faces are stored along with corresponding labels derived from the student name.
- The recognizer is then trained using these samples.

The train_recognizer() function compiles a mapping of student names to label IDs and returns the trained recognizer and name map.

Recognition Process:

During attendance capture, the webcam continuously reads video frames. Each frame is converted to grayscale, and Haar Cascade is used to detect faces. These detected faces are compared against the trained model, and if the prediction confidence is acceptable (below a defined threshold), the student's name is retrieved. Only newly recognized students for a session are recorded to avoid duplication.

5. Attendance Recording System

Attendance entries are recorded in a SQLite database. Each attendance record includes:

- Subject name
- Lecture type (e.g., theory or lab)
- Faculty name
- Timing
- Student name
- Date (auto-fetched using Python's datetime.now())

This structure supports both filtering and detailed attendance reporting.
The function record_attendance() inserts a new row into the attendance table only when a student is successfully identified and not already marked for the same session.

6. Attendance Viewing Interface

The "View Attendance" section allows users to retrieve attendance logs based on session parameters:

- Subject
- Lecture type
- Faculty
- Timing

The system queries the database for records matching the selected criteria and displays a list of student names who were marked present on that day.
This functionality enables easy verification and management of records.

7. System Flow

1. User logs in or signs up.
2. Admin registers students and captures facial images.
3. System trains face recognizer with existing images.
4. During class, admin selects subject/session info and captures attendance.
5. System detects and recognizes faces in real-time, marking attendance accordingly.
6. Admin can view attendance for any session directly from the UI.

8. Advantages of the System

- Fully contactless attendance process
- Real-time facial recognition through webcam
- Secure authentication with username/password login
- Efficient data storage using a lightweight SQLite backend
- Easy-to-use web interface built with Streamlit

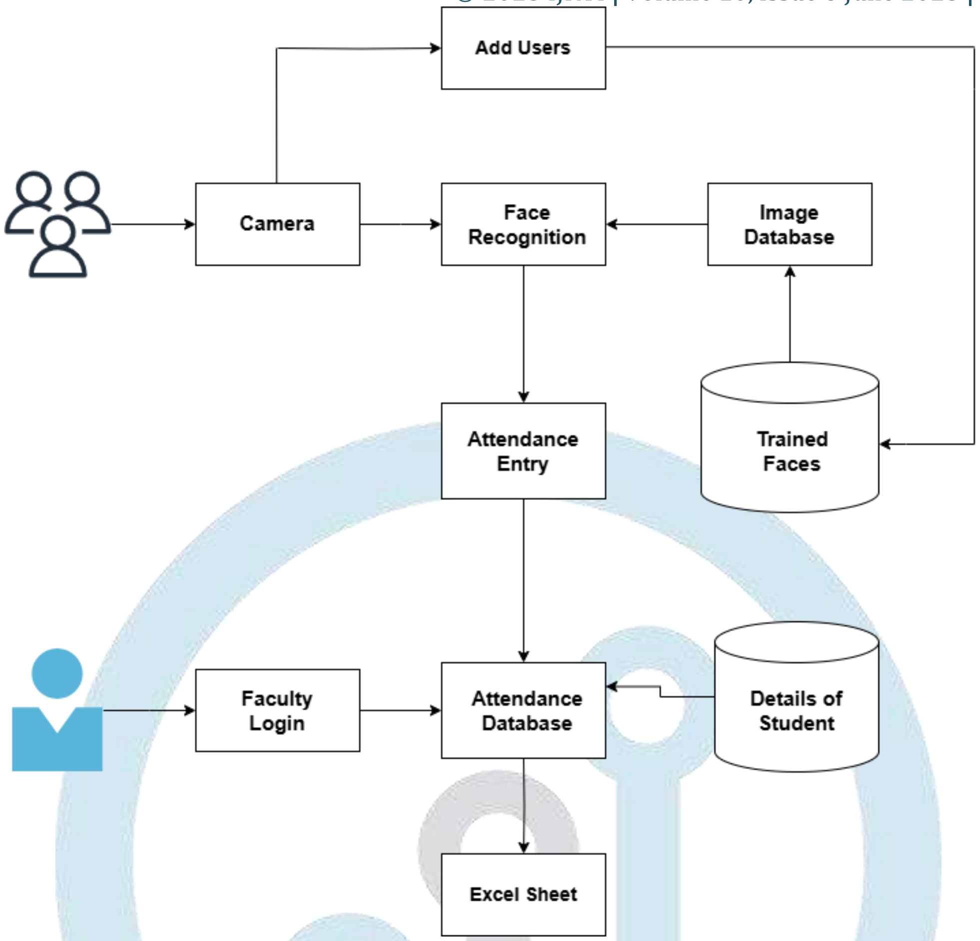

Figure 1: Facial Recognition Based Attendance System Workflow

Methodology:

The system is developed using an iterative approach and involves several core phases:

2.1 Data Collection

A dataset of facial images is created by capturing multiple photos of each user from different angles and lighting conditions. These images are labelled with the user's name or ID and stored for encoding. Each individual typically has 10–15 images in the dataset to ensure robustness in recognition.

2.2 Preprocessing

Captured images are resized and converted to RGB format as required by the face_recognition library. Preprocessing also includes normalization of brightness and contrast to improve detection in varying light conditions.

2.3 Face Detection

Using Haar Cascade classifiers or HOG-based detection, the system identifies face locations in video frames. Each frame from the webcam feed is scanned for facial regions, and the bounding box coordinates are recorded.

2.4 Feature Extraction and Encoding

The face recognition library generates 128-dimensional facial embeddings for every known face in the dataset. During runtime, detected faces are also encoded and compared with the known encodings using Euclidean distance.

2.5 Face Recognition and Matching

If the distance between a detected face and a known encoding is below a threshold (typically 0.6), the system identifies the user. The name is then displayed on-screen and the attendance log is updated.

2.6 Attendance Logging

Once a person is identified, their name and timestamp are recorded in a CSV file or stored in a database. Duplicate entries are avoided by checking if the individual has already been marked present on the same day.

Result:

The system was tested with a dataset of 30 users in varied conditions (indoor lighting, daylight, slight head tilts). The performance was measured based on accuracy, speed, and robustness.

Performance Metrics:

- Recognition Accuracy: ~95% under good lighting
- False Positives: 1–2% with untrained faces
- Response Time: ~1.2 seconds per frame on standard laptop (i5 CPU, 8GB RAM)

Observations:

- Frontal and slightly tilted faces were detected successfully.
- The system struggled with masked faces or partial occlusions.
- Repeated detection of the same face was avoided through cooldown timers.

Screenshots/Outputs:

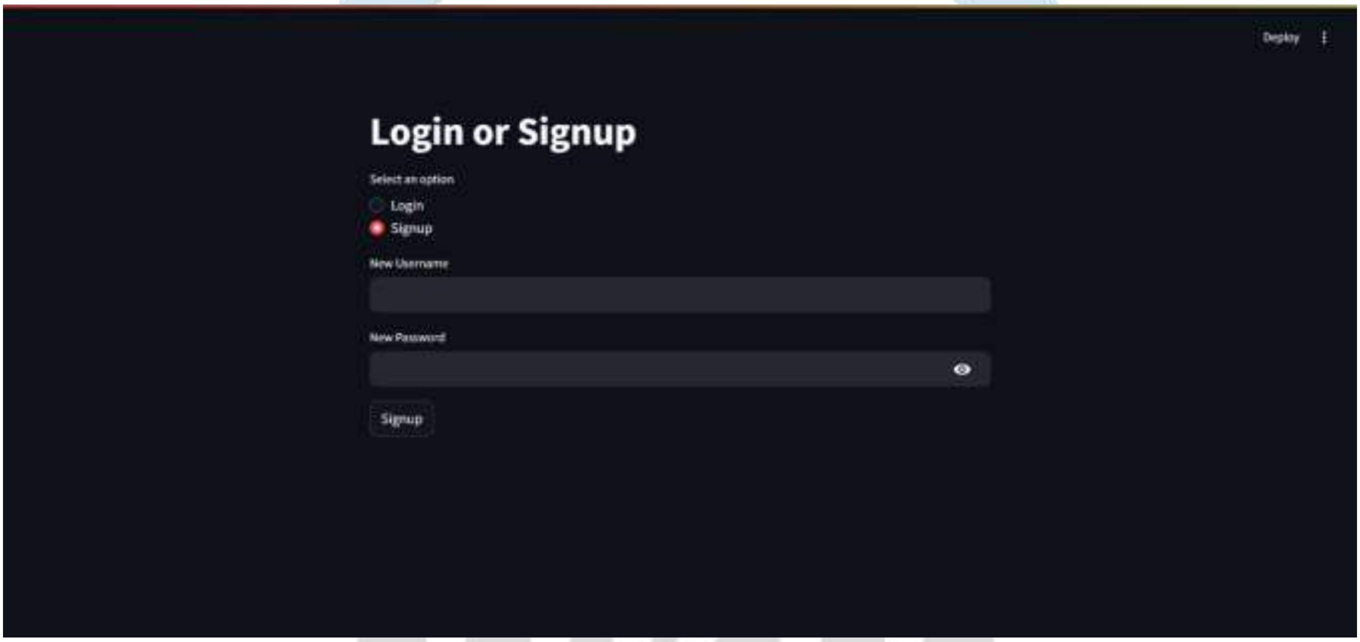

Figure 2: Interface For Faculty Signup / Login

Figure 3: Interface For New User Registration

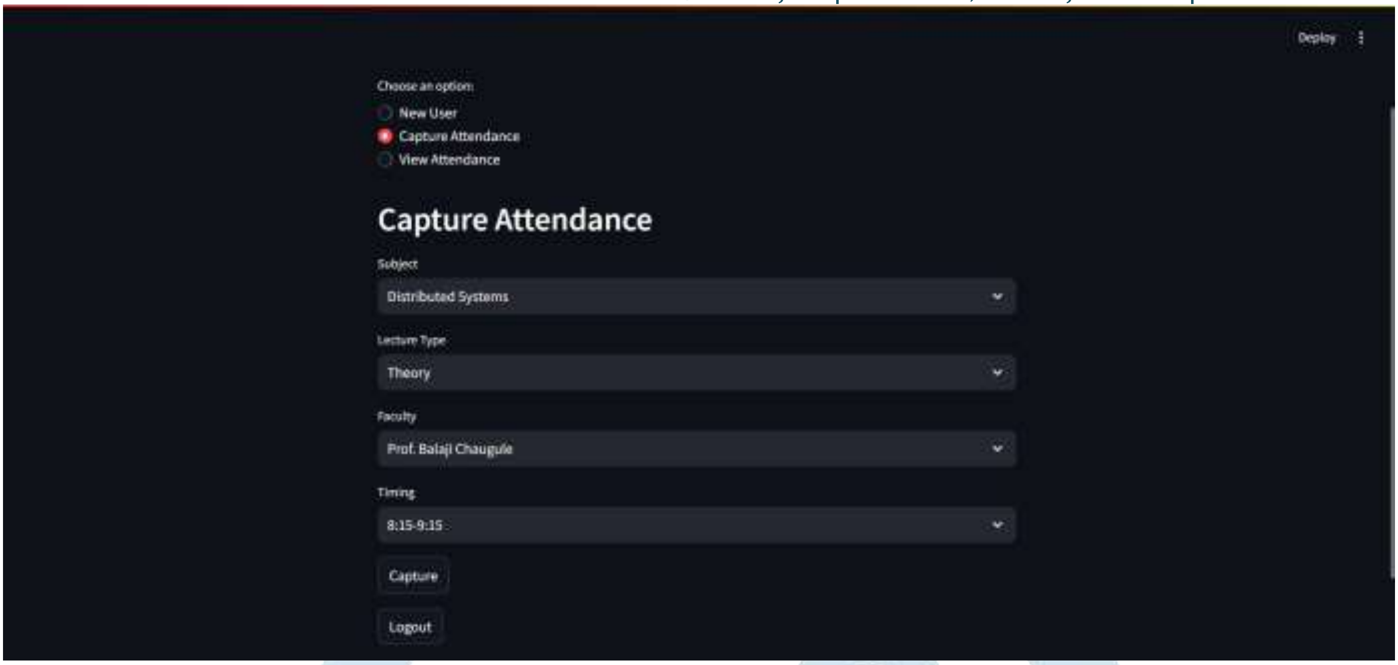

Figure 4: Interface For Capturing Attendance for a Particular Lecture

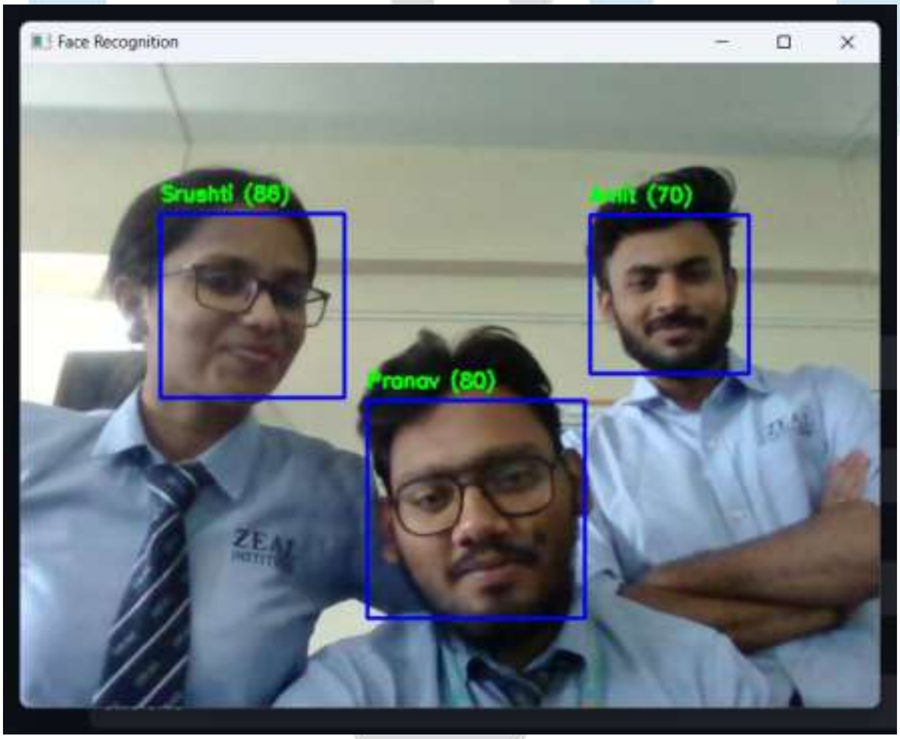

Figure 5: Live Camera Feed Showing Detected Faces with Labels

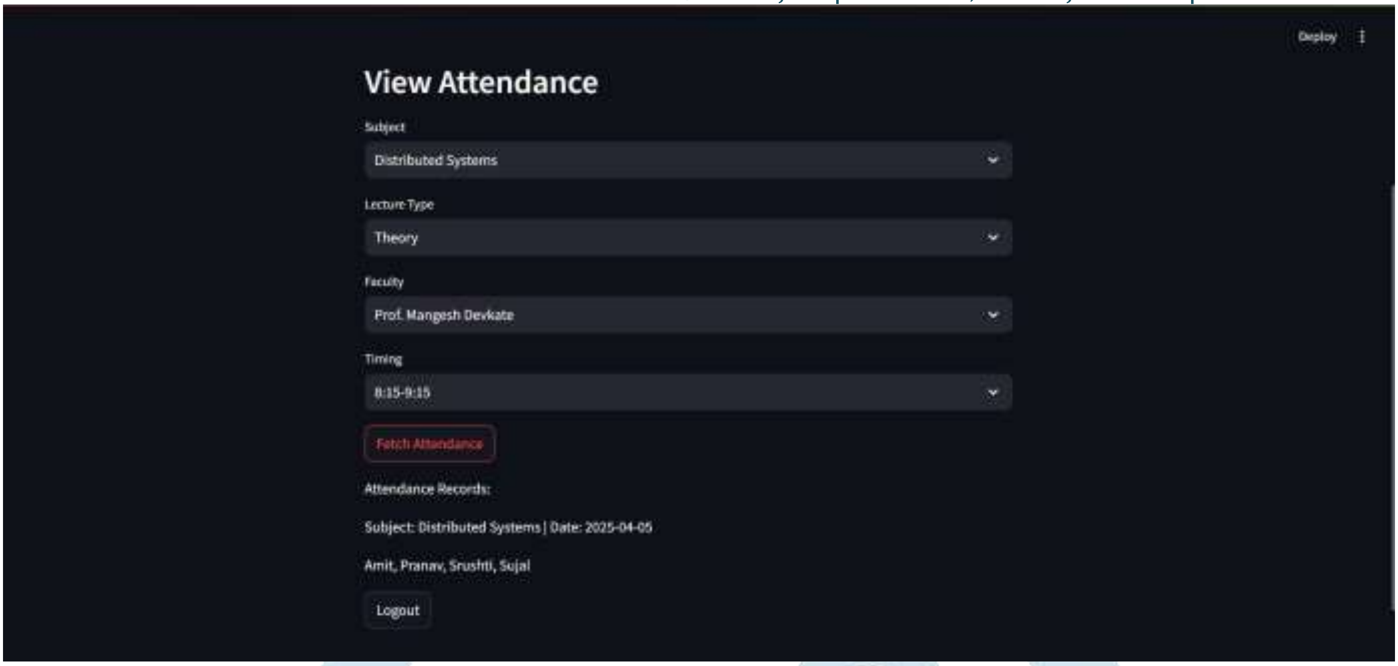

Figure 6: Interface For Viewing the Captured Attendance for a Particular Lecture

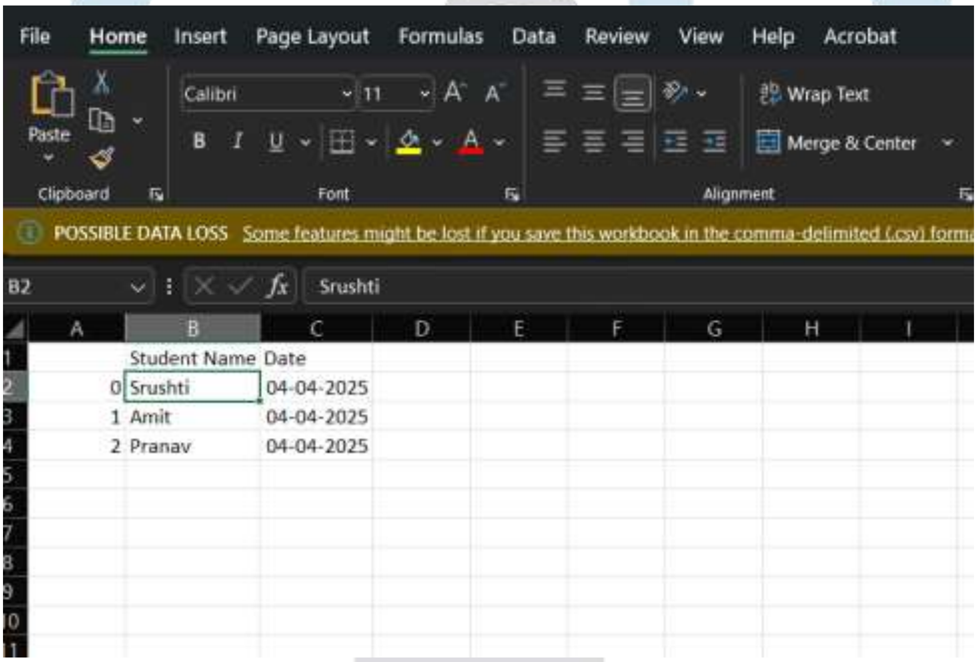

Figure 7: Attendance Excel File with Timestamped Entries

Conclusion:

The implementation of a facial recognition-based attendance system marks a significant step toward the automation of routine administrative processes using artificial intelligence and computer vision. The proposed system effectively addresses many limitations inherent in traditional attendance systems, such as manual entry errors, proxy attendance, and the need for physical contact through biometric devices. By leveraging Python, OpenCV, and the face_recognition library, the developed solution provides a contactless, real-time, and user-friendly method of recording attendance.

Throughout the development and testing of the system, it has demonstrated high recognition accuracy under well-lit and controlled environments. The attendance marking process is executed automatically once a face is recognized, with entries stored in a structured format that can easily be accessed or analyzed. Moreover, the modular architecture of the system allows for straightforward maintenance, updates, and future scalability.

The system not only improves operational efficiency but also enhances security and hygiene—critical aspects in modern educational and workplace settings. It also lays the foundation for more sophisticated biometric-based solutions by introducing machine learning into practical, everyday applications.

In conclusion, this facial recognition attendance system presents a viable and cost-effective alternative to conventional methods. It has the potential to be deployed in various real-world environments such as schools, colleges, corporate offices, and secure facilities, where accurate and tamper-proof attendance tracking is required. With further development and integration of advanced features like cloud connectivity, liveness detection, and mobile access, the system can be transformed into a fully-fledged smart attendance platform.

Future Work:

The following enhancements are planned for future versions of the system:

- Cloud Integration: Store attendance data in cloud databases for remote access and analytics.
- Mobile App Support: Develop a cross-platform mobile app for user-side notifications and admin monitoring.
- Liveness Detection: Implement real-time checks to detect spoofing using photos or videos.
- Facial Mask Detection: Add support for recognizing faces with masks using deep learning models.
- Voice or OTP-Based Verification: Combine facial recognition with voice biometrics or OTP for multi-factor authentication.
- Large-Scale Deployment: Pilot the system in real classrooms or offices to evaluate scalability and usability in real-time environments.

References:

[1] Golasangi A., Choudri M., Bulla P., & Devaraddi V. (2024). A Survey on Face Recognition Based Attendance System. International Journal of Research in Engineering, Science and Management, 7(2), 15-18

[2] Siddiqui M. H., Pednekar H., Sakat P., Qadir Q. A., & Manke P. (2024). Facial Recognition-Based Attendance System. Vasant dada Patil Pratishthan's College of Engineering. https://doi.org/10.13140/RG.2.2.20991.21921

[3] Gupta V., Kashyap M., Gupta V., & Singh P. (2024). Smart Attendance System Using Face Recognition: A Machine Learning Approach. International Journal of Research Publication and Reviews, 5(3), 932-939. https://doi.org/10.55248/gengpi.5.0324.0634

[4] Joshi S., Shinde S., Shinde P., Sagar N., & Rathod S. (2023). Facial Recognition Attendance System using Machine Learning and Deep Learning. International Journal of Engineering Research & Technology (IJERT), 12(04). https://www.ijert.org

[5] Gupta S., Jain V., & Bhat V. A. (2023). Next-generation attendance tracking: Automated face detection for lecture attendance. Multidisciplinary Science Journal, 5(e2023ss0309), Supplementary Issue: Management (3rd ICAKMPET, 2023). DOI: 10.31893/multiscience.2023ss0309. Published Online: August 29, 2023.

[6] Bhagat S., Kashkari V., Srivastava S., & Sharma A. (2022). Face Recognition Attendance System. International Journal for Research in Applied Science & Engineering Technology (IJRASET), 10(1), 280-283. https://doi.org/10.22214/ijraset.2022.39702

[7] Ashritha K., Yuktha K., & Bhukya S. (2022). Automated Attendance System Using Face Recognition. International Journal for Research in Applied Science & Engineering Technology (IJRASET), 10(6), 2096-2099. https://doi.org/10.22214/ijraset.2022.44212

[8] Soundarya S., Ashwini P., Rucha W., & Gaurav K. (2021). A Review Paper on Attendance Management System Using Face Recognition. International Journal of Creative Research Thoughts (IJCRT), 9(11), 63-68. https://doi.org/10.2021/IJCRT

[9] Gowda D. H. L., Vishal K., Dubey N. K., & M. R. P. (2020). Face Recognition Based Attendance System. International Journal of Engineering Research & Technology (IJERT), Vol. 9, Issue 06, June 2020. Available at: http://www.ijert.org

[10] Smitha Hegde, P. S., & Afshin. (2020). Face Recognition Based Attendance Management System. International Journal of Engineering Research & Technology (IJERT), 9(5), 1190–1192. https://www.ijert.org