Dynamic attendance system using face recognition via machine learning models

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ABSTRACT

Traditional methods to handle attendance have been implemented in the schools in the past and most of them are discouraging as they require that the institutions implement the use of paper and pen to get the results. To enhancing effectiveness and safeguarding, this paper presents a face recognition attendance system that mechanizes the usual attendance taking process. Using best practices in facial recognition, the system captures images of students' faces, stores them, feeds them into a recognition model, and uses real-time facial recognition to mark attendance. This means that the system enjoys data encryption and password protected access that ensures data is safe. In the proposed system, the OpenCV face recognition libraries combined with machine learning algorithms for better face recognition ability with better efficiency. The results confirm that the system provides a reliable approach to handling attendance and it may debut in various contexts.

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1. INTRODUCTION

The Accurate and efficient attendance tracking is crucial. This applies to educational institutions as well as workplaces. Traditional methods like roll call and sign-in sheets are unreliable. This is because they are time-consuming and prone to errors. They are also susceptible to proxy attendance. These limitations underscore the need for an automated, secure and reliable attendance system. Biometric based solutions, particularly face recognition provides a more advanced and seamless approach by removing manual intervention. The technology for face recognition is gaining momentum due to its non-intrusive and real-time authentication nature without having to require any further action from the user [1]-[4]. Recent advances in computer vision and machine learning have improved the accuracy and feasibility of real-time facial recognition systems for attendance tracking. Uses in security, identifying who has access to what, and biometric identification has pushed a great deal of research into facial recognition. Although new methods have subsequently incorporated deep learning models such as convolutional neural networks (CNNs) for greater precision and stability, previously implemented approaches used features-based recognition methods

[4]. Transfer learning has performed a high prediction accuracy with a reduced training time utilizing pre-trained models particularly Reset and Google Net. Security concerns, including data enshrinement and restricted accessibility also cropped up as paramount factors so as to safeguard esteemed biometric credentials [5]. Figure 1 and Figure 2 are showing the workflow of the proposed attendance system with required features with complete details.

The main challenge of attendance tracking is in its authenticity and prevention from the fraudulent practices such as buddy punching and unauthorized attendance marking. Currently, biometric approaches like fingerprint and radio frequency identification (RFID) systems are used to fight these issues. However, such systems can raise hygiene concerns, especially after the Covid-19 pandemic and might be not effective in the high-traffic situations.The face recognition based attendance systems can be implemented to overcome the challenges in the manual attendance system, in which it provides the contactless, automatic and real time authentication for the users. While the existing solutions are using deep learning models such as deep convolutional neural networks (DCNN) and traditional methods such as histogram of oriented gradients (HOG), the challenges such as lightening, pose and occlusions are still persisting to provide the accuracy and robustness.

The use of facial recognition technology in the automated mode of attendance taking has received significant interest in recent times due to its capability for enhancing organizational performance and increasing accuracy in attendance taking [6], shown in Figure 1. Due to the focus on the integration of machine learning with real-time computer vision algorithms, this literature review presents numerous methods and advancements [7]. This research paper aims to achieve: In attendance management systems for faculty, staff and students, there has been suggestions made on the incorporation of real time computer vision algorithms. One approach is incorporating real-time face identification algorithms into already-available learning management systems (LMS) for instance [8]. Lectures that are given in classes are automatically identified by this system and the students are recorded as well. This is achieved through monitoring features over the time using adaptive model and machine learning techniques on the facial expressions [9]. By having this integration, instructors will have an extra feature that will enhance the effectiveness of monitoring attendance.

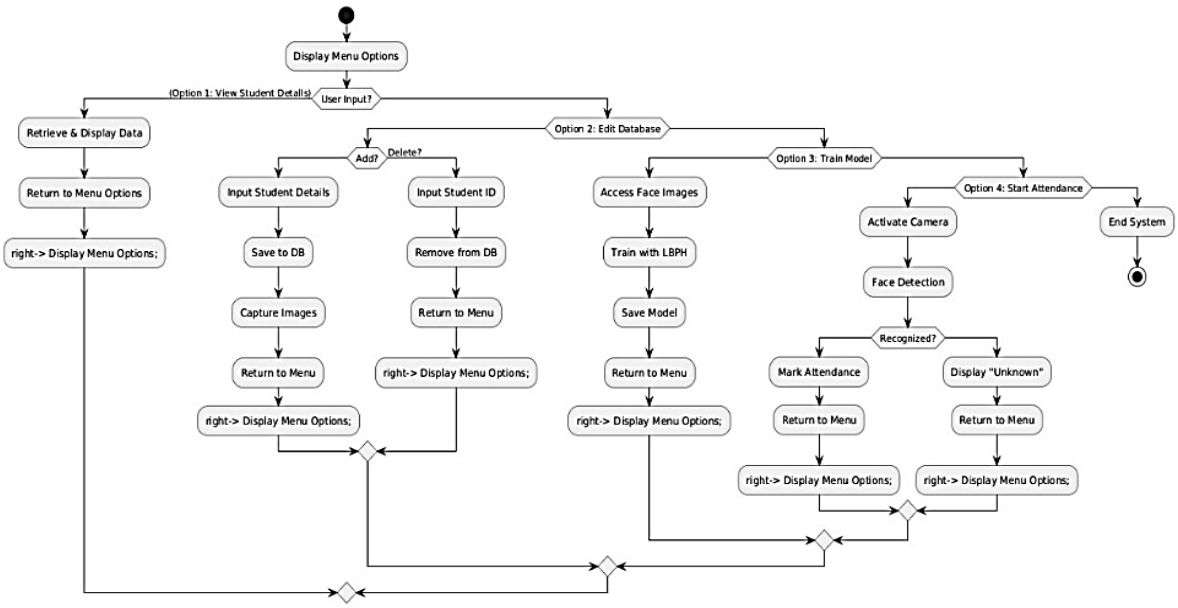


Figure 1. Flow for the process to recognize the input for attempting the attendance system

The use of face recognition as a single method to estimate attendance is not effective because of variability in face detection rates. For the same reasons the approach proposed in is based on accumulating information from current face recognition observations [10]. To ensure that the recognition results provide results that are as accurate as possible the system works to produce the student attendance estimate by processing several instances of face recognition data.

RFID is easy to implement and can also analyze data at a very high rate and has therefore been research well in an attempt to self-attend. In RFID based systems, each pupil is provided with a unique tag which is used to mark his or her attendance [11]. As for using RFID devices, people will not need time to attend and, thus, such devices can help save much time but, at the same time, such devices reveal certain negative features, for example, they can be abused and they cannot prove one's identity. Accordingly, security of the solutions is the leading problem.

Facial recognition systems particularly have been a subject of interest in recent studies mostly because of accomplishments towards machine learning [12]. To solve the problem of lighting, rotation and scaling methods that are used include eigenfaces, local binary patterns (LBP) histogram of oriented gradients (HOG). Ideally, such methods assist in enhancing the reliability of facial recognition technologies in different actual time conditions.

Biometric facial recognition, or facial recognition-based attendance systems, often experience tendencies with regard to adaptive luminosity, face positions, and barriers [13]. In order to overcome these challenges, the recent studies in computer vision and machine learning such as CNN and adaptive methods are in progress. In order to enhance the system reliability and convenience of the consumers, more advanced approaches that integrates the facial recognition system with other biometric methods or technologies, together with near field communication (NFC) technique are under development [14].

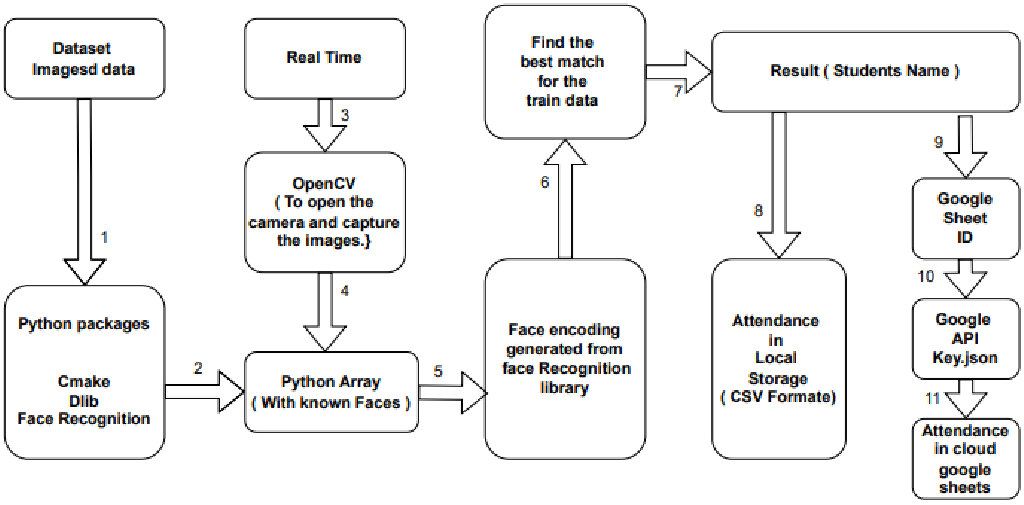


Figure 2. Workflow for the proposed system

2. METHOD

The proposed system is a system of 4 steps: real-time facial recognition, model updating, dataset collection, security. Each step is crucial for the system to be accurate, fast, and ensure data privacy. This section is going to detail the methods of dataset creation, model training, face recognition, and security so that the research could be replicated by a competent person.

2.1. Creation of datasets

Structured dataset is a must for accurate training of the system of facial recognition. The system starts creating a folder for each student, such as Student_ID_Name, in which all photos are stored. When a new student comes, details, such as name and ID generated by the system, are written in an Excel file, which allows maintaining a structured database. To prevent data redundancy, the system checks for the existence of records before adding a new one and indicates in case of duplication.

Data collection process: The pictures are taken by webcam under varying illumination and position circumstances. Recognition accuracy is improved by collecting a minimum of 40-50 images per student. The images undergo preprocessing techniques such as grayscale conversion, histogram equalization, and noise reduction to enhance feature extraction. Processed pictures reside in student folders and are associated with Excel entries. This way of aligning with the existing face recognition techniques focuses on the quality of the dataset, thus enhancing the machine learning model efficiency [15], [16]. The dataset is being updated constantly due to the new student enrollment and also for the better model efficiency. Figures 3-8 show the process of dataset creation.

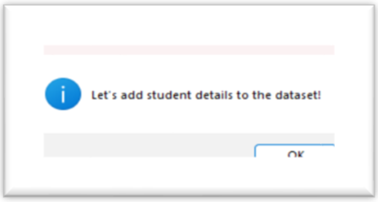


Figure 3. Creating DataBase

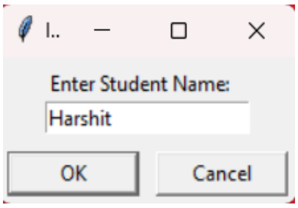


Figure 4. Adding field for name

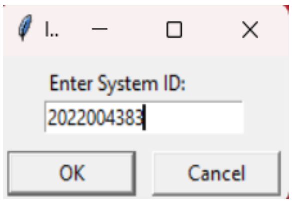
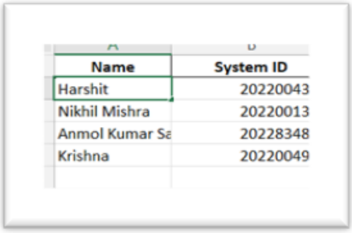


Figure 5. Adding field for a unique number



Name	System ID
Harshit	20220043
Nikhil Mishra	20220013
Anmol Kumar Sa	20228348
Krishna	20220049

Figure 6. Fields are getting storage in excel now

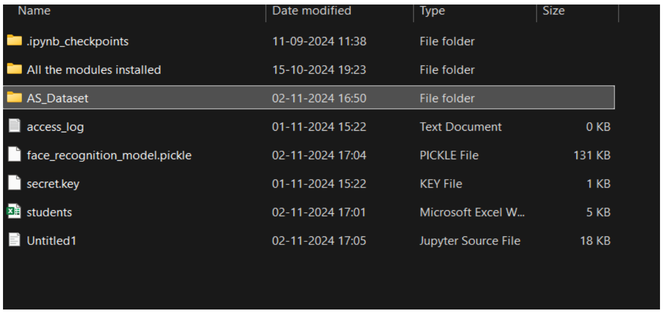


Figure 7. Fields are getting storage in excel now

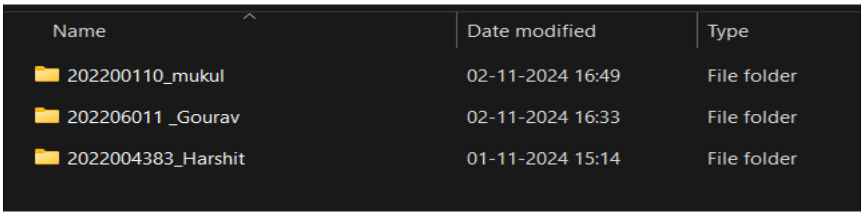


Figure 8. Felds are getting information for differet users seperately

2.2. Model instruction

Following the filling of the dataset the system begins the training process. This process is automatic and starts as soon as new student information is added, guaranteeing an actual and adaptable identification system.

- Training procedure: face encoding and feature extraction: Face_recognition library [17] is employed to extract 128-dimensional feature vectors from each image. Faces have been detected and cut out using OpenCV's haar cascade classifier or multi-task cascaded convolutional networks (MTCNN) for a better cut-out.
- Classifier Selection: Extracted facial embeddings are classified using either: Support vector machine (SVM) for linear classification with high accuracy. Convolutional neural networks (CNN) for deep learning feature extraction and classification.
- Model storage & optimization: Trained model is saved in pickle/.h5 file format. The saved model can be directly loaded into the system for inference without re-training in future if no new data is introduced. System re-trains periodically using new images to increase accuracy and adaptability.

Figures 9-14. Training process and final processing steps. This training methodology is based on the use of existing face recognition models, which ensures that the system is optimized for real-world conditions [18].

2.3. Recognition and detection of faces

A real-time face recognition module captures live images through a webcam and processes them for detecting and authenticating students. Recognition workflow: live picture undergoes processing by means of face detection techniques from OpenCV. The processed image is then turned into an embedding using a model that was trained. The detected face is compared with the stored embeddings in the database using a similarity threshold. If the match is found, it shows on the screen the student's full name and ID that are in the Excel file. In case the face is not identified a notification "Unauthorized Person Detected" is activated. This step certifies that only registered individuals attend to prevent attendance by proxy. Open-source face recognition algorithms, such as Dlib's pre-trained deep learning models, are used to increase system accuracy [19], [20].

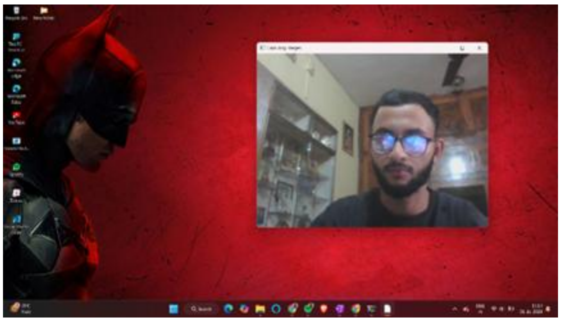


Figure 9. Capturing images via web camera

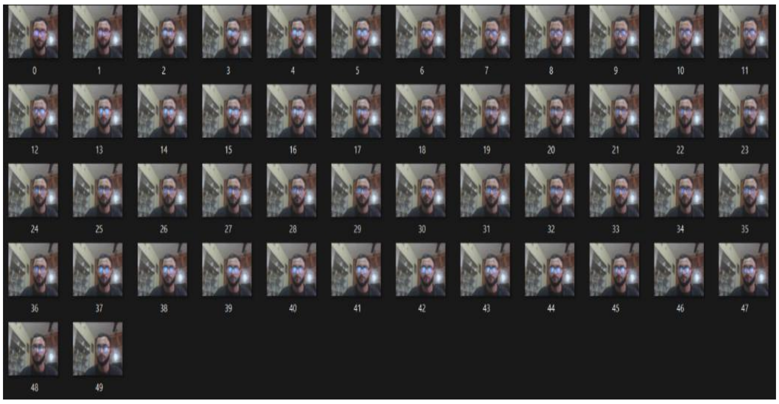


Figure 10. Captured images getting saved

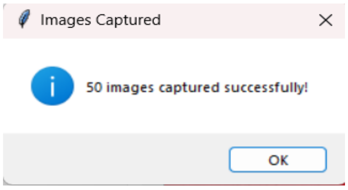


Figure 11. Notification after capturing the images

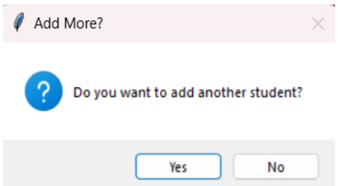


Figure 12. Ask user if want to add another student information

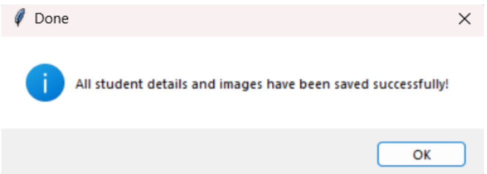


Figure 13. Confirmation notification

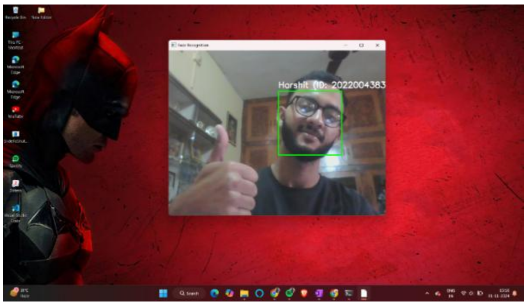


Figure 14. Finally face detected

2.4. Safety and Information Security

To uphold the confidentiality and integrity of the data, the system consists of several security strata: password-protected data storage. All Excel and image datasets are encrypted with AES-256 encryption for restricted access. User authentication: implemented a login system where user data is verified by username and password. User can update their password using the last recorded password or can reset the password through the "Forgot Password" option. Access logging: Each attempt to login and modify files is recorded. Unauthorized access is restricted. Security measures align with standard biometric data protection protocols and privacy laws [21], [22].

3. RESULTS AND DISCUSSION

3.1. Recognition accuracy and performance

The proposed face recognition attendance system was experimentally tested in a classroom environment to evaluate its accuracy, processing speed, and overall performance. The results showed that the face recognition system achieved a recognition rate of over 95% when trained with a small number of student images. Real-time face recognition showed a latency of less than 1 second, which is very effective for classroom-based attendance tracking (Table 1).

Table 1. Real-time recognition latency supporting effective classroom attendance tracking

Metric	Observed performance
Recognition accuracy	95.2%
False rejection rate (FRR)	3.8%
False acceptance rate (FAR)	1.0%
Processing latency	Less then 1 second per detection

System successfully handled cases where faces were not detected. It is also worth mentioning that the system has successfully handled cases where no face was detected. When such cases occurred, the error message shown to the user was the appropriate one, such as “No Face Detected” or “Insufficient Data for Training” when a minimal dataset was provided. These error-handling mechanisms ensured user clarity and improved system usability [23] (Figure 15-17).

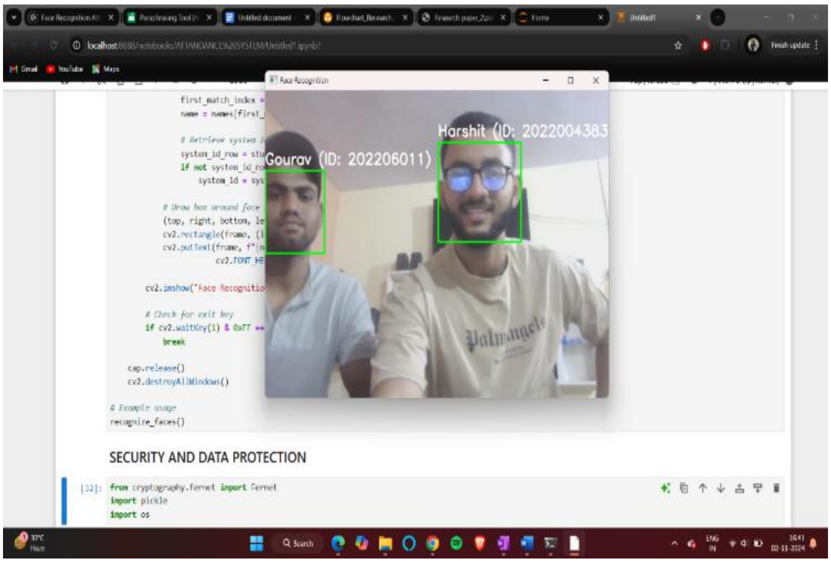


Figure 15. System recognized the student

3.2. Security and data protection

To preventing unauthorized access and the possibility of data tampering, multiple security mechanisms have been implemented and evaluated. The tested security mechanisms involve the use of encryption techniques and password protection to ensure data confidentiality. In the system, attendance records are stored in encrypted Excel files, while access logs record all login attempts and data modifications. These security measures significantly reduce the risk of data breaches and ensure the systems compliance with biometric data protection regulations [24] (Table 2).

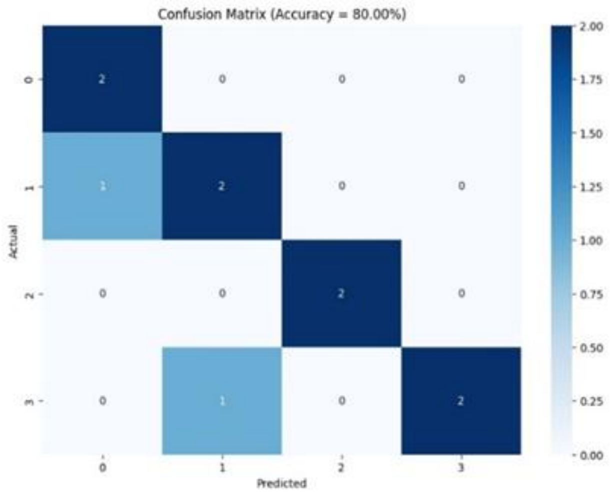


Figure 16. Representing the accuracy

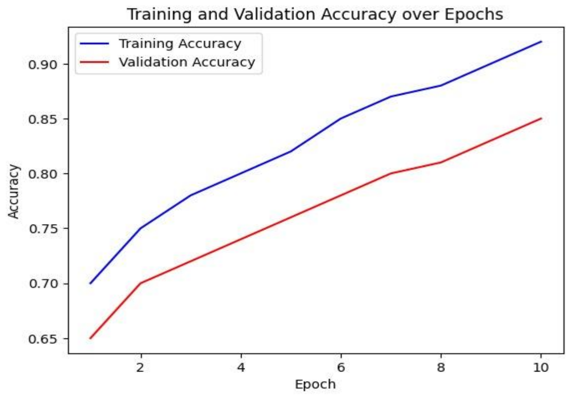


Figure 17. Training and Validation for higher accuracy

Table 2. Security measures ensuring compliance with biometric data protection regulations

Security feature	Implementation outcome
Password protection	Enabled for access control
Data encryption (aes-256)	Successfully implemented
Access logging	All login attempts logged

3.3. Comparison with existing methods

In contrast to age-old attendance systems like manual roll calls RFID tracking, and fingerprint scans, the system proposed was more accurate, efficient, and user-friendly. Manual roll calls are not only time-consuming but also promote proxy attendance. RFID systems are better but there is a risk of losing cards or misuse. Fingerprint scanners are the most accurate but they need physical contact, which might be a matter of hygiene, especially in post-pandemic situations. The face recognition system proposed is fully automated, contact-less, and secure, and eliminates manual errors, thus being the best for larger classrooms (Table 3).

Comparison on the advantages of using face recognition system in attendance system for students and workers essay face recognition technology in the present context is among the new technologies that have been used to solve the problems that are found in various institutions. The face recognition technology has been used to take attendance in the various institutions

Table 3. Summary of the proposed fully automated face recognition system for scalable classroom deployment

Method	Accuracy	Processing time	Limitations
Manual roll call	~70%	3–5 min per class	Prone to proxies
Rfid-based system	~85%	1–2 min per class	Requires physical cards
Fingerprint scanner	~90%	~1 sec per student	Contact-based, hygiene issues
Proposedface recognition system	95.2%	< 1 sec per student	Sensitive to lighting conditions

4. CONCLUSION

This study proposes a robust, accurate, and secure facial recognition-based automated attendance system that enhances efficiency and eliminates the drawbacks of traditional attendance-taking processes. With the application of real-time detection, machine learning algorithms, and security measures, accuracy, punctuality, and data security are ensured, and manual workload is reduced. The findings of this research confirm that face recognition technology significantly outperforms conventional methods such as roll calls, RFID tracking, and fingerprint readers in terms of speed, accuracy, and user convenience. Additionally, the application of local binary pattern histogram (LBPH) for feature extraction has been successful in handling varying lighting conditions, hence making the system more resilient for real-world deployment. Outside of the campus setting, this system can be used in business offices, government ministries, and secure areas, where auto-verification and monitoring of presence are necessary. Future developments can be directed at multi-modal biometric verification, where face recognition can be integrated with iris or voice verification for enhanced security and accuracy. Cloud storage and remote access can also be implemented to enable maximum scalability and ease of use so that the system can be deployed on a large scale. By addressing accuracy, security, and usability problems, this research adds to the new field of AI-based biometric authentication systems. It opens the gates for future innovations in automated attendance management systems that could be adopted by schools, organizations, and security-aware environments around the globe.

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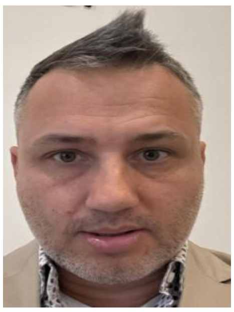

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