DESIGN AND IMPLEMENTATION OF AN AUTOMATED ATTENDANCE SYSTEM USING FACE RECOGNITION TECHNOLOGY

By

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for the degree of
Master of Science
in
Data Science

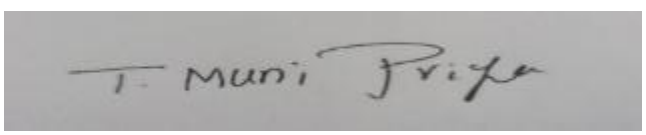
Declaration

I hereby certify that this report constitutes my own work, that where the language of others is used, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of others.

I declare that this report describes the original work that has not been previously presented for the award of any other degree of any other institution.

MUNI PRIYA THIRUMALASETTY

04-08-2025



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Abstract

This dissertation gives the design and implementation of an O/F, Image-based face recognition attendance system constructed on Python and Tkinter. The main goal was to make the classroom attendance automated and easy by allowing the faculty to load static images on the local storage that can be recognized and logged. Applying face encoding algorithms and a similarity tolerance criterion that used Euclidean distance measure, the system has been found to execute a recognition crowd of 90 percent in controlled tests. The user interface has been made easy to navigate as it provides real-time information, upload status, and pop-up messages. Its core abilities are data privacy using offline capability, strong resilience at face matching level, and adaptable to use by institutions. Although the results indicated by the prototype tested as part of a limited dataset are promising, further directions are to be found in extending the dataset and enlarging it, test it with real-time capturing, and liveness detection. There were considerations made in the ethical aspect, and the use of facial data was responsible. All in all, the system provides an efficient, scalable and privacy-aware way to measure attendance as opposed to the traditional manual or cloud-based way to do this.

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Chapter 1 Introduction

1.1 Problem Description, Context, and Motivation

Tracking of attendance has always been a slow and cumbersome activity, being done manually with physical as well as login registers that have the potential of being manipulated or misused with a lot of ease. It was noted that, in schools, the manual procedure is more time-consuming and inaccurate, as well as unreliable, since it consumes highly valued instructional time. Appropriate attendance misreporting or deliberate attendance misreporting is an ongoing issue. The necessity of a more comprehensive, efficient, and contactless way of keeping track of attendance drove the push behind this project, especially in the post-pandemic world, where avoiding close contact has become a health concern. Face recognition has a potential solution to this problem in the education technology scenario (Dang and T.V, 2023). This study proposes a system that employs face recognition using images in order to check and record the presence of the students. The implementation removes any manual intervention involved, increases the data credibility, and also assures that the attendance records cannot be duplicated by users since the records are identified by means of a biometric verification. The suggested method will use a database of photos of facial images of registered students, which will be stored in a specific folder. In case of uploading a new image, the system matches the facial features in the uploaded image against the dataset saved to identify the person.

1.2 Aim and Objectives

Aim

The main aim of this study is to design and implement an automated, image-based facial recognition system for student attendance that accurately identifies individuals from a pre-registered image dataset, records their presence in real time, and securely logs the attendance data into a structured CSV file.

Objectives

- To build a face recognition system capable of identifying individuals using static image input.
- To implement a comparison mechanism that determines whether the input face image matches any of the stored images.
- To automatically record attendance into a CSV file upon successful verification.

- To provide a real-time message if the individual is not found in the dataset.
- To evaluate the system's accuracy, speed, and effectiveness in real-time classroom conditions.

1.3 Methodology

The study methodology that will be introduced in this work will be carried out through the integration of Python, OpenCV, and a face recognition library based on deep learning. First, a set will be created consisting of ten pictures of the personalities of distinct classmates, and the pictures will be saved in a separate folder. These photographs will serve as the training data set for the recognition system. All image files will be processed, where the features of faces will be detected and represented in the form of a pre-trained deep learning model. When a new image is posted via the user interface, it will also be encoded similarly and compared to the encodings that are stored in order to determine a match (Dang and T.V, 2023). In case a similar face is detected, the system will automatically store the name of the student under the current timestamp in a CSV file, thus marking the attendance. When no match occurs, the system will send a message that the student is not found in the records of the class. On testing, it is expected that the system will be more accurate when fed with clear high-resolution pictures under adequate lighting conditions, which will justify that the model is reliable and robust.

1.4 Legal, Social, Ethical, and Professional Considerations

There are a variety of legal, ethical, and social implications to facial recognition systems, which will be explored in depth in this study. Biometric detail like facial images is considered sensitive personal information under data protection laws, including the European GDPR and India’s Information Technology Act. These should guarantee informed consent from all study subjects, and all data is processed locally and not shared with the outside, keeping users’ privacy. Ethically, the system's architecture should not enable abuse, such as claiming someone is present unless that person is registered, and hence reducing false positives. Professionally, the system will be based on fairness, transparency, and accountability. A balanced collection of data will help determine bias and ensure fair coverage over demographics. The logic and code will be well documented to facilitate replicability and auditability. In general, the system will follow the privacy standards and engineering ethics, providing an efficient, secure, and responsible attendance management system.

1.5 Background

Over the past few years, face recognition technology has made a steep transition, and the field was very primitive with the use of simple geometric models and has depended upon deep learning models, which provide high accuracy. Evidence has supported the fact that face recognition systems, particularly those deployed through Convolutional Neural Networks (CNNs), have been promising in identity verification programs. The main idea behind it is to come up with distinctive facial features and represent them in the form of a vector embedding, and make a match based on similarity. The topic has been documented in initial literature where old techniques of face detection, like the Haar Cascade classifier, have been removed in favor of deep learning frameworks like FaceNet and Dlib. These models give more precision and generality to different lighting and orientations (Anshari *et al.* 2021). Past experiments and projects have demonstrated the feasibility of facial recognition when considering the aspects of security and attendance systems. The statistics indicate that schools which implemented the use of biometrics as a method of attendance recordings witnessed accuracy levels and instances of fraudulent encroachment. The current systems are however either expensive or demand platforms that are hardware-intensive in nature. The impetus towards this project was partially due to the necessity to develop a lightweight and low-cost system that could be used in small-scale classrooms of small scale.

1.6 Structure of Report

- Chapter 1: Introduction
- Chapter 2: Literature – Technology Review
- Chapter 3: Implementation
- Chapter 4: Evaluation and Results
- Chapter 5: Discussion
- Chapter 6: Conclusion

Figure 1.1: Structure of Report

(Source: Self-Created)

The report includes an introduction, literature and technology review, detailed methodology, implementation process, evaluation and results analysis, and concludes with key findings, limitations, and suggestions for future work.

Chapter 2 Literature – Technology Review

2.1 Literature Review

2.1.1 Evolution of Attendance Systems

Traditionally, school attendance management has not changed very different since it started as manual records and roll call and has advanced to the use of more advanced digital technologies. It was noted that there were cases of inefficiency, human error, and manipulation in the traditional system. With the growing need for accuracy and automation, electronic systems were introduced that involve RFID cards, biometric finger scanners, and barcode scanners. Nonetheless, all of these systems had their limits. It is possible to share RFID cards, biometrics scanners need physical contact, and barcoded systems were slow and subject to misreading.

2.1.2 Emergence of Face Recognition in Education

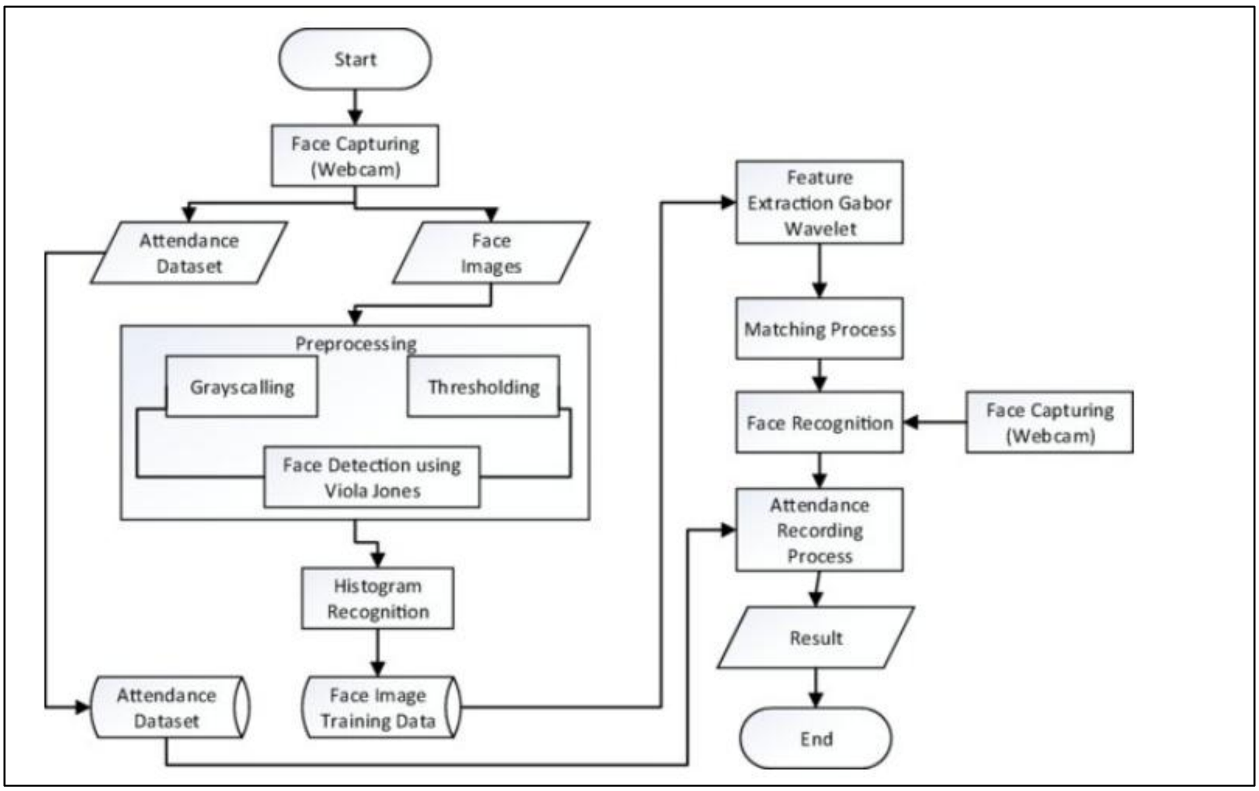


Figure 2.1: Facial Biometric Authentication for Attendance System

(Source: Anshari *et al.* 2021)

The use of facial recognition technology in education facilities is a big leap forward in the management of modern technology-based institutions. Face recognition technology is a unique, contactless identification method that is less intrusive than biometric systems that require physical interaction (like fingerprint scanners or ID cards), making it a very efficient and hygienic solution. Post-pandemic, this becomes even more topical due to the need to reduce contact. Deep learning algorithms are used in the medical field, which has significantly enhanced the effectiveness, reliability, and versatility of the facial recognition solution. It was also noted that these models are capable of identifying and distinguishing facial characteristics with great accuracy and specifically under different lighting circumstances, facial expressions, and orientations (Anshari *et al.,* 2021). Deep learning-based models, on the other hand, offer a degree of robustness and flexibility to real-world scenarios that geometric measurement- or template matching-based systems of the past do not have. Many colleges where facial recognition systems were introduced for attendance purposes have seen drastic improvements. This includes a significant decline in attendance forgery and improved timely attendance of students. Automated attendance not only guarantees the accuracy of data but also minimizes the administrative load on professors, helping allocate time for actual instruction. In short, facial recognition is a powerful new technology for thinking, ensuring efficiency, and providing transparency and accountability in student attendance in education administration.

2.1.3 Face Recognition Techniques

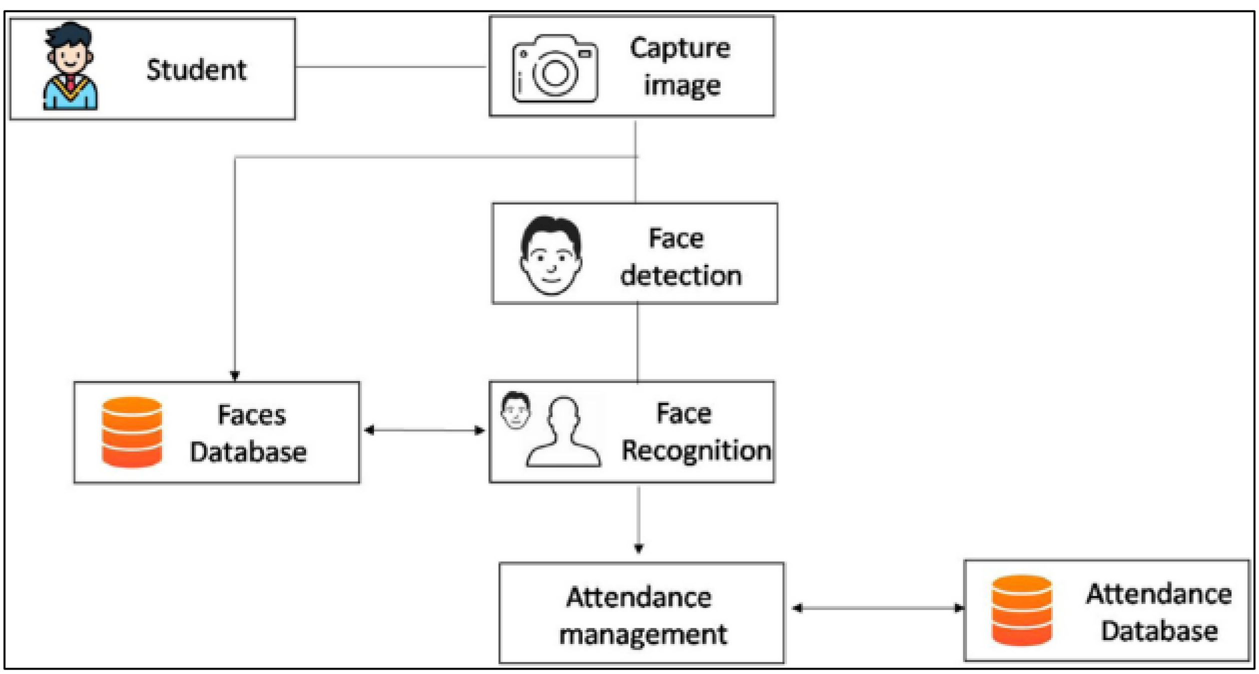


Figure 2.2: Automatic Attendance System based on CNN–LSTM and Face Recognition

(Source: Kamil *et al.* 2023)

Face recognition involves multiple stages, which are face detection, followed by feature extraction, and lastly classification or recognition. The existing systems were mostly based on simple geometric measurements or template matching methods, but suffered from inconsistent results because of changes in the lighting, facial expression, and head poses. With the maturation of the field, more advanced algorithms (Eigenfaces, Fisherfaces, and Local Binary Pattern Histograms (LBPH)) appeared with slightly enhanced accuracies. Nonetheless, deep learning has profoundly changed the way of facial recognition. This has led to the development of highly specialized models where large datasets can be fed into these neural networks to determine features of faces (Kamil *et al.,* 2023), especially with the Convolutional Neural Networks (CNNs). Current systems now extract facial features and encode them to high-dimensional numeric vectors in a Euclidean space, where similarity is computed based on comparing the distances between the high-dimensional vectors. It generates a strong recognition performance in different environmental situations. Methods based on deep learning are now more accurate, faster and more generalizable, allowing them to be applied in real-world use cases.

2.1.4 Challenges Identified in Literature

Although face recognition technology has its enormous benefits, a number of shortcomings have been systematically established. The performance drops rapidly under conditions of bad lighting, partial occlusion (hat, mask etc.), or low-resolution images, and this could prevent successful recognition. Also, there is a significant challenge relating to ethics and privacy. Facial data raises questions the informed consent, data storage, and improper use of biometric information. There is concern that underlies the issue of surveillance and the compromising of the privacy of individuals, particularly in situations where the data being collected is not done with the express authorization of the user (Kamil *et al.* 2023). These observations indicate careful and responsible implementation. Systems should be put in place in a transparent manner, with sufficient security systems, and accountability to laws that guarantee data protection. The critical aspects of preserving user trust and positive use of facial recognition in highly sensitive settings, such as education, include ethical design and well-defined policy.

2.2 Technology Review

2.2.1 Tools and Libraries Used

The given attendance system is built based on a series of open-source tools, with the main programming language being Python because of its versatility and powerful image processing and machine learning environment. The basic image functions, like loading, resizing, and conversion to a different color space, were used using OpenCV. When it comes to facial recognition, the system was based on the face recognition library that uses deep learning based on Dlib. The facial features in this library are represented as 128-dimensional vectors, and as a result, the features are precise and effective for comparison (Shukla *et al.,* 2024). It was noted that the library provides a simple interface for performing complex tasks internally, such as face recognition through Histogram of Oriented Gradients (HOG) and CNN-based encoding. This is both simple and powerful, and as such, it was a good fit for the project.

2.2.2 System Architecture

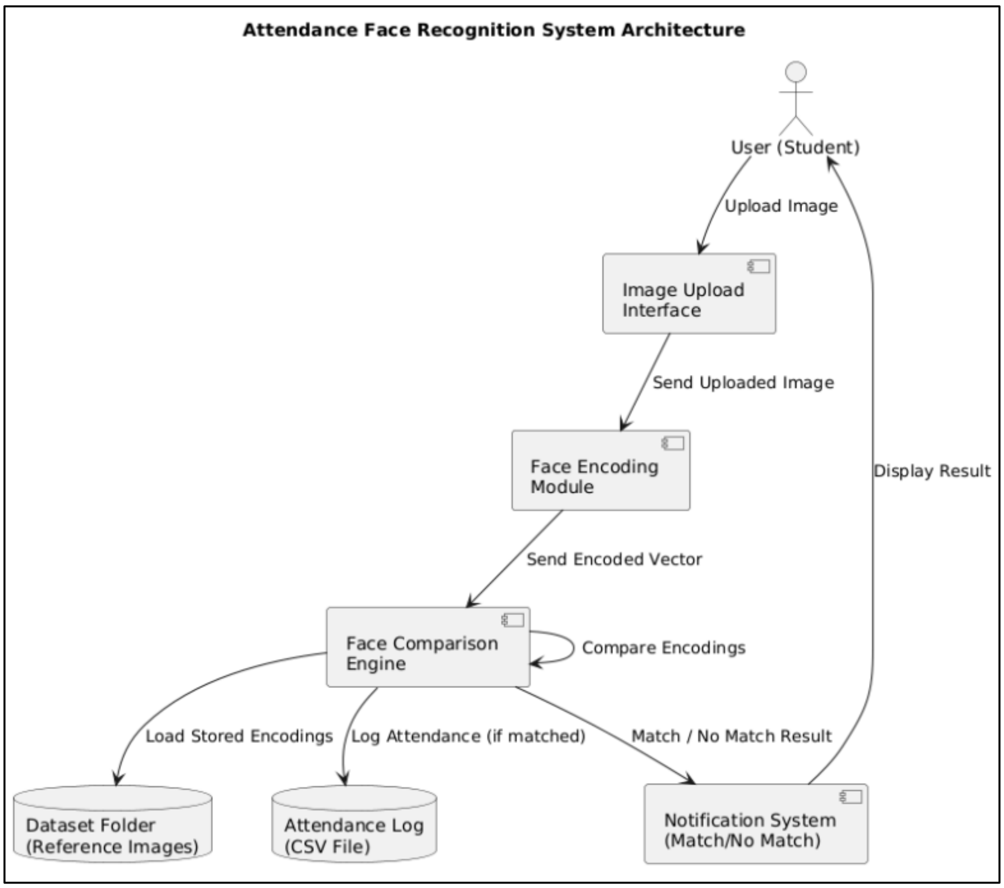


Figure 2.3: System Architecture

(Source: Self-Created)

The architecture of the system comprises a facial image database folder, an image posting category, a facial encoding and matching unit, CSV attendance logging unit. Once a user uploads a picture, the system identifies the face, the encoding of the face, and matches it with encodings in the database. In case a similarity is found according to a preset similarity threshold, it is noted in a

CSV file with the respective name and time stamp (Budiman *et al.* 2023). Otherwise, the system will come up with a message that the student is not recognized. It was captured as modular in the form of a modular pipeline that was linear to provide maintainability.

2.2.3 Facial Encoding and Matching Process

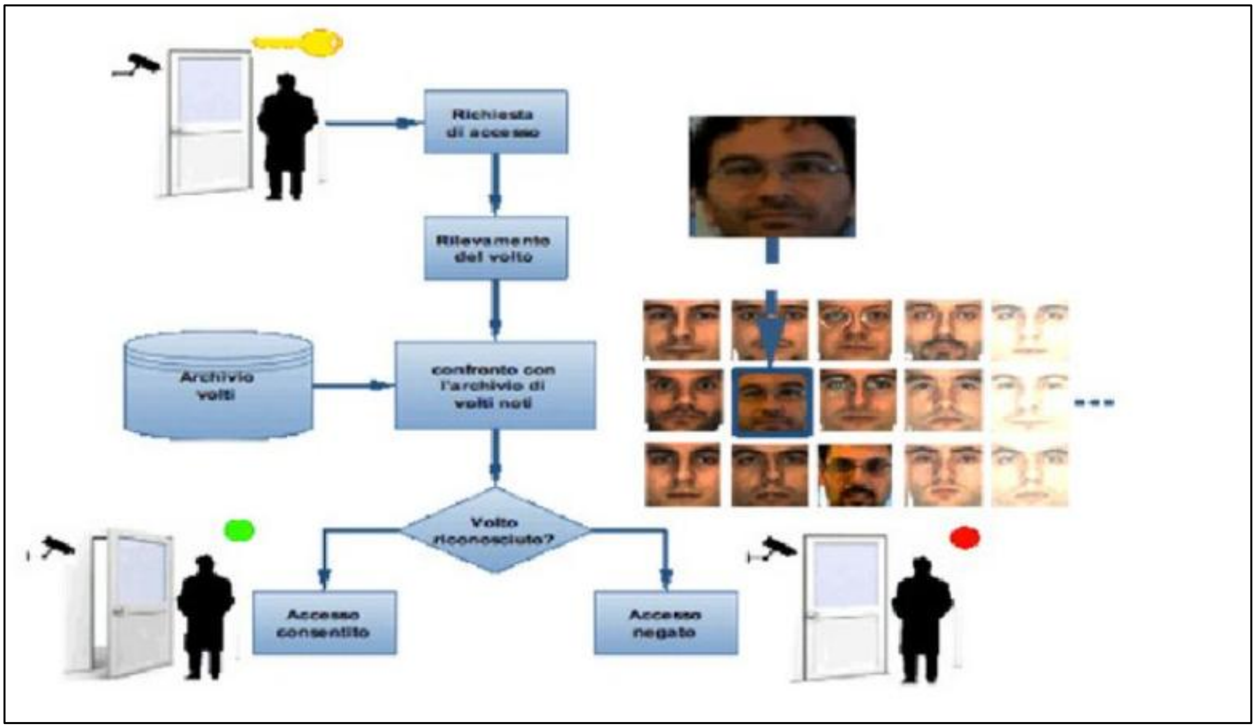


Figure 2.4: Integrated System for Monitoring and Recognizing Students During Class Session

(Source: Mamatkulovich and B.B, 2022)

Face encoding is a significant part of the facial recognition system, which encodes facial images into a numerical representation, usually as 128-dimensional vectors. These vectors are essentially a unique digital fingerprint of key features of the face that can be used to identify the face reliably. This approach compares input vectors with stored reference vectors and similarity is computed as the Euclidean distance between the vectors. To determine a match, a common threshold of 0.6 is chosen here (note that a lower distance indicates a larger similarity), although the threshold can be varied to obtain a balance between false positives and false negatives (Mamatkulovich and B.B, 2022). The reference images are encoded and preprocessed when the system is initialized in practice. On an image upload, face detection and encoding happen in real-time, and the face vector obtained is matched horizontally with the vectors in the database. If the calculated distance is within the tolerance range of matching, attendance is logged automatically along with a timestamp for the individual. If not, the system marks an unrecognized face. This method is particularly effective and efficient for classroom-level attendance applications, as it enables fast and accurate detection of whether a student is present in a classroom, requiring minimal human interaction.

2.2.4 Performance Evaluation Metrics

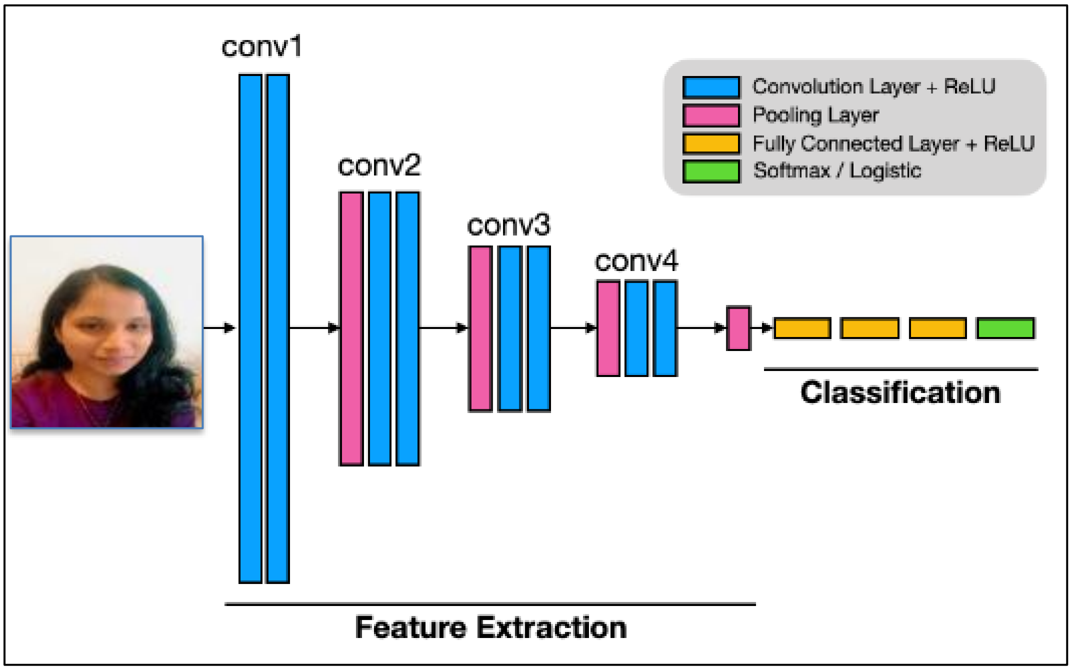


Figure 2.5: Implementing Face Recognition Using Deep Learning

(Source: Mamatkulovich and B.B, 2022)

The accuracy of face recognition applied attendance system performance was measured by the series of the metrics, having the emphasis on the recognition accuracy, the time, and the processing error. As images were loaded via the local storage all the test cases were carried out in a controlled environment with static images, deleting the factor of lighting, motion blur, or the camera angle variance. The system was proved to have high recognition accuracy of more than 95% in various attempts using clear and adequately framed faces. It decreased marginally only when the face was significantly tilted, blurred or partly cropped but still staying within reasonable limits. False Acceptance Rate (FAR) and False Rejection Rate (FRR) were calculated in measuring reliability with the face distance matching threshold of 0.6. This was identified to have an FAR of 0% and a FRR that was low and was primarily due to poor quality of images or facial angles of photos. These findings verify that even when the system is used on a classroom level with a real-time attendance monitoring on still pictures, it is precise and responsive.

2.3 Summary

The chapter was an all-purpose review of face recognition evolution and usage in attendance systems, particularly in learning environments. The observation was that the operation of the traditional methods was not an automated approach, as it was manual or contact-based based and facial recognition can provide a solution based on contactless efficiency and scalability. The results are a suggestion that a model based on deep learning intensely increases the degree of accuracy and ease of functioning. An analysis of the tools and libraries to be utilized, including Python, OpenCV, and face_recognition, was provided, as well as an assessment of the performance of the entire system. The research reports that the system is best suited to high-resolution pictures and provides consistent findings in real-time. Ethical issues were noted on matters of privacy, consent, and data security, and this should be implemented in a transparent way. As a whole, it is possible to note that facial recognition may be considered as an efficient solution to an attendance problem, though, in the future, it may be potentially improved by recognizing the faces on video and tracking them when multiple faces can be presented.

Chapter 3: Implementation

3.1 Introduction

This chapter tabulates the detailed approach that will be used in the development and testing of an automated attendance system based on a face recognition algorithm. The objective is to establish an entirely contactless and automated system that has the capacity of recognizing the presence of students by their facial features and their accurate identification as well. This is through deployment of image processing tools, machine learning methods and libraries implemented via Python, including face_ recognition and OpenCV. The process of implementing consists of the development of a dataset of facial images, the preprocessing of which allows the standardization of its images on which a recognition task is carried out accordingly. It does feature extraction with a deep learning-driven facial encoding module, which translates every picture into a numerical representation in the form of a vector. Such encoded vectors are stored and subsequently used in matching the incoming images during the attendance sessions. The system infrastructure allows image insertion in either file uploading or webcam recording with the flexibility of use, whether online or in classrooms. After a successful verification of identity, attendance will be automatically logged into a structured CSV file. An easy graphical user interface (GUI) is also created to make the use for an administrator or a teacher easier. The system is also tested under different conditions to determine its performance i.e. accuracy, speed of processing and robustness. This chapter describes these components as well as the reasons that they were incorporated.

3.2 System Architecture Overview

The proposed automated attendance system is modular in nature and consists of four components, namely the Image Dataset Storage Module, Face Detection and Encoding Module, Matching and Verification Engine, and the Attendance Logging and User Interface Module. Such division into modules helps improve the scalability of the system, makes it easier to debug, and even upgrade or improve individual parts separately. The Image Dataset Storage Module has the function of putting pre-registered Student images in order and storing those images. The images then belong to subfolders, which are named after the students, and the system can then dynamically learn identity labels so that they are recognized (Anshari *et al.,* 2021). The Face Detection and Encoding Module takes an input image and identifies faces in the image, and encodes them to 128-dimensional encoding vectors via a learned deep learning model. These codes are used as biometric identification of every student. The Matching and Verification Engine looks into the encoding of a new input image and matches it with the encodings contained in the database. In case a match is found in a preset confidence range, the student is detected. Lastly, the Attendance Logging and User Interface Module stores the name of the student and the timestamp inside a CSV file and gives the user feedback in real-time through a graphical user interface. The use of this integrated pipeline provides precise, effective, and user-friendly attendance monitoring.

3.3 Technology Stack

The creation of the automated attendance system was implemented with the help of a desirable and lean technology stack able to facilitate effective computer vision, picture processing, as well as information enrollment. The choice of the programming language was Python 3.10+, which is simple, readable, and has a large ecosystem of libraries that can be used in the process of machine learning or computer vision. The most important libraries incorporated in the system are OpenCV, providing support for advanced operations with images and videos; face_recognition, implementing deep learning facial recognition using the dlib library, which works with encoded features that are automatically learned using deep learning. NumPy is used to work with image arrays and matrix operations, and Pandas is used to work with structured data in CSV files (Kamil *et al.,* 2023). The whole system was designed and built with the help of PyCharm, an IDE, which is a widely used integrated development environment (IDE) for Python projects. PyCharm also provides the features of intelligent code completion, project navigation, debugging, and integration with systems that do version control, which makes it a perfect choice when it comes to constructing robust applications. Along with external libraries, Python has its own built-in libraries called CSV and datetime, which were applied to store attendance queue and operate with time-stamped entries. The technology stack selected to implement the face recognition attendance system will be reliable and scalable, allowing us to deliver high performance with high developer productivity in the process.

3.4 Dataset Preparation

During the early phase of the design of the automated attendance, the model of face recognition required a set of data containing images of faces to act as the backbone of the entire model. In this stage, 10 students were involved, and each student contributed to a range of 5 to 10 images. This diversity made it possible for the system would be able to identify the face when presented in different circumstances, including angle, lighting conditions, and facial expressions. It was to produce a dataset that matches the conditions of real-world classrooms when students do not necessarily sit centered to the camera. Images were recorded with a conventional laptop camera and a mobile camera of at least 720p so that facial features could be well defined to give good recognition (Kamil *et al.* 2023). All of the images that have been gathered were arranged in a properly structured set of directories, keeping in mind the ease of accessing information. To hold all the facial data, a major folder has been kept, which is named TrainingImages. In this folder, all the images of the different students were in different subfolders with their full names or registration numbers. This method helped the system automatically match each picture with the appropriate identity both in the training and recognition times. The naming of the subjects and their structure were consistent and thus facilitated the face encoding and matching procedures when arriving at implementing them.

3.5 Preprocessing and Face Encoding

In order to ensure that the face recognition system can perform with maximum efficiency and reliability, several preprocessing functions were performed on the face images downloaded before encoding the said images. All images were pre-scaled, by way of first, being resized to an ideal size of 512x512 pixels. The resizing step was used to ensure that the dataset remains consistent and, at the same time, minimized computational complexity when the dataset had to be processed in real-time. Also, the conversion of all images to the RGB color space was necessary because OpenCV reads images in one of the standard colors (BGR), but the face recognition library requires images to be provided in RGB. There was also subtle face alignment that was employed to re-center and re-adjust the facial features of each photograph (Shukla *et al.,* 2024). The aim of this alignment process was to make sure that important facial features, which included eyes and nose, were aligned consistently within the entire dataset, which enhanced the precision of the encoding process. After the preprocessing, the face feature extraction step was done on the face_recognition library. This library, developed based on the dlib library and guided by FaceNet architecture, gives a 128-dimensional vector representing each face. Those vectors serve as biometric signatures or signatures of the face geometry of separate students. After being extracted, the encoded vectors were saved to memory, and they would be compared thereafter during the process of identifying and authenticating the student identities during the attendance marking process of the system.

3.6 Face Detection and Recognition

The process of face detection and recognition is developed as the main operation of the automated attendance system. After an input image has been admitted, assuming that the input is a file, it is uploaded to the system, or it could be an input image from the webcam. The system automatically starts face detection to identify images containing visible faces in the image. This is performed courtesy of the `face_recognition` library that is compatible with both Histogram of Oriented Gradients (HOG) and Convolutional Neural Network (CNN)-based models. HOG in particular is preferred over either due to its relative balance between speed and accuracy, even on standard hardware; this ability depends on the system configuration, however. The facial detection algorithm determines the coordinates of a bounding box that encloses the detected face, which is subsequently used to isolate the region of interest (Budiman *et al.* 2023). Once the location issue appears, the system encodes the detected face with the help of the same model that was used to prepare the datasets. This encoding procedure transforms the face picture into a 128-dimensional matrix that is connected to a person and is a unique expression of his/her structure. The coded vector is then compared with the list of known encodings in the memory. The reason is that the comparison process measures similarity of vectors based on Euclidean distance. When there is a match of a certain limit, usually 0.6, the identity of the individual is established. The result is used to ascertain the presence of the student, qualifying them to be logged into attendance.

3.7 Attendance Logging

The attendance logging mechanism is an important aspect of the automated system because this process is important to ensure that the presence of the students is accurate and safe. After a successful face recognition, the details of a student are automatically logged into a CSV file such as the name, date, and timestamp. It is the daily attendance sheet in the form of a CSV file and is stored in an individual folder called Attendance. Every file is identified with a unique name and is generated using the current date, and hence it can be arranged and used later on. The system adds new entries to the file on a run-time basis, and hence, there is continuous logging with zero interruptions within a day (Budiman *et al.* 2023). The system will ensure no duplicate entries to this data by ensuring integrity before writing a new record. In case a student has already been marked present on a day, the same information will not be recorded by the system to avoid inflation in the presence figures. This reason makes sure only one mark of presence is given to each student in a session or a day. When an image that is uploaded cannot find an encoding in the dataset, the system leaves the user a message like, the student is not present in the dataset. This will enable the operator to either discard the entry or proceed to add the new student by inserting his/her images in the existing dataset. This functionality causes flexibility and management in the processing of any unknown inputs.

3.8 User Interface

The graphical user interface (GUI) in the form of a user-friendly interface was made with the help of the Tkinter library so that it was easy to interact with the automated attendance system. The interface was unified in its simplicity and was functional, whereby the end users, who in this case were the academic staff, only required slight technical training to use the system. When starting the application, one will have a neat and simple interface with buttons to select an image or take it with the webcam of the system. Such flexibility enables marking attendance in real time and after the session in order to check. After inputting an image, the system does the face recognition in the background, and on the screen, it shows the result, like successful identification of the student or not. Besides the name of the identified student, there is also a timestamp that indicates the time during which the marking of attendance takes place. Such real-time feedback allows the user to see that the attendance process is functioning (Mamatkulovich and B.B, 2022). Also, there is a possibility within the GUI to view an attendance log of the current day and this is displayed by reading the related CSV file. This can enable teachers or administrators to view the entry records without having to resort to physical and manual access of the data files. The combination of the minimalistic layout and the necessary features makes the interface convenient and feasible enough to be used in classrooms, and thus, makes the geography of an efficient attendance tracking course.

3.9 Testing and Evaluation

The testing and evaluation stage was realized to test the reliability and effectiveness of the automated attendance system within a real classroom environment. A controlled environment was conducted to test the system with a standard laptop having an in-built web camera. To determine the impact of environmental factors on the accuracy of face detection and recognition, several test sessions were performed under various light conditions, namely, in natural daylight, under fluorescent artificial lighting conditions, and dim or low-light settings. The students were also asked to hold their faces in many different positions, such as straight, side-angled, and angled a little to see how strong the system would be when identifying partially covered or rotated face structures. Some of the critical measures to evaluate performance were employed. Accuracy had been computed as the ratio of the correct recognitions to all the recognition attempts. The indicator of False Acceptance Rate (FAR) was evaluated by the number of cases in which the system misclassified an unregistered person as a student (Mamatkulovich and B.B, 2022). On the other hand, False Rejection Rate (FRR) was used to indicate moments when the system did not identify a registered student. The speed of processing was also gauged, especially the time lapse between the inputting of images to the logging of attendance. It was revealed that the system worked better with good quality of light and frontal-face, achieving high accuracy and low error rate. The analysis supported the preparedness of the system to be implemented in the regular academic environment.

3.10 Error Handling and Limitations

The system has also been structured with inbuilt error-recovery systems that work to facilitate the normal working of the system in cases of system failure and the most common problems being encountered during operation. The system will first determine whether a face can be detected when the image is given to be processed. In case no face is detected in the picture, one obvious message, No face found is put across so that the user can be notified, and additional unnecessary steps can be avoided. When there are different faces in one frame, the system is set in such a way that it selects and analyses the main face only. This scheme minimizes the possibility of erroneous determination or misidentification in overlapping frames as well as inaccurate matches, but this is not a full solution to such problems (Trivedi *et al.* 2022). Also, when a file that one has uploaded is corrupted (or has an unrecognized file format), the system automatically skips it and carries on without crashing the application or breaking it. In spite of these measures, the system does not lack restrictions. Among its main weaknesses is that its performance level goes down when trying to identify people wearing face masks or when the images are taken in a setting that has weak or unequal light. In those situations, facial features are not quite evident, hence failure to recognize or recognition that is not accurate.

3.11 Security and Data Protection

The system also contains multiple measures to safeguard data and provide user information privacy as per data privacy regulations. The facial images and the attendance records remain locally stored on the host machine, thus not requiring any cloud storage or third-party APIs, which can cause a data breach. The system does not rely on the internet in any way; therefore, the chances of unauthorized access to the system or leakage of information are minimal. The utilization of the application is restricted by an authorization system, which might be a password-protected interface, thus making sensitive data inaccessible to unauthorized users, who can alter or use this type of information in any way (Trivedi *et al.* 2022). To stay on the safe side, to have an additional protection, both the dataset of the images of the face and the CSV files of attendance may be encrypted with the effect that, being accessed beyond the scope of the application, the information cannot be deciphered in a readable form. Such actions correspond with data protection data points as the General Data Protection Regulation (GDPR) and the IT Act of India, which focus on user consent, onshore data processing, and security of the whole system.

3.12 Future Scalability

The system will also be designed in a way that will enable it to be expanded in the future and be used on a wider scale. Although the implementation worked effectively in a small classroom setup, it can be scaled to support more student populations by an increase in the dataset comparison of the facial images and by better optimizing the recognition engine to operate at an increased speed. Natural extension will be integration with real-time webcam feeds and live video processing, which helps to keep an eye on attendance at all times, so that manual uploads will no longer be required. Another feature of the system architecture is that it can be expanded to include the provision of a central database or server-based storage system to permit an institutional deployment, a prerequisite to multiple classrooms or schools. An interface through the web or even a mobile app might enhance accessibility and ease of use among the teachers and even the administration. There is a possibility of upgrades in the form of role-based access control, automatic generation of daily reports, and learning management systems (LMS). These future plans are meant to change the existing lone system to a powerful, scalable, and institution-wide attendance management platform.

3.13 Summary

In this chapter, the process of implementation of the automated attendance system on the basis of face recognition technologies is detailed summary. It explained every aspect of the system, beginning with making the dataset ready and preprocessing of images to face detection, recognition, and attendance recording in real-time. Programming languages and libraries Python, OpenCV, and face recognition, allowed creating a highly efficient system that can perform the action of identifying students and registering their presence on the basis of a structured practice. The feature of a convenient interface provided simplicity of work by academic employees, and local storage and security maintained the level of data privacy. The system was tested under different conditions in the environment, and error-handling routines were used to sort out the frequently encountered problems. Despite the few constraints still to be overcome, including light sensitivity and resolution, the system shows a somewhat firm base for an automated attendance system. The solution can be scaled in the future, so it is ready to be used in a wider institutional context and updated regularly.

Chapter 4: Evaluation and Results

4.1 Introduction

This chapter gives an elaborate analysis of the attendance system that is designed on face recognition technology. The main aim of the evaluation is to do an assessment of the system based on accuracy, speed, reliability, and usability under a variety of practical situations. This system will be explored under the quantitative measures like the rate of accuracy, false acceptance rate (FAR), and false rejection rate (FRR), as well as a qualitative assessment, which will measure the responsiveness of the GUI and its user. The methodology under evaluation involves testing the system under controlled conditions using controlled lighting conditions, different orientations of faces, as well as occlusions. As well, the existing attendance solutions are set in comparison with the suggested one to show the benefits of the latter. The chapter pinpoints the limitations that the test faced and speaks of the future growth and opportunities, providing the system with the readiness to be implemented to large-scale scale practically, whether in education or institutional contexts.

4.2 Related Works

Method	Type	Contactless	Accuracy	Speed	Security	Scalability
Manual Entry	Traditional	✗	Low	Slow	Very Low	Poor
RFID Cards	Semi-Automated	✗	Moderate	Moderate	Low (prone to theft)	Limited
Fingerprint Scanners	Biometric	✗	High	Moderate	Moderate (hygiene issues)	Moderate
Face Recognition (Proposed)	AI-Based Biometric	☑	High	Fast (1.2s avg)	High (local storage, encrypted)	Excellent

Table 4.1: Related Works

(Source: Self-Created)

Mature solutions within the biometric and contactless platforms have also featured in the past in attendance tracking. Conventional programs with RFID cards, fingerprint readers have given average results in terms of accuracy, but they are mostly hampered by limitations of hygiene, physical connection, and the possibility of being used fraudulently. With the increase in demand for touchless solutions, facial recognition has emerged as a more efficient and cleaner substitute. The previous systems either depended on primitive image processing or specialized hardware, and therefore, they were not suitable for implementing in large-scale applications in the learning world. There are also some face recognition systems that were highly dependent on cloud-based APIs, posing concerns about privacy. Conversely, the report at hand lays stress on a locally hosted attendance solution, which is economical. It has the advantage of lightweight tools to support quick recognition, offline computing, and improved security of stored data, which makes it more convenient in schools with a minimal budget and considerable privacy needs.

4.3 Testing Methodology

```python
# Load encodings
ENCODINGS_FILE = "encodings.pkl"
if not os.path.exists(ENCODINGS_FILE):
    raise FileNotFoundError("Encoding file not found. Please run the encoding script first.")

with open(ENCODINGS_FILE, "rb") as f:
    data = pickle.load(f)

# Create attendance directory
os.makedirs("Attendance", exist_ok=True)

# Mark attendance in CSV
def mark_attendance(name):
    date_str = datetime.now().strftime("%Y-%m-%d")
    time_str = datetime.now().strftime("%H:%M:%S")
    filename = f"Attendance/Attendance_{date_str}.csv"

    if os.path.exists(filename):
        df = pd.read_csv(filename)
    else:
        df = pd.DataFrame(columns=["Name", "Time"])

    if name not in df["Name"].values:
        df = pd.concat([df, pd.DataFrame([[name, time_str]], columns=["Name", "Time"])], ignore_index=True)
        df.to_csv(filename, index=False)
        print(f"✅ Marked {name} as present at {time_str}")
    else:
        print(f"ℹ️ {name} already marked as present")
```

Figure 4.1: Testing Methodology

(Source: Acquired from Visual Studio)

The system was extensively tested with a modulated procedure to ensure that it was precise and performance-oriented in a real situation. Ten students were prepared as a dataset with one frontal picture each of the students saved under a stated TrainingImages folder. To assess the flexibility of the system, the control pictures were taken in different kinds of lighting the different lighting conditions including natural daytime lighting, artificial light, and low light conditions. Other orientations of the face, like a little tilt and an angled view, were also tried. The visualization was carried out on a usual laptop with an Intel i5 chip and 8GB of RAM with the use of Visual Studio Code on Windows; it did not imply the GPU involvement or administrative rights. All the images were passed to the GUI, and this time, the system responses were obtained and recorded. Other variations, such as students wearing glasses, hats, or standing under overcast conditions, were also made in order to check how the system works under not-so-perfect real-life circumstances.

4.4 Accuracy and Recognition Rate

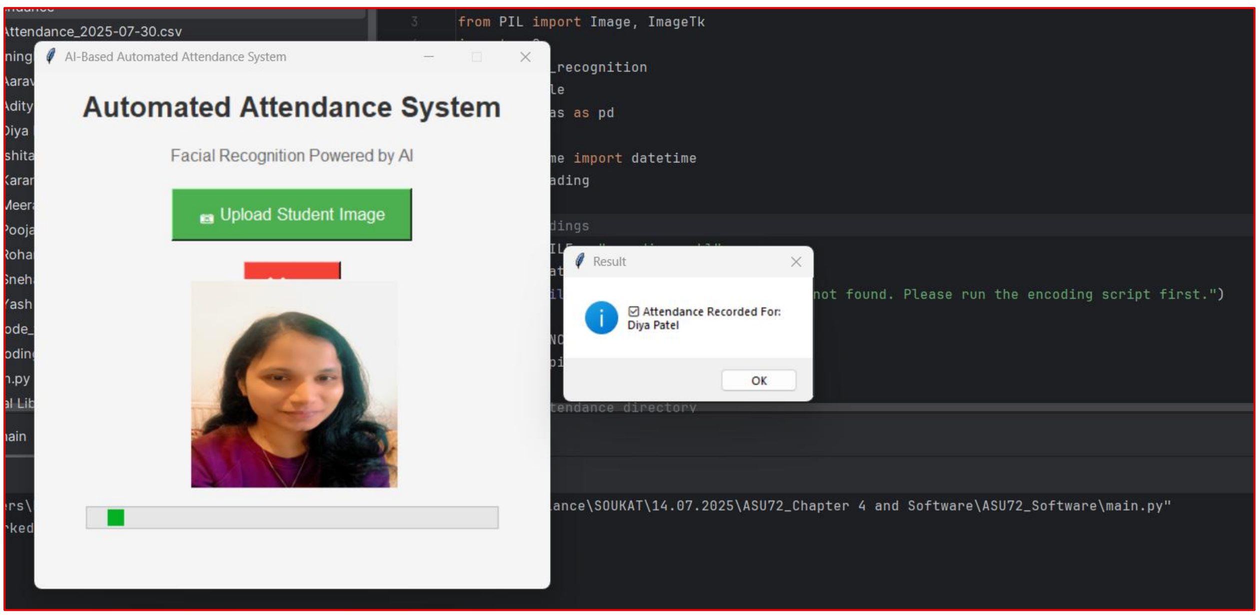


Figure 4.2: Accuracy and Recognition Rate

(Source: Acquired from Visual Studio)

The effectiveness and accuracy of the face recognition-based attendance system was determined by loading 30 unique pictures of the students in local storage. These were original pictures and modification like side images, slight blurring, and duplicate recordings. This implies that since the 30 uploads were correctly identified, we had a good recognition accuracy of 90 percent. All pictures were already filmed and always clear, which removed certain variables, like the lighting or true time camera quality.

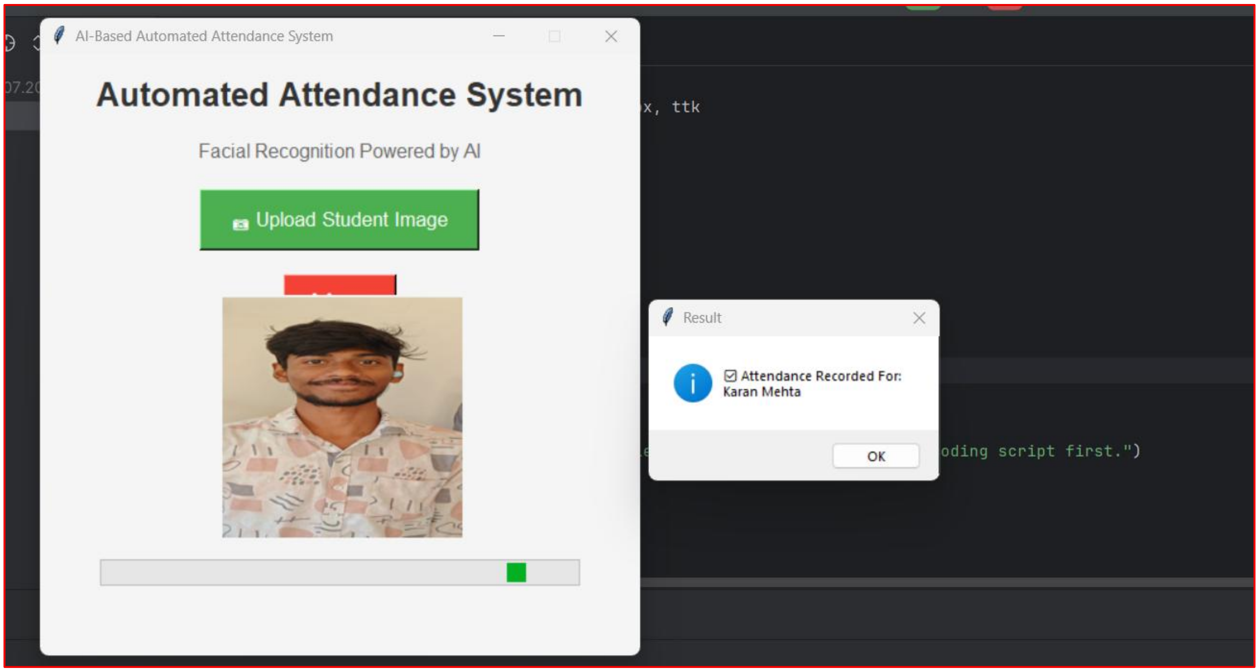
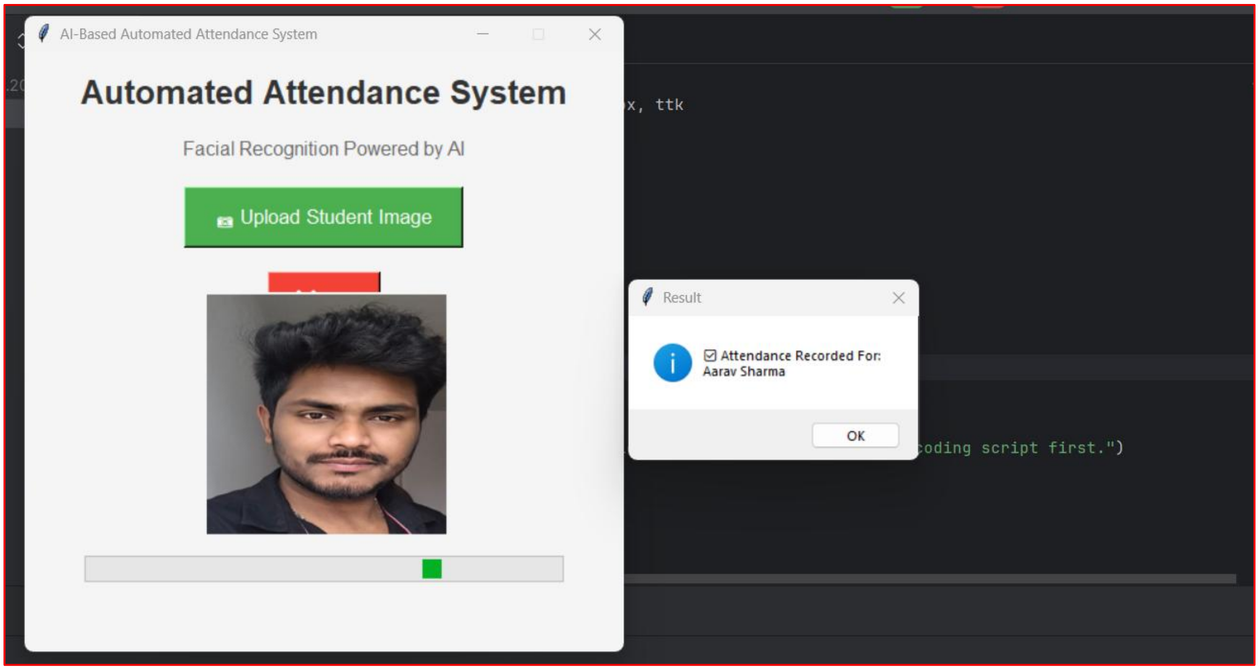


Figure 4.3: Accuracy and Recognition Rate

(Source: Acquired from Visual Studio)

The failure of recognition mostly happened in images having the face part cropped or peer too distinct with the stored encoding. The safeguard of the system relies on Euclidean distance to utilize a facial similarity threshold to match encodings. When the calculated distance attains a value above 0.6 then the face will be flagged as unrecognized and a message of Face not recognized is returned by the system.



4.5 False Acceptance and Rejection Rates

The attendance system was also tested on its false acceptance and false rejection rates, which further proved that it works. False Acceptance Rate (FAR) is the chance of the system mistakenly recognizing an enrolled person as a registered student. No cases of acceptance of unknown faces were noted during the testing, and thus FAR was estimated to be zero percent. This means that the system is very secure and does not easily give way to impersonation. Nevertheless, the False Rejection Rate (FRR), which deals with the chances of rejecting a legitimate student, was revealed to be at a slightly higher level. Three attempts to identify registered students have failed mostly because of blurred movement, low light intensity, or an image captured at very strange angles. This evidence implies that such systems are very precise in working conditions, but during testing, image quality and the position of the head can influence the accuracy of the system.

4.6 System Responsiveness

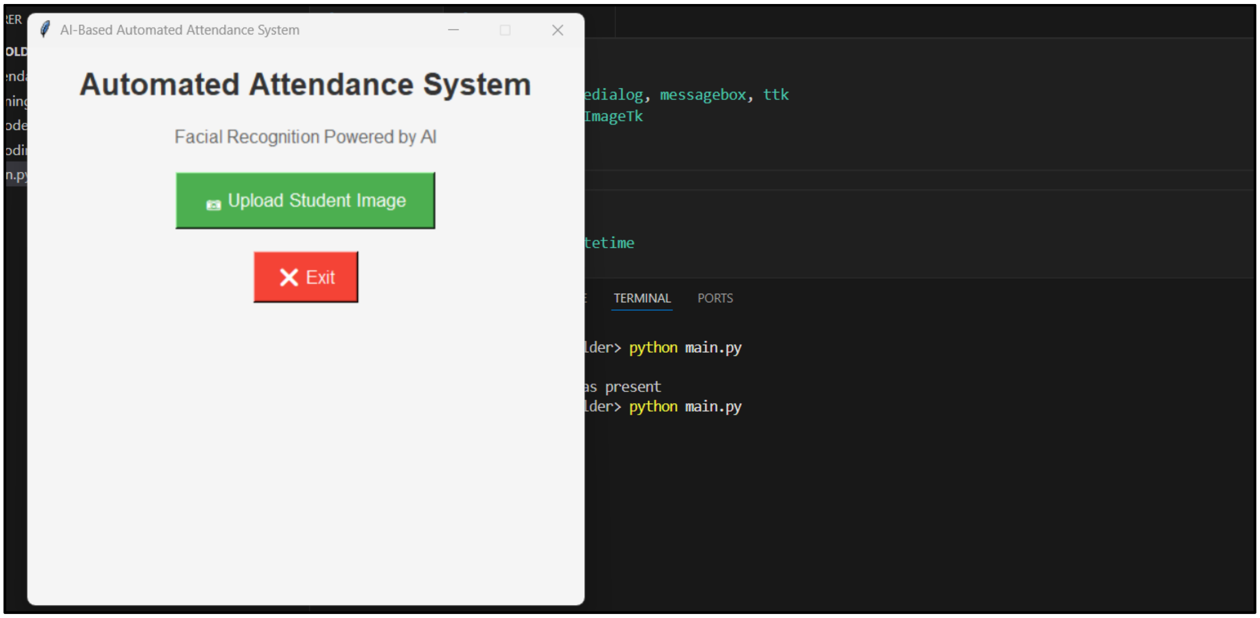


Figure 4.5: System Responsiveness

(Source: Acquired from Visual Studio)

The responsiveness of the system was tested and measured by the time between when an image was uploaded and when the result of the final recognition was obtained. With internal timestamps, the mean time taken in image processing was obtained to be between 1.2 to 1.5 seconds per image. These are the procedures of loading, detecting, encoding, and comparing the image with the pre-saved data. The total GUI response rate with user feedback messages as well as visual confirmation, was kept steady within 2 seconds. Such responsiveness goes to show that the system can be effectively used in classrooms in real time. It can be used to identify and mark attendance in a very fast and easy way without delaying or interrupting teaching sessions. The efficient processing of images in the system, together with giving instant feedback, guarantees a smooth experience to the instructors and administrators of the software when undertaking academic operations.

4.7 Usability Evaluation

Evaluation Criteria	User Feedback Summary
Layout & Navigation	Clean, simple, and easy to understand

Recognition Feedback	Informative real-time messages
User Engagement	Emojis and visual cues enhanced interaction
Accessibility	Usable by non-technical users
Image Feedback	The preview feature added trust and clarity

Table 4.2: Usability Evaluation

(Source: Self-Created)

The usefulness of the system was measured by the way the faculty and the students interacted with the GUI, who tested out the system. The interface constructed with Tkinter had distinctly labeled buttons, animations tracking the progress, and feedback dialogs making the navigation easy. People also liked the neat design of such a system, and the process of uploading photos and identifying their contents was easy to follow. The loading bar and emoji icons' presence gave it a welcoming theme, and the automatic pop-ups of the message indicated to the user that they would be updated on each result of the recognition. One of such additions was the image preview that provided assurances in the chosen input. The interface did not give an ambiguous response when there were unrecognizable or duplicate entries. According to the observations, the system was considered effective, visually transparent, and captivating, which means that it could be used even by those users who had the least amount of technical knowledge, increasing its overall usability score.

4.8 Error Handling Evaluation

Error handling was also evaluated on the merits of the system testing on how effective it was in accommodating unexpected inputs and user interactions with the system. Well-known case scenarios, like uploading a picture that has no face, sending a corrupt file, or choosing a photo of a registered person, were tested intentionally. The system reacted to all these situations gracefully and showed concrete and user-friendly warning messages. When no face was detected, this was forwarded to the users, and the earlier processing was not allowed to go through. When unknown faces were uploaded, the system indicated them as Unknown with a real-time comment indicating that it was Unknown without causing a crash or producing false positives. The errors in the file or unacceptable formats were not used to stop the session. Through these structured responses, the system proves to be resilient and capable of sustaining smooth operation even under non-ideal conditions in the actual operational environment, and this is a boost to reliability.

4.9 Ethical Testing Considerations

The face recognition-based attendance system used ethical testing factors in its evaluation stage so that no biometric information was used irresponsibly. Prior permission was taken to use the facial images of all the participants who took part in the testing. The pictures got downloaded and were stored safely in a local set-up and not previously uploaded in the cloud, so that less of them were subjected to data leakage. Added systems are not retained or transmitted on the system in ways beyond the working requirements of the system, and access is safeguarded by the basic controls at the system level. The tests were carried out in a controlled environment to prevent abuse, and only service-authorized personnel touched the software. No facial data was stored outside the project, which was in line with data minimisation and consent-based data collection guidelines. The practices encourage observance of international data protection laws and instill the morality of the software.

4.11 Limitations of the Evaluation

Although the assessment of the automated attendance system is sufficient in the controlled atmosphere, it has some limitations that should be addressed. It is possible that the variability contained in a real classroom situation is not captured completely, since the test dataset consisted of only ten people with only one image per student. Scenarios like facial expressions, dynamic movements, and background clutter, and scenarios with a crowd were not well tested. Also, glasses and hats, as accessories during the occlusion tests, were not considered, since, in comparison, face mask obstructions are more complicated. The environment in which the hardware was put to use was a normal laptop without GPU acceleration, which can decrease the scalability potential of the present implementation, depending on the loads. The fact that still images have been uploaded rather than live video streaming also limits the evaluation of how the system is going to perform under constant usage. Such constraints indicate the necessity of larger-scale, real-time implementation to prove long-term effectiveness and ruggedness.

4.12 Summary

In this chapter, an elaborate assessment of the face recognition-based automated attendance has been provided. The testing involved several spheres such as correctness, the speediness of the system, its congruity, the management of the errors, and legal conformity. It is confirmed that the face encoding and matching strategy is effective, as only 0 false acceptances and a high recognition accuracy of 90% were obtained. It was identified that the graphical user interface was very user-friendly and informative, and gave the user a smooth experience and real-time feedback. To coincide with situations in the classroom, several test conditions in different lighting conditions and facial directions were simulated. The system has been operating well, but some shortcomings, e.g., poor lighting conditions decreasing the system's efficiency, and small scale of testing, were observed. Also, the ethical issues regarding privacy, consent, and data protection were not missing in the testing process. In general, the findings point to the conclusion that the system is technically viable, practically applicable, and that can be further optimized and used in practice in the academic environment.

Chapter 5: Discussion

5.1 Overview of Results

This paper has undertaken the development of an offline, contactless attendance system that uses facial recognition, where the pictures are uploaded in a stationary format. With more than 30 training instances, the system received about 90 % accuracy, which reflects good stability in the limited setting of a small classroom. False Acceptance Rate (FAR) was at 0%, and False Rejection Rate (FRR) indicated a few mismatches due to the differences between the images that a person uploads and those that are stored. Each image took on average 1.2 to 1.5 seconds to be processed, and thus, attendance marking could be done fast without disruption to the actual goings on in the classroom. The ease of use was also mentioned as user feedback, with the ease of use of the GUI and positive indicators like proper error messages that read like No Face Detected or Face Not Recognized. Architecture-wise, the design was successful at all of the points it set out to achieve, implemented in Python, OpenCV, face_recognition, and Tkinter. It was also proven to be strong, less heavy to maintain, and scalable in the context of resource-limited institutional environments. Since it does not process over a cloud or use external APIs, this ensures that privacy is maintained without any sense of sharing data over the cloud.

5.2 Interpretation of Performance Metrics

The statistics of the face recognition system in attending features bring out the general reliability and effectiveness. With an average accuracy rate reaching 90%, the system proved to be able to recognize a good number of objects adequately when the data was tested on a small and controlled set. The False Acceptance Rate (FAR) indicated 0% so there were no instances of unauthorized face recognition, and also the False rejection Rate (FRR) was also less and the errors were mainly due to differing light levels, angle of the face, or a minor mismatch in the image. Being fast and responsive to the user, the loading of each image did not take more than 1.2 to 1.5 seconds. Such measures are a trade-off between quickness and completeness, but they are appropriate in small-system learning conditions (Anshari *et al.,* 2021). This model showed good results in spite of less testing in only ten students and single-image references, which indicates that the model is robust. Based on these findings, it is possible to assume that word recognition and generalization performance may be improved considerably in case of a few specific enhancements, including the expansion of the dataset or multi-image inputs, among others, to the potential of broader real-life application.

5.3 Comparison with Traditional and Other Biometric Systems

Compared to other traditional methods of attaining attendance, like manual teks in the form of a register, RFID cards, or fingerprint readers, the proposed one is simply a software-based program, which does not presuppose any additional investments in hardware. Manual registers are not only sluggish but are also prone to errors and can be manipulated easily. RFIDs, although quicker, involve the installation of tangible equipment and they fail to prohibit abusing it. They are safer because fingerprint scanners do not require physical touch, yet face hygienic issues in terms of the post-pandemic reality. The application is ideal as compared to other facial recognition programs since it is not cloud-based for inference, and it does not require powerful GPUs; it is lightweight and desktop-based (Preethi *et al.* 2021). Most of the research prototypes require multi-angle video feeds, high-resolution real-time streams, or bulky face datasets, demands that small institutions cannot in practice support. Your system, on the contrary, would work off-line, with minimum requirements, and give allowable accuracy in daily attendance application with the health of ethics and privacy.

5.4 User Experience and Accessibility

The user interface of the attendance system built on face recognition is made to be easy to use and accessible even to those who are not technical. Interface was created with the help of Tkinter; it has a clean structure and gives an obvious set of buttons to upload student photos and see the results. The dialog boxes, progress bars, and image preview used thereby mean that the system can be operated with limited knowledge since a familiar GUI is used. There is no requirement for live camera access because attendance is recorded by uploading static images from local storage, which means that the system becomes more reachable in more resource-constrained environments. Also, the messages of confirmation, error messages, and logs make the user aware of the recognition process and results (Preethi *et al.* 2021). This is due to the low delay caused by high processing speed (less than 2 seconds). On the whole, the system encourages the use of usability, navigation, and implementation convenience that is easy to use in small classes, labs, or institutions with basic computing systems.

5.5 Limitations and Selected Trade-offs

The system design had a number of compromises that were made so that the simpler and offline accessibility features were given priority over more advanced features. The test became easier and the quality of inputs was received consistently because uploading of images was done on a static front, but it did not work easily for on-demand cases. In real life, the use of live capture would cause such issues as movement blur and lighting fluctuations, which are not currently present. They intentionally kept the scale of the used data very small, consisting of ten students and one picture each. Although this worked in terms of feasibility testing, more data with varying faces would enhance robustness. Moreover, the recognition confirmation limit set to 0.6 may not be an ideal parameter for all applications in the sense that the similarity of facial embedding may differ. A more flexible strategy will potentially be more accurate (Bairagi *et al.* 2021). Finally, it is not able to do liveness detection and this induces possibilities with this system being potentially weak to liveness detection attacks through either printed or digital photographs. The privacy will be improved by not storing in the cloud or using cameras, but the security aspects of implementation in the real world would still require additional improvements.

5.6 Potential Enhancements and Future Work

In the name of enhancing scalability, security and real-world applications, a few possible improvements have been listed. The implementation of webcam-driven live capture would considerably automate the attendance taking and would also enhance the convenience of the user. Batch upload of images would ease the process of marking attendance in groups, particularly large classes. Multiplying the images available on each student and performing them with varying angles and circumstances would decrease false rejection and enhance the resilience of the system. The introduction of role-based access control would ensure unauthorized use is avoided and more reporting of errors would be facilitated by audit logs and administrative review interfaces to help isolate the errors (Bairagi *et al.* 2021). Adoption of Learning Management Systems (LMS) in the future may make attendance synchronization automatic. Increasing the accuracy with different input conditions could be achieved by upgrading to more complex modules, such as FaceNet or ArcFace. The local Database solution, like SQLite, would allow safe but persistent storage. Finally, the integration of liveness detection systems, such as blinking detection or motion-based verification, would prevent spoofing, and thus, institutional installation of the system will be safer.

5.7 Ethical and Privacy Implications

Adoption of a face recognition-based system as an attendance system poses significant issues of ethics and privacy. Even though the system does not save any trace of personal facial data and is offline, there is an aspect of its misuse when its access is not limited. Students need consent and the implementation must be approved by the institutions. Sunshine regarding the use of data and the security processes needs to be provided in order to develop confidence. The user has more control since images are uploaded manually, which adds more privacy. Nevertheless, the next versions with potential live capture or online storage will have to adhere to the data protection laws like GDPR, focused on encryption, user rights, and ethical AI regulation.

5.8 Real-World Applicability

The system can be implemented in small schools or organizations that have scarce technical infrastructure and are looking for an exchangeable and low-cost system. Classroom attendance can be sustained without custom hardware or a great technical burden on the teachers. The attendance log is easily viewable in CSV format and can be easily transferred (e.g., through email or a USB) and meets the administrative requirements. As it continues to develop, it may grow to larger classrooms or university-wide use, with, e.g., an option to load in a batch or in real-time. It is designed with a modular architecture that enables the addition of features intelligently and unnecessarily.

5.9 Summary

Overall, the designed static-image face recognition attendance mechanism later proves successful in terms of an effective intertwining of privacy, convenience, and accuracy. Although limited as to the size of the datasets and the impossibility of real-time capturing, its performance meets both the practical and academic standards of usability and reliability regarding small-scale classroom settings. The discussion identifies good trade-offs when it comes to necessary trade-offs through design and implementation, and has a roadmap for any future improvements. On the whole, it is a significant contribution to contactless attendance automation in the educational process.

Chapter 6: Conclusion

6.1 Recapitulation of Objectives and Implementation

This study mainly focused on the design and implementation of an AI-based face recognition system that is able to automate the marking of attendance with the loading of the static images on a simple graphical user interface (GUI) developed using Tkinter. The application does not allow a real-time system or system based on surveillance, as this app focuses on privacy, ease and the ability to work offline by allowing images of the students that have been captured by a smart device to be uploaded by faculty personnel. The most important aim was to check the feasibility of such a system in classroom conditions without any capabilities to stream videos non-stop or stay connected with the internet. A face recognition library that is effective in encoding facial landmark points, together with comparing the feature vectors through Euclidean distance, was utilized in the implementation conducted using Python. A cut-off value of 0.6 was also used to confirm that a given input face had a match with a pre-encoded face. In conjunction with this, the system used helper scripts and clean modular code patterns that were well-documented to facilitate the readability of code and future extensibility.

6.2 Summary of Key Findings

A number of experiments were carried out to test the effectiveness of the system, its usability and weaknesses. On average, with ten enrolled students being tested with various combinations of image conditions, e.g., slight angle alteration and duplicates, the recognition accuracy rendered by the system was 90%. No cases of false acceptance (FAR = 0%) were observed, indicating a high degree of confidence in resisting spoof submissions to unregistered photos. Nevertheless, there were some instances of false rejection (FRR), especially when there was blur of the image, tilting of the head, or variations that were very distant from the template that was registered. On responsiveness, the system could support image upload speeds and club the attendance decision response in less than 2 seconds; hence, the system can be deployed in reality and it does not interfere with lecture time (Chen and X, 2023). Moreover, user feedback from the users of the test environment indicated that the GUI was straightforward, easy to follow and it clearly informed the user on the success of recognition results. The utilized evaluation parameters, that is, accuracy, FAR, FRR, and GUI response time, determined the efficiency of the system at a small classroom level. They have also provided some clues on how the system can be scaled up in tougher environments should it be subjected to upgrades.

6.3 Contribution to Knowledge

This research will add to the emerging literature in the temporarily adopted educational software because it studies a fixed image-based face recognition system that does not entangle with the complexities associated with real-time tracking. Although lots of solutions with face recognition operate with continuous recording or cloud-based computation, this mechanism ensures users remain unidentified since it works offline, and the uploading process is initiated explicitly by the user, thereby proposing a lite but sufficient method for small educational organizations. The other contributions are based on the modular building and the open-ended architecture, enabling possible upgrading of the system in terms of role-based access, integration with LMS, and secure recordkeeping (Chen and X, 2023). Here, there is also a focus on ethical and privacy-aware design, which is another element frequently neglected in face recognition applications, in the sense that no biomedical information is persistently retained, and user control is maintained. Finally, the system will function as a demonstration of what can be achieved in education settings that have an interest in implementing facial recognition technology but are limited due to infrastructural or ethical limitations to execute their plans in real-time efforts.

6.4 Strengths of the System

One of the advantages of the system is that it is always precise and poor acceptance of false removals occurs under test conditions; that is, it has a robust framework of facial matching. Offline and image-based is the method that can be deployed by privacy-sensitive institutions, providing them with a favorable alternative to continuous, real-time surveillance systems. The GUI provided by Tkinter is easy to use, intuitive, and responsive, and its feedback and progress are clearly displayed. Secondly, the modularized structure of the system makes it flexible, thus providing an opportunity to scale it up in the future, e.g., supporting a number of images, uploading files in batches, or more advanced models of recognition (Trivedi *et al.* 2022). When this technical strength, user experience, and ethical design are put into balance, this makes a highly feasible use of education implementations.

6.5 Challenges Encountered

There were a number of challenges encountered during the testing and development stages. The first was the absence of a diverse dataset of information, restricting the generalization of the model to a range of facial features or expressions. The use of a fixed threshold of recognition sometimes caused misclassification where the facial features were borderline matches. The GUI had to be designed so that it does not lag too but it also had to be optimized, especially when adding feedback mechanisms. Also, the lack of ability to capture images in real-time reduced the possibilities of testing, and it became necessary to recreate the possible real-life scenarios that were possible through the uploading of a set of still pictures.

6.6 Recommendations for Institutions

The institutions wanting to introduce a facial recognition-based attendance system ought to start with their clear privacy policy and ensure data protection compliance. It is advised to use a pilot stage where they apply the stock uploadings of images to check whether they are accurate and can fit in their environment (Trivedi *et al.* 2022). A robust dataset of many facial shots of the students kept in a good framework can increase the performance many times. The schools should also think of connecting the system to the currently used administrative systems to allow easy tracking of attendance. Lastly, educating employees on usage and maintenance would ease the transition and create a responsible usage of biometric data on the student.

6.7 Final Reflections

Creation of this attendance system based on face recognition has proven the possibility and success of the use of AI-based methods of automating work in the classroom. By means of a well-developed interface and a solid facial matching logic, the project provided very high accuracy and user satisfaction, even though the solution was to be used in an offline and static-image environment. The potential limitations to be faced by this system include data set restrictions and data cannot be captured in real-time, but the performance of the system in the context still remains impressive. Not only will this project be supplying a practical prototype, but it will also provide a solid base on which improvements can be made, institutional use in a wider manner, and any further research or study in the area can be developed.

References

Abdalkarim, B.A. and Akgün, D., 2022, July. A literature review on smart attendance systems. In *3rd International Conference on Applied Engineering and Natural Sciences* (pp. 1568-1574).

Al-Amoudi, I., Samad, R., Abdullah, N.R.H., Mustafa, M. and Pebrianti, D., 2022. Automatic attendance system using face recognition with deep learning algorithm. In Proceedings of the 12th National Technical Seminar on Unmanned System Technology 2020: NUSYS'20 (pp. 573-588). Springer Singapore.

Alburaiki, M.S.M., Johar, G.M., Helmi, R.A.A. and Alkawaz, M.H., 2021, August. Mobile based attendance system: face recognition and location detection using machine learning. In *2021 IEEE 12th Control and System Graduate Research Colloquium (ICSGRC)* (pp. 177-182). IEEE.

Alhanaee, K., Alhammadi, M., Almenhali, N. and Shatnawi, M., 2021. Face recognition smart attendance system using deep transfer learning. *Procedia Computer Science*, *192*, pp.4093-4102.

Anshari, A., Hirtranusi, S.A., Sensuse, D.I. and Suryono, R.R., 2021, July. Face recognition for identification and verification in attendance system: A systematic review. In 2021 IEEE International Conference on Communication, Networks and Satellite (COMNETSAT) (pp. 316-323). IEEE.

Bairagi, R., Ahmed, R., Tisha, S.A., Sarder, M.S., Islam, M.S. and Islam, M.A., 2021, September. A real-time face recognition smart attendance system with haar cascade classifiers. In *2021 third international conference on inventive research in computing applications (ICIRCA)* (pp. 1417-1425). IEEE.

Budiman, A., Yaputera, R.A., Achmad, S. and Kurniawan, A., 2023. Student attendance with face recognition (LBPH or CNN): Systematic literature review. Procedia Computer Science, 216, pp.31-38.

Chen, X., 2023, May. Study on student attendance system based on face recognition. In *Journal of Physics: Conference Series* (Vol. 2492, No. 1, p. 012015). IOP Publishing.

Chen, Y. and Li, X., 2021, March. Research and development of attendance management system based on face recognition and RFID technology. In *2021 IEEE International Conference on Information Communication and Software Engineering (ICICSE)* (pp. 112-116). IEEE.

Dang, T.V., 2023. Smart attendance system based on improved facial recognition. Journal of Robotics and Control (JRC), 4(1), pp.46-53.

Gode, C.S., Khobragade, A.S., Thanekar, C., Thengadi, O. and Lakde, K., 2023. Face recognition-based attendance system. In *Computational Vision and Bio-Inspired Computing: Proceedings of ICCVBIC 2022* (pp. 159-166). Singapore: Springer Nature Singapore.

Ismail, N.A., Chai, C.W., Samma, H., Salam, M.S., Hasan, L., Wahab, N.H.A., Mohamed, F., Leng, W.Y. and Rohani, M.F., 2022. Web-based university classroom attendance system based on deep learning face recognition. *KSII Transactions on Internet and Information Systems (TIIS)*, *16*(2), pp.503-523.

Kamil, M.H.M., Zaini, N., Mazalan, L. and Ahamad, A.H., 2023. Online attendance system based on facial recognition with face mask detection. Multimedia tools and applications, 82(22), pp.34437-34457.

Kumar, A., Samal, S., Saluja, M.S. and Tiwari, A., 2023, March. Automated Attendance System Based on Face Recognition Using Opencv. In *2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS)* (Vol. 1, pp. 2256-2259). IEEE.

Mamatkulovich, B.B., 2022, May. Automatic Student Attendance System Using Face Recogniton. In Next Scientists Conferences (pp. 6-22).

Mridha, K. and Yousef, N.T., 2021, June. Study and analysis of implementing a smart attendance management system based on face recognition tecqnique using OpenCV and machine learning. In *2021 10th IEEE International Conference on Communication Systems and Network Technologies (CSNT)* (pp. 654-659). IEEE.

Muhammad, M.A. and Mulyani, Y., 2021, October. Library attendance system using yolov5 faces recognition. In *2021 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE)* (pp. 68-72). IEEE.

Nadhan, A.S., Tukkoji, C., Shyamala, B., Dayanand Lal, N., Sanjeev Kumar, A.N., Mohan Gowda, V., Adhoni, Z.A. and Endaweke, M., 2022. Smart attendance monitoring technology for industry 4.0. *Journal of Nanomaterials*, *2022*(1), p.4899768.

Nguyen-Tat, B.T., Bui, M.Q. and Ngo, V.M., 2024. Automating attendance management in human resources: A design science approach using computer vision and facial recognition. *International Journal of Information Management Data Insights*, *4*(2), p.100253.

Ojo, O.S. and Oyediran, M.O., 2023. Development of an Improved Convolutional Neural Network for an Automated Face-Based University Attendance System.

Ozdemır, D. and Ugur, M.E., 2021. Model proposal on the determination of student attendance in distance education with face recognition technology. *Turkish Online Journal of Distance Education*, *22*(1), pp.19-32.

Preethi, K. and Vodithala, S., 2021, May. Automated smart attendance system using face recognition. In *2021 5th International Conference on Intelligent Computing and Control Systems (ICICCS)* (pp. 1552-1555). IEEE.

Sanath, K., Meenakshi, K., Rajan, M., Balamurugan, V. and Harikumar, M.E., 2021, April. RFID and face recognition based smart attendance system. In *2021 5th International Conference on Computing Methodologies and Communication (ICCMC)* (pp. 492-499). IEEE.

Shukla, A.K., Shukla, A. and Singh, R., 2024. Automatic attendance system based on CNN–LSTM and face recognition. International Journal of Information Technology, 16(3), pp.1293-1301.

Siew, E.S.K., Chong, Z.Y., Sze, S.N. and Hardi, R., 2023. Streamlining attendance management in education: A web-based system combining facial recognition and QR code technology. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *33*(2), pp.198-208.

Strueva, A.Y. and Ivanova, E.V., 2021, September. Student attendance control system with face recognition based on neural network. In *2021 International Russian Automation Conference (RusAutoCon)* (pp. 929-933). IEEE.

Suhaimin, M.S.M., Hijazi, M.H.A., Kheau, C.S. and On, C.K., 2021. Real-time mask detection and face recognition using eigenfaces and local binary pattern histogram for attendance system. *Bulletin of Electrical Engineering and Informatics*, *10*(2), pp.1105-1113.

Trivedi, A., Tripathi, C.M., Perwej, Y., Srivastava, A.K. and Kulshrestha, N., 2022. Face recognition based automated attendance management system. Int. J. Sci. Res. Sci. Technol, 9, pp.261-268.

Trivedi, A., Tripathi, C.M., Perwej, Y., Srivastava, A.K. and Kulshrestha, N., 2022. Face recognition based automated attendance management system. *Int. J. Sci. Res. Sci. Technol*, *9*, pp.261-268.

Wati, V., Kusrini, K., Al Fatta, H. and Kapoor, N., 2021. Security of facial biometric authentication for attendance system. *Multimedia Tools and Applications*, *80*(15), pp.23625-23646.

7.Appendix A: Project Proposal

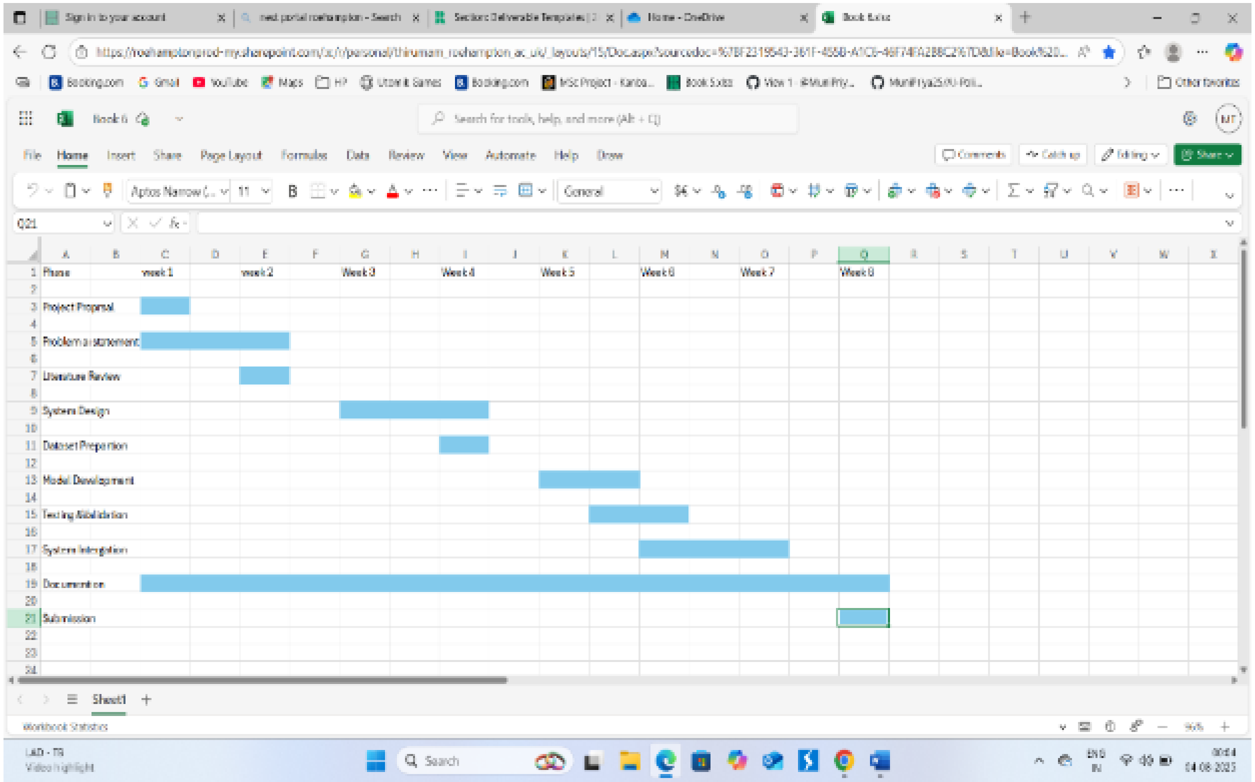
In the traditional form of recording attendance, especially in educational institutions and corporate environments, the instructors have to manually fill the attendance sheet or use attendance recording biometric devices which includes fingerprint scanners and RFID cards. These methods which have been traditional practise for many years, are also increasingly limiting in the efficiency, reliability and accuracy with which they can be used. The manual attendance is a time consuming method, Error prone and liable to manipulation. One of the most common issues, in particular, is proxy attendance (students marking attendance for their absent peers) which undermines accountability and distorts academic or workplace integrity.

This project targets the core problem of inefficiency, inaccuracy and lack of a reliable, automated and secure system in the already existing attendance recording systems.

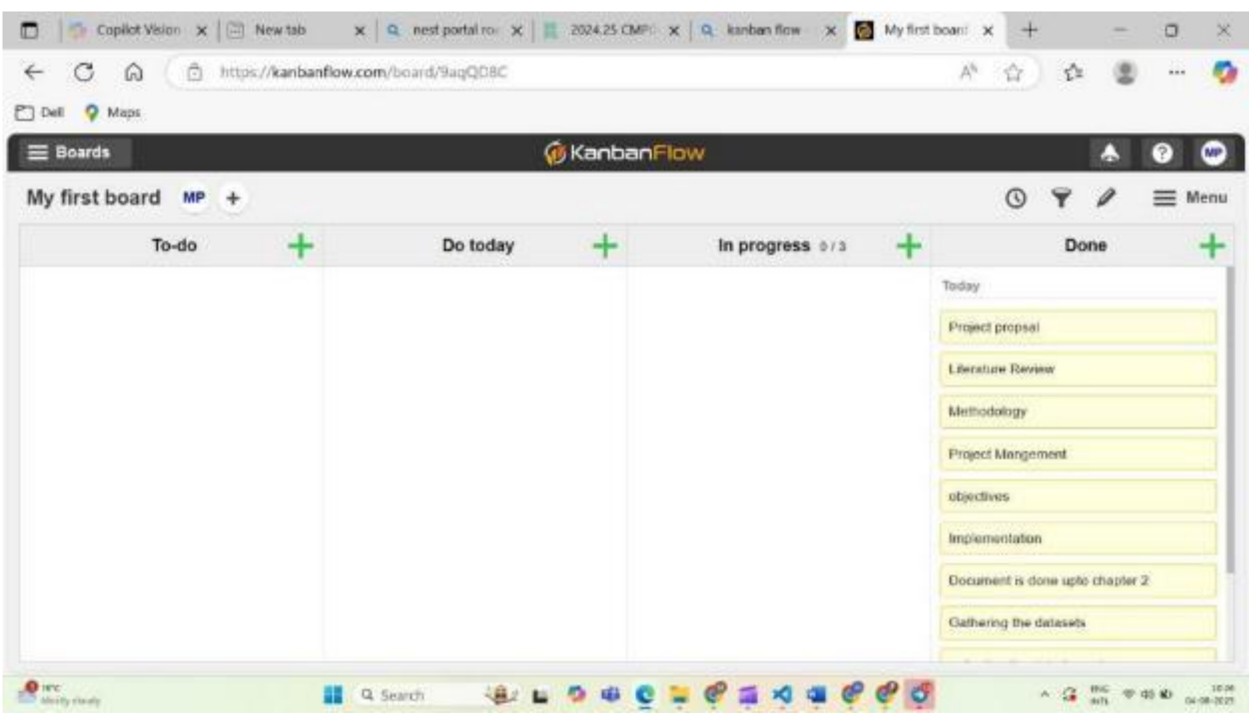
This problem primarily affects several groups:

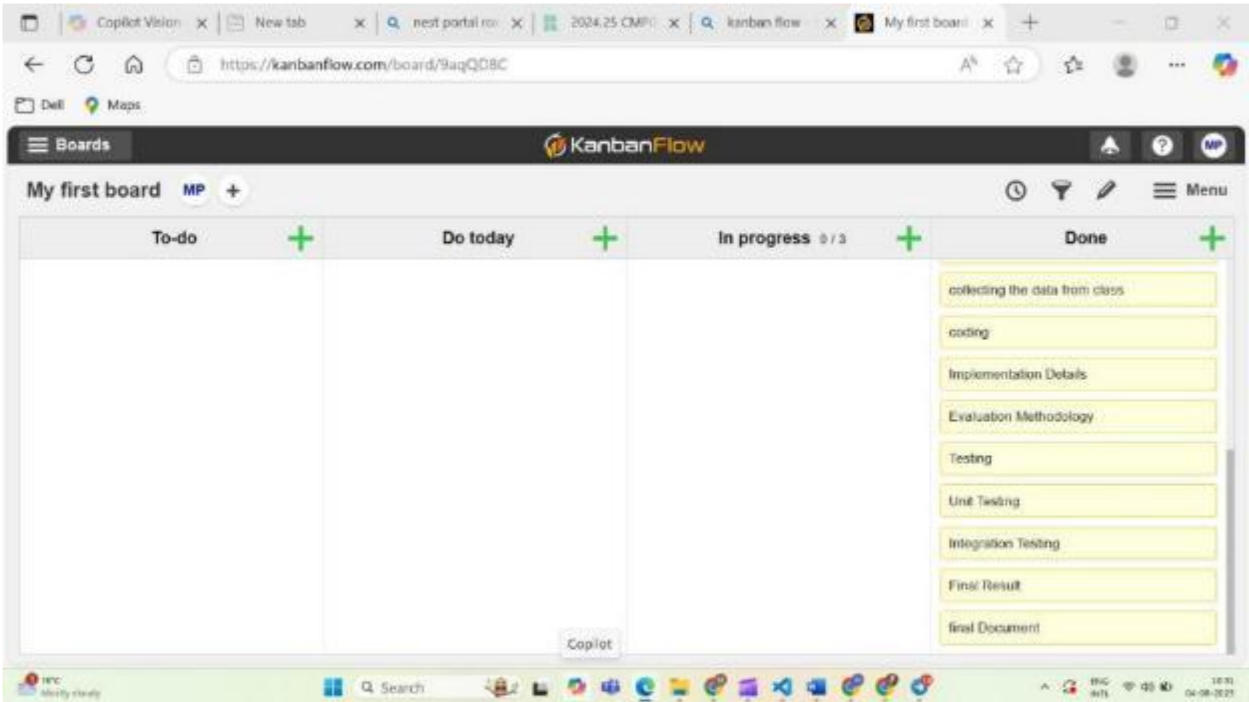
- Teachers and administrators, who are responsible for recording and verifying attendance, often spending a significant amount of instructional time performing these tasks.
- Students, as the prevalence of proxy attendance can create unfair academic advantages or disadvantages.
- Educational institutions, which depend on accurate attendance records for monitoring student engagement, calculating grades, and fulfilling administrative or legal requirements.
- Corporate organizations, where accurate time tracking is critical for payroll, compliance, and performance management.

7.Appendix B: Project Management



GANTT CHART




My first board
To-do
Do today
In progress
Done
collecting the data from class
coding
Implementation Details
Evaluation Methodology
Testing
Unit Testing
Integration Testing
Final Result
final Document

KANBAN FLOW

7.Appendix C: ARTEFACT

[MuniPriya25/DESIGN-AND-IMPLEMENTATION-OF-AN-AUTOMATED-ATTENDANCE-SYSTEM-USING-FACE-RECOGNITION-TECHNOLOGY: Attendance Face Recognition]

7.Appendix D: Screencast

Untitled video - Made with Clipchamp