NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF SOFTWARE ENGINEERING

ATTENDANCE SYSTEM BASED ON FACE RECOGNITION

M.Sc. THESIS

MODIBO KEITA

Nicosia

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M.Sc. THESIS

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January, 2025

Approval

We certify that we have read the thesis submitted by Modibo Keira titled "**Attendance System Based on Face Recognition**" and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master in Engineering.

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Declaration

I hereby declare that all information, documents, analysis and results in this thesis have been collected and presented according to the academic rules and ethical guidelines of the Institute of Graduate Studies, Near East University. I also declare that as required by these rules and conduct, I have fully cited and referenced information and data that are not original to this study.

Modibo KEITA

16/01/2025

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Modibo KEITA

Abstract

Facial Recognition-Based Attendance System

Modibo Keita
M.Sc, Department of Software Engineering

February 2025, 63 pages

Attendance Monitoring systems have become an essential component of educational institutions. This thesis presents a facial recognition-based attendance monitoring system that aims to build an automated attendance monitoring system and provides an easy way to track students' presence which records student attendance by detecting and recognizing their faces. The study starts by introducing the problem of manual attendance marking and its deficiencies, With this automated system the students don't need to physically mark their attendance. However, the innovation of technology helps to develop a sophisticated and automated system that provides a lot of advantages over a manual system and minimizes mistakes or organizational issues. Additionally, the system integrates the MySQL recods for managing and storing attendance data and image processing regarding the system's capacity to identify and discern faces and mark attendance. Testing the system with real-time data shows the accuracy and efficiency in tracking student presence. This system can significantly improve attendance monitoring by providing both time-saving and reliable solutions for educational institutions.

The recommendation includes future improvements for scalability, emphasis accuracy and mobile platform integration.

Key Words: face recognition, attendance system, image processing, automation, machine learning.

Özet

Facial Recognition-Based Attendance System

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Katılım İzleme sistemleri eğitim kurumlarının vazgeçilmez bir bileşeni haline gelmiştir. Bu tez, otomatik bir katılım izleme sistemi oluşturmayı amaçlayan ve öğrencilerin katılımını yüzlerini algılayarak ve tanıyarak kaydeden öğrencilerin katılımını takip etmenin kolay bir yolunu sağlayan yüz tanıma tabanlı bir katılım izleme sistemi sunmaktadır. Çalışma, manuel katılım işaretleme sorununu ve eksikliklerini tanıtarak başlar. Bu otomatik sistemle öğrencilerin katılımlarını fiziksel olarak işaretlemelerine gerek kalmaz. Ancak, teknolojinin yeniliği, manuel bir sisteme göre birçok avantaj sağlayan ve hataları veya organizasyon sorunlarını en aza indiren sofistike ve otomatik bir sistem geliştirmeye yardımcı olur. Ek olarak, sistem katılım verilerini yönetmek ve depolamak için MySQL kayıtlarını ve sistemin yüzleri tanımlama ve ayırt etme ve katılımı işaretleme kapasitesiyle ilgili görüntü işlemeyi entegre eder. Sistemin gerçek zamanlı verilerle test edilmesi, öğrenci varlığını izlemedeki doğruluğu ve verimliliği gösterir. Bu sistem, eğitim kurumları için hem zamandan tasarruf sağlayan hem de güvenilir çözümler sunarak katılım izlemeyi önemli ölçüde iyileştirebilir.

Öneri, ölçeklenebilirlik, vurgu doğruluğu ve mobil platform entegrasyonu için gelecekteki iyileştirmeleri içerir.

Anahtar Sözcükler: yüz tanıma, katılım sistemi, görüntü işleme, otomasyon, makine öğrenimi.

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List of Abbreviations

AI:	Artificial Intelligence
OpenCV:	Open Source Computer Vision Library
GDPR:	General Data Protection Regulation
LBP:	Local Binary Pattern
LBPH:	Local Binary Patterns Histogram
HOG	Histogram of oriented gradient
MTCNN:	Multi-task cascade convolutional neural network
PCA	principal component analysis
CSS	Cascading Style Sheet
MySQL:	My Structured Query Language
JS:	JavaScript
HTML:	Hypertext Markup Language
PHP:	Hypertext Preprocessor
LFW:	Labeled Faces in the Wild benchmark
GPU:	Graphics processing unit
LDA:	Linear Discriminant Analysis
SVM:	Support vector machine
API:	Application Programming Interface

MAS:	Manual attendance system
DL:	Deep Learning
CNN:	Conventional Neural Network
RFID:	Radio Frequency Identification
ML:	Machine Learning
BF:	Bilateral Filter
SSD:	Single Shot Multibox Detector
AAS:	Automated Attendance System

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CHAPTER I
Introduction

1- Overview of Facial Recognition-Based Technology

Attendance provides a crucial part in educational institutions. This research explores an attendance system that utilize facial recognition-based technology to identify and dicern faces and mark attendance. This technique overcomes the traditional way of tracking student attendance, which can have some issues such as being time-consuming, and inefficient when students are marking their attendance by labelling their name or ID Number [1]. However, an automated system which uses biometric identification such as fingerprint, and iris using IFRD cards has its limitations, advantages and disadvantages, therefore this is where the face recognition method comes in to overcome these limitations and propose a solution which facilitates the automation of attendance tracking without time-consuming, and ensure efficiency, accuracy, and reliability.

The classical attendance systems rely on manual ways to mark attendance, in which there is a possibility to fake it or be prone to inaccuracies. Additionally, the problem could be the inefficiency of existing systems and liability concerns. However, the advancement of technology emphasises how face recognition technology can offer potential and the best way to solve this problem is by automating attendance marking which minimizes human intervention, avoids fake attendance tracking, and improves security, liability, and ensures better results. The traditional way of tracking student attendance in educational institutions faces many challenges, such as time management, and the possibility of faking it [2]. Despite the progression of technology, there are still various issues to address. This study explores how the integration of face recognition technology can facilitate attendance tracking, and ensure efficiency, security, accuracy, and liability [3]. One of the most important components of the efficient work of educational institutions is attendance monitoring. Responsibility and student performance assessment depend on it.

However, the traditional way of recording student presence is obsolete, expensive and neither very reliable.

Therefore automatically improved systems have appeared with the progression of technology that promotes significant changes in the newest way to record attendance. The main objective of implementing such an automated system is to record attendance, which aims to design and develop an automated attendance system to increase tracking's precision, and effectiveness of student's presence through face recognition-based technology. The study aims to analyse the effectiveness of this system by minimizing attendance fraud and emphasising the insurance of user experience for both students and faculty [4]. Educational institutions have numerous challenges to efficiently monitoring attendance which is the most important in the educational field, indeed to overcome those challenges efficiently, this is where the automation of monitoring attendance system come in with biometric applications such as face recognition, which enable automatically marking attendance [5]. That prevents fake attendance marking because some student can mark the absence of their classmate as present which leads to false records and complicates the tracking of attendance [6]. Nowadays, various educational institutions and organizations devote a lot of time tracking presence for numerous of person manually, however, the manual attendance system is being replaced by technology such as biometric systems and radio Frequency Identification (RFID). Therefore using RFID and biometrics is time-consuming because it will require standing in a queue to mark attendance [7]. In figure 1 represents the process for face detection.

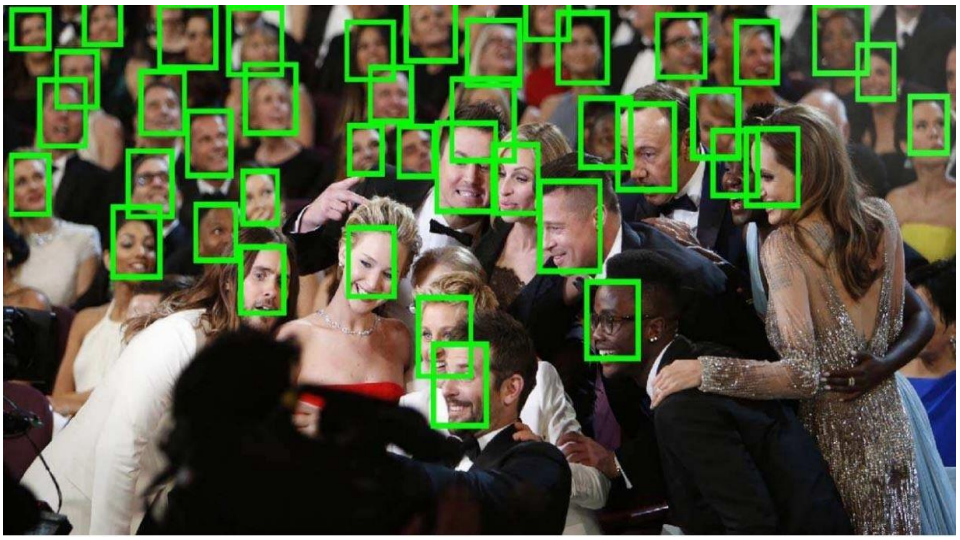

Figure 1.

Face Detection

2- Research Questions

2.1 How efficient and accurate is face recognition-based attendance compared to traditional methods?

In the educational field ensuring efficiency and accurate attendance tracking is more essential than ever. The classic attendance tracking techniques, which rely on the manual way to mark attendance progressively became outdated because of new advancements in innovative technology and have been replaced by these innovative biometric solutions, whereas face recognition technology comes in to replace those outdated methods and proposed the effectiveness, accurate and secure way to implement facial recognition-base automated attendance management system using face recognition technology [2].

Facial recognition-based attendance systems methods are generally highly prcise as well as effective than conventional techniques such as fingerprint, manual attendance or ID card systems. Face recognition technology is a biometric which uses a unique face ID to verify and identify a person [8]. However, the accuracy and efficiency of face recognition technology have been proved by many studies, moreover, the traditional methods are time-consuming because like the fingerprint system require every student to put their finger to mark attendance which is time-consuming to get done. Whereas facial recognition system is more authentic, robust, fast and secure approach compared to other traditional methods, it employs advanced algorithms and Artificial intelligence (AI) to improve accuracy and reduce human errors. Additionally face recognition technology applied to attendance system monitoring provides reliability, efficiency, accuracy, and advanced security features, whereas it uses AI technology to prevent fraud, and ensure seamless operation [9]. The advantages and benefits of using face recognition technology for monitoring attendance systems, are improved accuracy, reliability, enhanced security and prevent fraud. Therefore Attendance tracking is essential in organizations and educational institutions, however using traditional methods can lead to some issues such as security issues, time-consuming and ineffectiveness. Some studies have

shown that manual attendance systems (MAS) can lead to a 3-5% rate of error, which can provide an undesirable result. Whereas facial recognition technology comes in to make a huge difference, this technology uses advanced artificial intelligence (AI) algorithms to detect, verify, and identify a person's face.

According to a survey by MarketsandMarkets, shows in the report that the facial recognition technology can have an accuracy rate up to 99.7%, which makes this technology a more efficient, accurate and reliable biometric method available. It prevents the possibility of human errors and fraud during the attendance marking.

2.2 What effects does the facial recognition-based attendance system have on educational institutions's usability as well as time effectiveness?

The effects of the facial recognition-based attendance system on usability and time performance in educational institutions and other organizations is meaningful. The use of this system includes a huge improvement which streamlines the attendance process by removing the need for traditional methods, such as manual attendance or ID card-based, enabling students to quickly mark their presence without wasting a lot of time [2]. The attendance system based on facial recognition technology significantly minimizes time-consuming when students mark their attendance. However, for the huge classrooms, where classic methods take place could take a lot of time for students to mark attendance. Whereas facial recognition-based attendance can complete the process in seconds. Time efficiency is critical in technique for tracking attendance, an attendance based on facial recognition is efficient, and accurate and does not require a lot of time to be done compared to the traditional way of tracking attendance [10]. Moreover, it impacts time efficiency and ease of use not only in educational institutions but even in organizations that can use this technology for monitoring employees' attendance by scanning their faces and identifying the person. Therefore people don't need to stand in a queue line for mark attendance, which requires a lot of time and is inefficient [11]. This is where an attendance based on facial recognition comes in to overcome these traditional methods by applying artificial intelligence (AI) algorithms such as computer vision using OpenCV, Deep learning (DL) or Machine learning (ML) using CNN [12].

However automating the attendance monitoring system using face recognition technology prevents time-consuming, inefficiency and ensures reliability, and improves the attendance system's precision and effectiveness. This design includes real-time tracking, educational institutions benefit from that real-time attendance, which is effortless and easily accessible for professors and administrative staff.

Table 1.

Impact On Time Efficiency

Factor	Impact on Time Efficiency	Impact on Ease of Use	References
Speed of marking Attendance	Significantly minimizes the time required to mark attendance, as facial recognition happens within seconds compared to traditional methods such as manual or ID card-based systems.	Students and staff can simply look at the camera, and the system logs attendance automatically, with no need for manual input.	(Faceitsystems LPP) (Barla Dikshit et al 2023)
Automation	Automates the whole process, eliminating the need for the professor to manually track class attendance. This system reduces the time-consuming.	The entire system is automatic, easy to use	(Faceitsystems LPP) (Barla Dikshit et al 2023)
Real-time Tracking	Administrators and professors can access attendance records in real-time through an online interface.	Easily accessible	(Faceitsystems LPP) (Valaparla Rohini et al 2022)

2.3 What are the technical and ethical considerations in implementing face recognition for student attendance tracking?

Implementing a facial recognition-based attendance system to track student's performance involves both technical and ethical considerations. Developing such a system must be carefully addressed to guarantee a secure and reliable system. The system must be able to identify the faces accurately in various situations, such as different lighting, angles, and facial expressions. Ensuring that the face recognition algorithm is working efficiently and effectively through the different student faces is a critical part of the facial recognition system [2]. Additionally, a system for automatic attendance (AAS) utilizing facial recognition must have the ability to verify and identify several faces, moreover is essential for avoiding misidentifications. Such a system must also ensure secure storage solutions comply with institutional policies, and ensure scalability while maintaining the integrity of data. The technical require also the setup of high-quality cameras and suitable network infrastructure for real-time processing. Which can prevent misidentification issues and avoid missing attendance of students. However ethical considerations are also one of the essential parts of a facial recognition-based attendance system, collecting biometric data like facial images elevates privacy concerns [2]. Educational institutions must ensure that data collection complies the regulations such as legislative framework known as the General Data Protection Regulation (GDPR) establishes guidelines for the gathering and use of personal data. Additionally, students must be aware of the use of their personal information. The system must ensure robust security protocols to sensitive biometric data from breaking, and prevent unauthorized access to facial recognition data which can lead to significant privacy violations.

2.4 What is the facial recognition-based system's rate of precision under different environmental conditions?

The accuracy rate of facial recognition systems can change significantly under several contextual factors, includind background complexity, lighting, camera

quality, and angles. The different environmental conditions are essential when it comes to implementing such an automated system using facial recognition technology, the entire system depends on it. Moreover, it has to be well stated to overcome these challenges, whether the system cannot handle these different environmental conditions that can lead to errors such as misidentifying, inefficiency, and other issues that make the system inaccurate [13]. In high-lighting conditions, in well-lit environments face recognition systems normally achieve higher accuracy which makes the face's features easily detected, and enables for high precise identification. However the poor lighting conditions, accuracy decreases in poorly lit environments, and it can make it harder for facial features to be detected, which can lead to errors and inaccuracy. Additionally, the poor quality of the camera can also lead to some issues such as the system might struggle to identify and recognize finer facial details. Moreover, angles and facial occlusion, when the face of a person is directly in front of the camera the accuracy can be higher, however, whether the face is covered (e.g. by glasses, masks or hair).

3- Using facial regnition in the attendance system. Using facial recognition technologies in attendance is growing quickly, particularly in educational institutions and organizations [14]. This technology automates the attendance tracking process and improves the accuracy and efficiency. However applying facial recognition-based attendance in educational institutions eliminates the need for manual attendance marking, saving time for professors and administrators which can also generate real-time attendance cords, reducing administrative workload and enabling easy monitoring of student's attendance records. However, face recognition can be applied in contactless attendance such as during pandemics like COVID-19 which provides a hygienic alternative to fingerprint or ID card-based systems, which require physical contact. Additionally, some organizations employ such automated systems using facial recognition technology to manage the attendance of their employees [1]. Moreover, it logs employee's clock-in and clock-out times, which minimizes the need for using ID card-based or manual logging systems and ensures accurate, efficient tracking of work hours. Additionally, it can be applied to access control systems to ensure that only authorized people can enter specific areas, improving workplace security. Facial recognition technology can be applied in many domains. Face recognition attendance system provides faster, more secure, and more

reliable attendance tracking compared to traditional methods, improving both time efficiency and accuracy. In figure 2 represents the diagram process of face recognition.

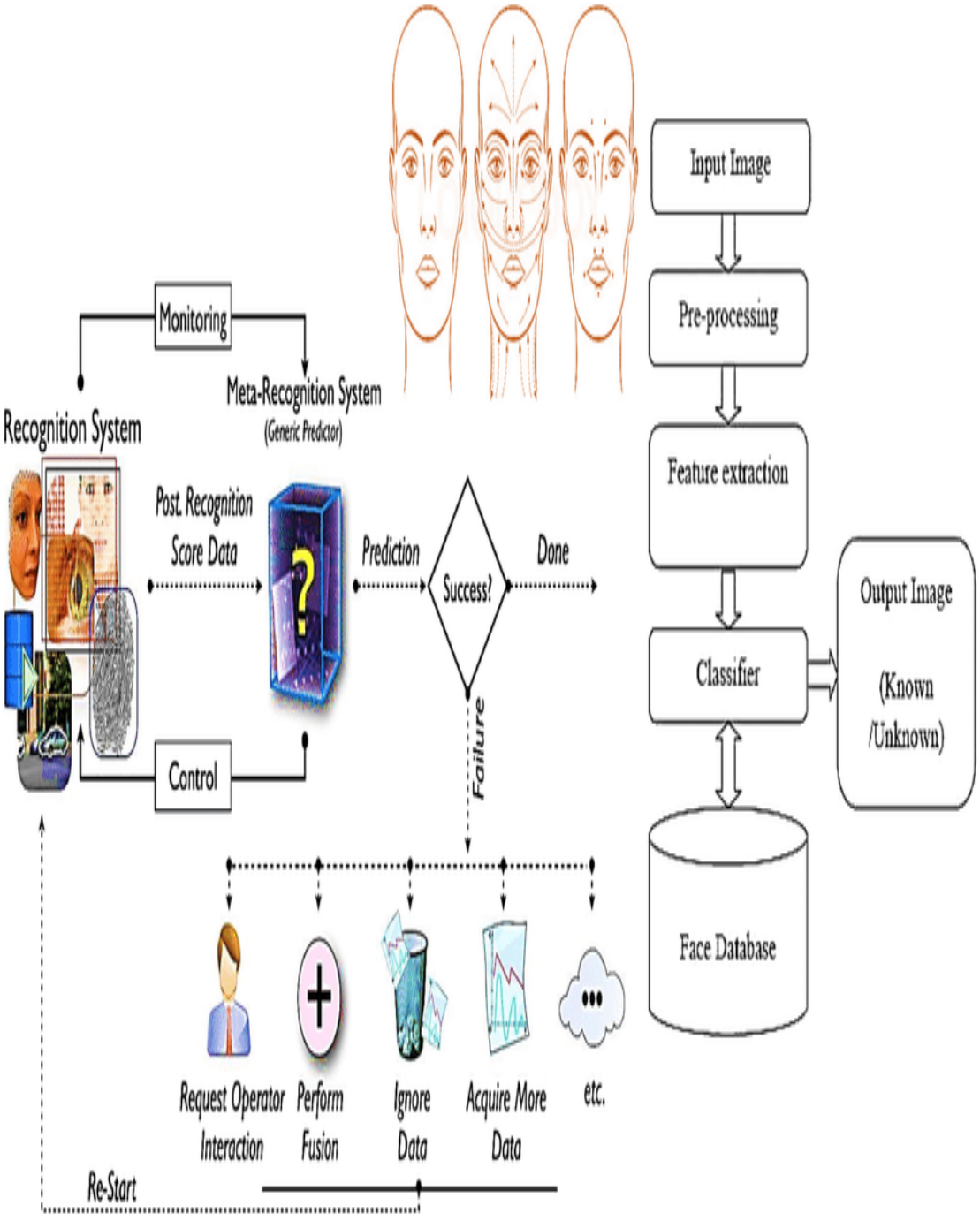

Figure 2.

Facial Recognition Process

Table 2.

Application Areas for Automated Attendance Based On Facial Recognition

N°	Application Areas	Description
1	Attendance Monitoring	Automatically track student's attendance in real-time.
2	Workplaces	Helps the administration to track the presence of the employees.
3	Students Performance	Provides insights into student attendance patterns for enhancing performance.
4	Access Control	Controls access to restricted within educational institutions using facial recognition
5	Surveillance Camera	Helps educational institutions to ensure security within the campus.
6	Identity Verification	Verifies the identity of persons through facial recognition.
7	Time management	Provides efficient scheduling and tracking for educational institutions activities based on attendance data.

4- Organization of the thesis

I- Chapter 1: Overview

In this sectection, we introduce whole study, also describe what is all about face recognition technology, the objectives of the study, and the application of facial recognition in different fields. We talk about research questions based on face recognition.

II- Chapter 2: Literature Review

Is discussed the primary goal of this section is to emphasize what other researchers or studies have done to prove the efficiency, and accuracy of the application of facial recognition-based attendance.

III- Chapter 3: Techniques

This section is focused on the techniques which points out the methodology applied in this study, and shows the entire process of the study, and the information about the research design, and data collection.

IV- Chapter 4: Results and Analysis

This chapter is about the result and analysis, which presents the different algorithms of artificial intelligence (AI) applied for facial identification, detection, and feature extraction.

V- Chapter 5: Discussion

This section presents the results from the proposed system and compares them with the techniques and outcomes from the current literature. In addition the main discussion will be focused on evaluating the effectiveness and the system’s precision.

VI- Chapter 6: Conclusion and Recommendation

This chapter outlines the results and provides some crucial suggections for additioanal research.

CHAPTER II

Literature Review

This section presents an overview of definitions of concepts in general, theoretical frameworks, also ongoing research on attendance systems based on facial recognition. The most recent studies on attendance based on facial recognition systems is focused on improving of efficiency and accuracy of attendance monitoring systems, therefore attendance monitoring systems have been a critical concern in educational institutions and organizations. However, the need for efficient and accurate attendance monitoring systems has been a significant subject for many researchers, classical or traditional manual attendance systems are frequently laborious and prone to human mistake [15]. Recent advancements in technology, and biometric systems, particularly face recognition, have provided significant and innovative solutions to these challenges. Face recognition technology offers a non-intrusive, rapid, and reliable technique for automating attendance monitoring [16]. The traditional way of marking attendance can be easily manipulated which proves the inefficiency and inaccurate of that method [17]. Refs [8] emphasizes the application of Support vector machine (SVM), convolutional neural network (CNN) and Histogram of oriented Gradient (HOG) algorithms in attendance monitoring systems, and highlights the reliability, and efficiency for automating attendance monitoring systems using these algorithms for facial detection, features extraction, and recognition.

Several investigations conductted int the recent past have demonstrated that the importance of automating attendance monitoring system in educational institutions and originations or workplaces is essential [2]. Despite the availability of many algorithms for automating tracking attendance is still challenging because the uses of facial recognition technology in systems for tracking attendance relies on using some algorithms such as OpenCV, Machine learning (ML) based on deep learning (DL) or Convolutional neural network (CNN), therefore the challenges of application of these algorithms can be related on some situations such as lighting, the poor quality of the camera. However the other manual methods have shown their limitation like card-based scanning or fingerprint, moreover, in ref [18] highlight on using the Haar Cascade algorithm for facial recognition-based attendance. The

traditional techniques of tracking student attendance were insufficient and inaccurate, although the insufficient of traditional methods other manual method was employed for tracking student attendance such as RFID, fingerprint etc. Moreover these methods show their limits and are considered time-consuming, prone to human error, and easy to manipulate attendance. However, that is where the idea of using facial recognition technology comes in for automating attendance monitoring by identifying each person with their faces [11].

Table 3.

Review of Existing Methods and Technologies

Method	Description	Technology applied	Advantages	Limitations
Manual Attendance	Classical based on pen-and-paper technique tracking attendance.	None	Easy to design and no technology need.	Time-consuming, Prone to human errors, and possible to manipulate
Barcode/QR code-Based Systems.	Students scan a barcode or QR code to record their attendance	Barcode/QR code readers, Mobile apps	Simple and quick to use, affordable technology	Requires manual management, depends on functional devices, and can be manipulated through proxy
RFID-Based Attendance	Radio Frequency Identification (RFID) cards are used to mark attendance	RFID readers, RFID cards	Automated And contactless attendance marking	Expensive infrastructure, vulnerable to card loss or abuse.
Biometric Fingerprint Systems	Students mark Attendance by scanning their finger	Fingerprint scanners	Very secure and not easy to manipulate	Poorer accuracy for faded or damaged fingerprints, and hygiene issues.

Facial recognition-Based systems	Utilizes facial recognition methods to identify and record attendance	Camera, face recognition software.	Automated, contactless, and reduces fraud	Accuracy might decrease in poor lighting or with poor quality of camera.
Mobile App-Based Attendance	Attendance is marked via apps, sometimes through the GPS for location verification.	Smartphones, GPS, mobile apps	Suitable for students.	Indispensable network connectivity and device access.
IoT-Integrated Systems	Uses IoT devices for automated attendance marking, can be combined with facial or RFID systems	IoT devices, Cloud servers	Tracking in real-time and scalable for large spaces.	Expensive in production and maintenance.

2.1 Face Recognition Technology

Face recognition is a biometric method which identifies each person based on unique facial features. Additionally, this approach involves numerous stages such as face detection, feature extraction, and matching of features with stored images. However several techniques have evolved to improve facial recognition efficiency and accuracy, each with unique capabilities.

Recently facial recognition technology has become the most popular biometric method applied in numerous domains such as educational institutions, organizations, and workplaces. Additionally, many research and scientists have shown in their studies that among the various biometric methods, facial recognition has several advantages over other biometric methods such as RFID, fingerprint etc [13]. Moreover, they have their advantages, however, compared to facial recognition these methods show their limits.

2.1.1 Traditional Algorithms

The initial algorithms, such as Eigenfaces and Fisherfaces, these algorithms used linear transformations of pixel intensity to represent facial images in a lower-dimensional space. Therefore using these algorithms can provide fundamental accuracy, however, these methods were too sensitive to lighting.

2.1.1.1 Eigenfaces

Eigenface is a holistic approach-based technique for facial feature extraction. It uses Principal Compnent analysis (PCA) to minimize the size of the data. The original data is projected onto a lower dimensional feature space, which is characterized by eigenvectors with large eigenvalues after PCA computes the covariance matrix's eigenvectors [12]. However, A collection of eigenfaces can be used to represent a face image. In a set of eigenfaces, for instance, a person's face may consist of 10% of eigenface 1, 7% of eigenface 2, etc. Principal Component Analysis (PCA) is used to create an eigenface from a sizable collection of training photos [19]. All of the images in this approach have a pixel size of nxn with images 256x256 pixels. Each image should now be converted to a column vector, which should then be inserted into a n 2xm matrix comprising all the images. A large portion of the upcoming matrix calculations used in PCA will be made simpler as a result. Let i be the image's index as a column vector, and let each column vector be called Γi. Repeat the process using the test photos in a different matrix, I.

The finding Average

$$\Psi = \frac{1}{M} \sum_{n=0}^{M} \Gamma n$$

Figure 3 represents an average face, where M is the training set's image count and Γ is the training set's image rate. This allows us to apply the equation $\Phi i = \Gamma i - \Psi i$ to mean-center our images.

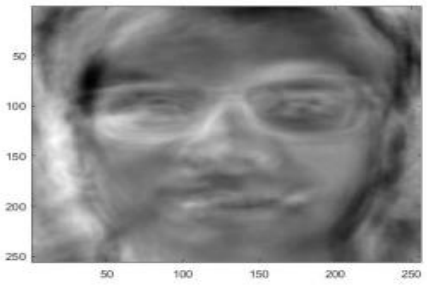

Figure 3.

Eigenfaces Feature Extraction

2.1.1.2 Fisherface. Fisherface decreases the dimensionality of the picture data using Linear Discriminant Analysis (LDA) as an alternative to PCA. LDA is a supervised learning technique, whereas PCA is an unsupervised technique. This is how the two approaches differ from one another [12]. Fisherfaces uses linear discriminant analysis, or LDA, to implement eigenfaces as well. Fisherfaces implement classes, which is the primary distinction between them and eigenfaces. Classes are defined in this context as a collection of distinct images of the same individual. There would be five classes if there were 100 photos in the entire collection, with 20 photos of each individual. This division of classes makes it possible to focus less on the variations in pictures of the same person and more on the variations in the faces of specific persons.

As we will see later, Fisherfaces essentially merely builds upon Eigenfaces by implementing many of the same methods [19]. For the time being, proceed as before at eigenfaces until you obtain your eigenfaces. We shall now discuss Fisherfaces' expansion on Eigenfaces. We must determine the scatter of data within classes, (Sb), and the scatter of data between classes, (Sw), so that we can collapse variance within classes and widen variation between classes.

$$S_b = \sum_{i=1}^{C} N(\mu_1 - \mu_2)^T(\mu_1 - \mu_2)$$

$$S_w = \sum_{i=1}^{C} \sum_{X_k \epsilon X_i}^{M} (U - \mu_2)^T(U - \mu_2)$$

Xk would stand for the kth class in the collection, N would be the number of samples in class Xi, and μi would be the class Xi mean image, whereas μ would.

2.2.1 Machine Learning Approaches. Among the techniques is ML used in artificial intelligence (AI), which has sub-algorithms such as deep learning (DL) and convolutional neural networks. However, that algorithm allows to train and enable systems to recognize, which includes supervised learning and unsupervised learning [20]. Additionally, the supervised learning technique involves applying a well-state feature set to keep track of some features for categorization and necessitates learning features from the test's input and output. A supervised learning algorithm learns from labelled training data, which enables us to estimate unexpected data outcomes [10]. An input learning system is used in the unsupervised technique, and no anticipated output variables are provided. Unsupervised learning techniques include cluster analysis and association mining algorithms. Compared to supervised learning, unattended learning algorithms allow us to perform more complex tasks.

2.2.2 Attendance Monitoring Systems

Attendance monitoring systems are a more important component for every organization or educational institution, which tracks people's performance in different fields. Moreover, traditionally attendance was managed manually, which has ranged from manual roll-call to automated tracking attendance using methods such as RFID cards and fingerprints. However, A smart card that incorporates radio frequency identification (RFID) technology is called an RFID card. To use radio waves for data transmission, storage, and reception, each RFID device has an antenna integrated into it that is connected to an RFID IC. An RFID card's primary purposes are contactless data transmission and automatic object identification. A sample image is represented in Figure 4

Fig 4.

RFID Card Utilization

2.2.3 Integration with Real-Time Face Recognition for Attendance

Integrating facial recognition in an attendance monitoring system enables automated entry of attendance tracking, however real-time face recognition minimizes time-consuming and avoids the possibility of cheating or human error while enabling efficient and accurate tracking [14]. Moreover implementing facial recognition-based attendance systems requires utilizing biometric methods, such as facial recognition technology which allows to use of artificial intelligence (AI) techniques, like machine learning (ML) [21]. Additionally, using machine learning to build a facial recognition-based attendance management system can be based on the subset of machine learning, which is deep learning (DL) and convolutional neural network (CNN).

2.3 Related Research

The researches provided in this work are arranged chronologically, emphasizing the progression of facial recognition technology and its utilisation in attendance monitoring systems. Additionally, in the basic studies in face recognition in the 1990s, early research concentrated on classical image processing methods such as Eigenfaces and Fisherfaces [20-19]. However, these methods represented face images in a lower-dimensional space using linear changes in pixel intensity. Consequently, these algorithms can offer basic accuracy; however, they are excessively light-sensitive and angles, and facial expressions [23]. This research provided the basic for existing face recognition regardless of its limitations. The introduction of machine learning models in the 2000s gained popularity, researchers used methods such as principal component analysis (PCA) and support vector machines (SVMs) to face recognition, which enhanced robustness [24]. However the emergence of convolutional (CNN) and deep learning models, which resulted in advances in facial recognition, DeepFace and FaceNet changed facial recognition through applying their capacity to manage high-dimensional, complicated data [25]. Additionally, these were trained on large datasets and reached high-level accuracy, which makes these methods appropriate for real-time uses, such as attendance monitoring systems [26].

Additionally, in 2019 Serign Modou Bah, et al [27] proposed an algorithm for improving the facial recognition method and its application in attendance monitoring

systems, it uses the Local Binary Pattern (LBP) algorithm in conjunction with sopthisticated image processing techniques including enhanced constrast, bilatral filtering (BF), histogram equalization, and picture blending to adress some issues related to efficiency and accuracy of facial recognition. However, this improves the accuracy of the general facial recognition system and allows to achieve of a reliable and sophisticated face recognition system, which can be designed in real-life areas as an automated attendance monitoring system.

In 2020 Ms Sarika Ashok Sovitkar et al [1] proposed some advanced algorithms for implementing a robust, accuracy and efficient automated attendance monitoring system. The proposed methods are based on facial recognition technology such as Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) applied for feature extraction in facial recognition methods. Principal Component Analysis (PCA) is used for the features extraction, which extracts lower dimensional and computes the Eigen faces, however, Linear Discriminant Analysis (LDA) is used for extracting more discriminating features from faces as Fisherfaces.

In 2022 Valaparla Rohini et al [7] designed an automated attendance system based on facial recognition, which aims to facilitate attendance monitoring tracking and overcome the traditional tracking attendance methods such as Radio Frequency Identification (RFID). Moreover, the designed system provides an automated attendance management system through facial recognition technology such as the Haar cascade classifier, which detects faces and the LBPH method, which recognizes the faces using the artificial intelligence (AI) method, which is machine learning (ML).

In 2022 Ashwin Rao [28] designed an automated attendance monitoring system to overcome the traditional manual attendance monitoring system, which is a standalone attendance system, that allows tracking, analysing and marking students' attendance in real time. However, the proposed system is based on the facial recognition method, which tracks students' attendance and marks their presence through a live camera in the classroom by taking a screenshot of the classroom, processing the face recognition, and recording the student's attendance currently present in the classroom.

In 2023 Barla Dikshit et al [2] implemented an automated attendance management system which concentrated on an automated attendance system for educational institutions and workplaces and overcame the traditional and manual tracking of attendance. Additionally, they applied some algorithms to train datasets of images and recognize faces through the streamline web camera, the used algorithms are the Haar cascade classifier, which allows to detection of faces, and the LBPH method enables to recognition of faces by comparing with the trained dataset. The designed system aims to track attendance automatically and allows the administration and lectures to access an Excel sheet of students or staff marked attendance.

In 2023 Ubong David Essien et al [29] highlighted the implementation of a facial recognition-based attendance system using a deep learning (DL) algorithm. However, according to the author deep learning-based face recognition systems provide high accuracy and good performance when it has come to compare to other techniques of facial recognition such as Eigen faces. Additionally, the new methodologies of facial recognition provide different stages such as face detection, face recognition, feature extraction, face alignment and face representation. Moreover, to ensure high-level accuracy and an efficient system they proposed the application of a multitask convolutional neural network (MTCNN) along with a deep learning algorithm, which is applied for the alignment stage, face detection and a lightweight hybrid. Additionally, emphasises a Python framework based on the DeepFace algorithm, which is applied for the extraction of the face feature, face representation, and face recognition combined with the FaceNet model. However, the technologies applied to achieve that accuracy and high-level performance, such as Hypertext Pre-processor (PHP) and programming interface (API).

In 2024 Atruba Feroze et al [21] proposed an automated system based on facial recognition technology applying educational institutions. However, the proposed system aims to address challenges related to facial recognition algorithms and overcome the classical methods being used in educational institutions, and workplaces. Additionally, these facial algorithms allow us to manage the attendance system efficiently, which are Local Binary Histogram (LBH), Principal Component Analysis (PCA), Eigenfaces, and Fisherfaces to improve system performance.

CHAPTER III
Methodology

Outlining the study's design and data acquisition methods is goal of this section, techniques for analysis, and research method applied to establish and assess a facial recognition-based attendance system. Additionally, the issues which the methodology section addresses include the method used for implementing facial recognition-based attendance monitoring systems. It involves a process of identifying participants and selecting data collection methods in the case of social sciences. An aggregate of qualitative and quantitative methods could be used to assimilate the thoughts into the problem effectiveness, user experience, and flaws related to facial recognition-based attendance monitoring systems. However, the proposed system involves designing and implementing a robust facial recognition algorithm integrated into student's attendance management system. Moreover, the algorithm used is face-api.min.js library, which is based on TensorFlow.js and offers face recognition features within the browser, by combining deep learning methods, particularly convolutional neural network (CNN), which is used for face detection, facial recognition, and face landmark detection.

3.1 Face Detection Models

- **Single shot MultiBox Detector (SSD) Combined with MobileNetV1**

For facial detection, this designed attendance management system uses a Single Shot Multibox Detector (SSD) based on MobileNetV1, which uses a Convolutional neural network (CNN) for facial detection. However, each face's location in a picture will be calculated by the neural net, which will then return the probability and bounding boxes for every face. The goal of this face detector is to detect face bounding boxes with high accuracy rather than low inference time. The quantized model (ssd_mobilenetv1_model) has a size of roughly 5.4 MB [30]. Although this face detector proves to be fairly accurate, SSD is not as quick (in terms of inference time) as other architectures, and real-time performance may not be achievable with this one unless the user's computer has a good Graphics processing unit (GPU). Additionally,

as it turns out, you don't always need that level of precision, and occasionally you'd want to forgo high accuracy in favor of a face detector that is far faster.

- **Tiny face detector**

Compared to the SSD Mobilenet V1 face detector, the Tiny Face Detector is a lot faster, smaller, and less resource-intensive real-time face detector; yet, it performs marginally worse when it comes to detecting small faces. This model should be your go-to face detector on mobile devices and clients with modest resources because it is very portable and web-friendly. The quantized model (tiny_face_detector_model) is only 190 KB in size [30]. Moreover, A bespoke dataset consisting of around 14,000 photos tagged with bounding boxes was used to train the face detector. Additionally, the model has been trained to predict bounding boxes, which completely cover facial feature points; as a result, it generally outperforms SSD MobilenetV1 when used in conjunction with later face landmark detection. This model is essentially an even smaller version of Tiny Yolo V2, substituting depthwise separable convolutions for Yolo's conventional convolutions. Because Yolo is completely convolutional, it can readily adjust to varying input image sizes, allowing it to exchange accuracy for speed (inference time).

- **Facial Landmarks Detection (Landmark Model)**

The landmark model uses a CNN for landmark detection. Additionally, the facial landmark model detects the key points on a face, such as mouth, chin, eyes, and nose. Which uses a Convolutional Neural Network (CNN) based algorithm to predict 68 landmarks on the face. However, this method aims to determine the orientation of the face, which can be helpful for the face alignment, and offering facial recognition high-level accuracy. Figure 5. Represents an image of the 68 landmarks on a face and Figure 6 show Face Landmark Detection.

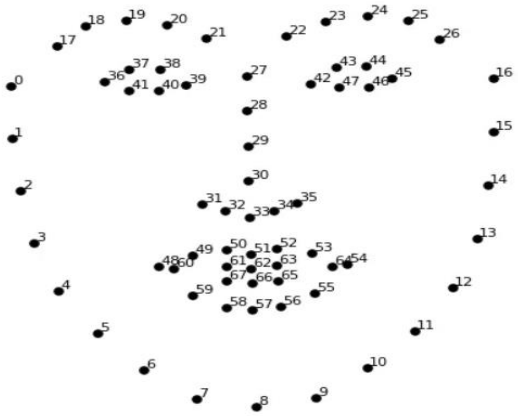

Figure 5.

68 Landmarks On a Face

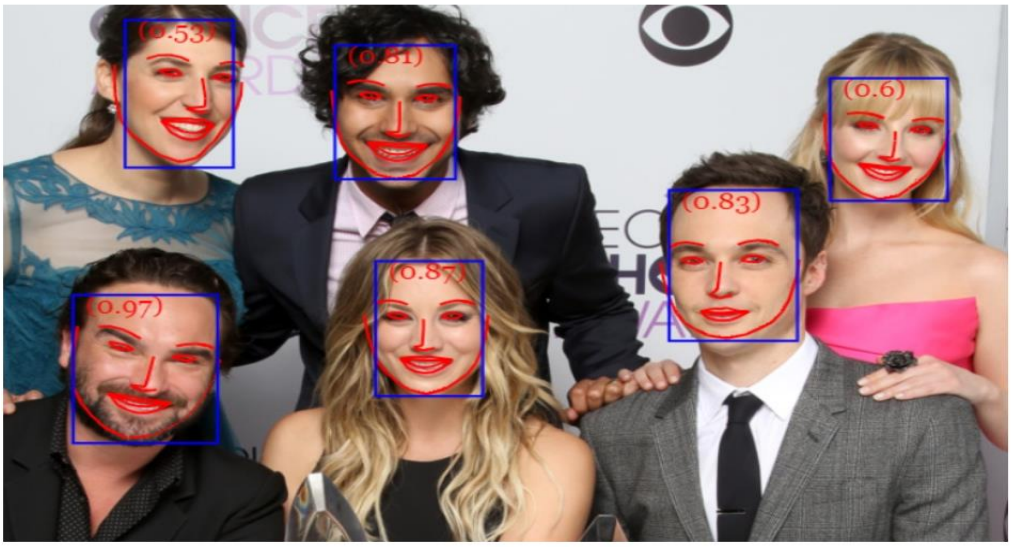

Figure 6.

Face Landmark Detection

3.1.1 Face Recognition Models

- **ResNet-34**

For face recognition, a ResNet-34 similar architecture is constructed to calculate a face descriptor (a feature vector with 128 values) from every given face image, which is used to define the characteristics of a person's face. Additionally, it can use

the model to recognize the faces, however, it is not restricted to the set of faces used for training. By comparing the facial descriptors of two random faces, it may calculate the Euclidean distance to see how similar they are. The neural net is comparable to the net used in the dlib face recognition example and the FaceRecognizerNet used in face-recognition.js. The model achieves a 99.38% prediction accuracy on the Labeled Faces in the Wild benchmark (LFW) for face recognition after the weights were learned through that method. The quantized model has a size of around 6.2 MB (face_recognition_model).

- **FaceNet**

FaceNet model applies a triplet loss function to develop that relates faces to a high-dimensional area**,** where facial similarity is represented by the distances between embedding. To increase the distance between embeddings of different people's faces and minimize the distance between embedding of the same person's face, the model is trained. However faces are encoded into feature vectors applying this approach, and each person is identified by comparing the embeddings. Additionally following the detection of a face, the embeddings are compared to previously stored face embeddings to recognize the face. Figure 7 represents facial recognition.

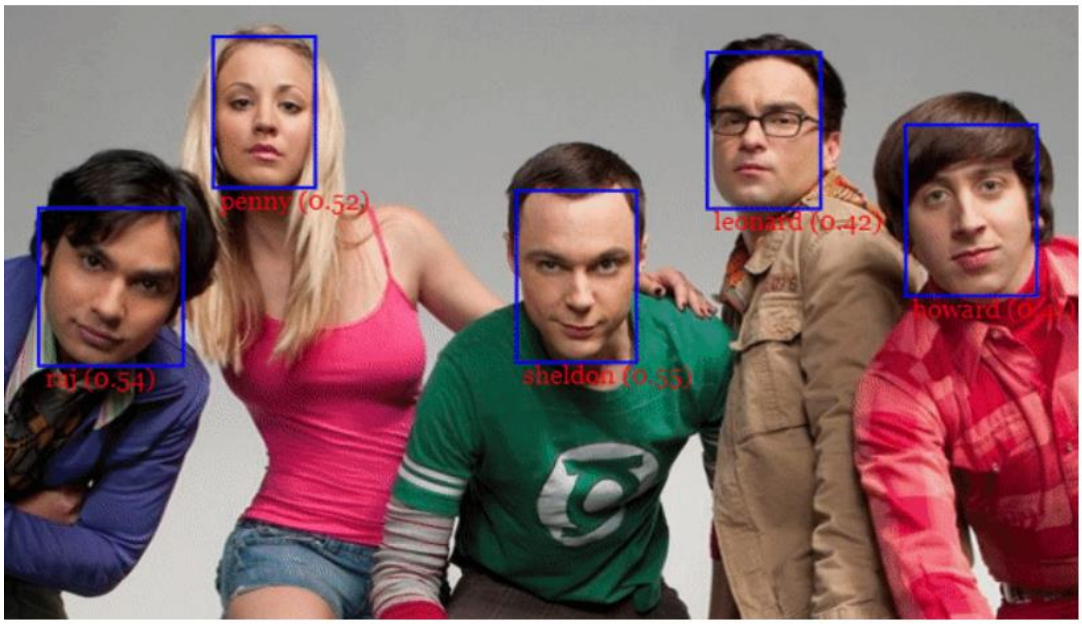

Figure 7.

Face Recognition

3.2 Proposed System

The proposed system's design and framework are provided in this section, covering its elements, procedure, and particular features. The proposed aims to offer and effective and reliable solution while addressing the deficiencies of present methods for facial recognition-based attendance monitoring systems. Everything that the user directly interacts with is usually included in the frontend of this web project for a facial recognition attendance management system. This includes the design, user interface, and user experience elements. The system makes it easier for students to have no trouble logging in, creating an account, and viewing their findings. However, created unique code that functions in their web browser to accomplish this. To make it happen, it utilizes tools like HTML, CSS, and JavaScript. These technologies support client-side interactions, form validation, and the creation of interactive features. The goal of the web project's frontend was to design an interactive, aesthetically pleasing, and intuitive interface that would allow teachers and students to communicate with the system and obtain the attendance report, with the system and obtain the attendance information. Additionally, a login page for approved users, a signup/registration page for new users, and instructions on how to control student attendance are all included in the online application.

These features allow us to employ an easy and error-free method of managing attendance while also attempting to offer a safe and user-friendly experience. Moreover, the front-end is in charge of transmitting data to the back-end and presenting the results to the user, while the back-end manages the processing and creation of results. This entails using APIs (Application Programming Interfaces) or other communication channels to integrate the front-end and back-end. When user input is transmitted to the back-end for processing, it guarantees that the user will see the results in the front-end interface. The face-api-min.js package, which is based on the deepFace technique for face detection and convolutional neural networks (CNNs), has been utilized in this instance. However, this approach provides comprehensive information and produces a result that shows the number of pupils who were there and those who were not. Students and instructors can create their accounts by inputting their information, including name, email address, and mobile number, using this system's interactive and user-friendly interface. Figure 8 show the

block diagram for the face recognition process. In addtion they can then use their username and password to log in. While lecturers can view all of the students' information and attendance records, students can view their information and mark their attendance.

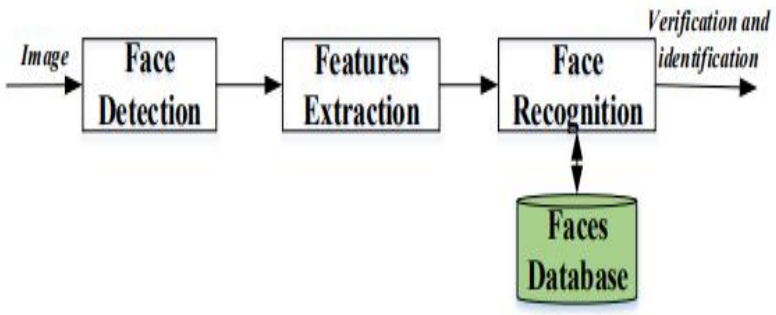

Figure 8.

Block Diagram for the Face Recognition Process

3.2.1 System Overview

The proposed system is based on a facial recognition-based attendance management system, it addresses the deficiencies of traditional or manual methods for managing attendance. However, the aims or objectives of this proposed system are to overcome the classical or traditional manual techniques applied to design an attendance system, such as radio frequency identification (RFID), fingerprint, or manual methods, which are pen-and-paper-based. Traditionally, the Attendance is manually recorded, the person will physically sign or write their names and identification numbers. However, the invention of technology helps to develop an electronic Attendance system that provides a lot of advantages over a manual system. Additionally, the proposed system is also integrated with other organizational software that enables real-time reports and helps to keep communicating with the efforts. This section will discuss the benefits, avenues, and challenges of the system.

However tracking attendance manually is repetitive, complex work that can be prone to errors, some people frequently mark for their absence or others. It can be extra difficult to track all learners' presence and difficult to manage single-student attendance in a large schoolroom for many students [31]. The proposed system used

the method of utilizing facial recognition and recognition context to constantly identify whether students are going to class or not and mark their attendance by comparing their faces with a database to match and mark attendance. This facial context takes a photo of a person using a web camera to distinguish that picture and compares the picture with the picture stored at the time of enrolment if it matches marks the attendance and displays the student's performance constantly. Figure 9 represents a diagram of the proposed system.

3.2.2 System Architecture

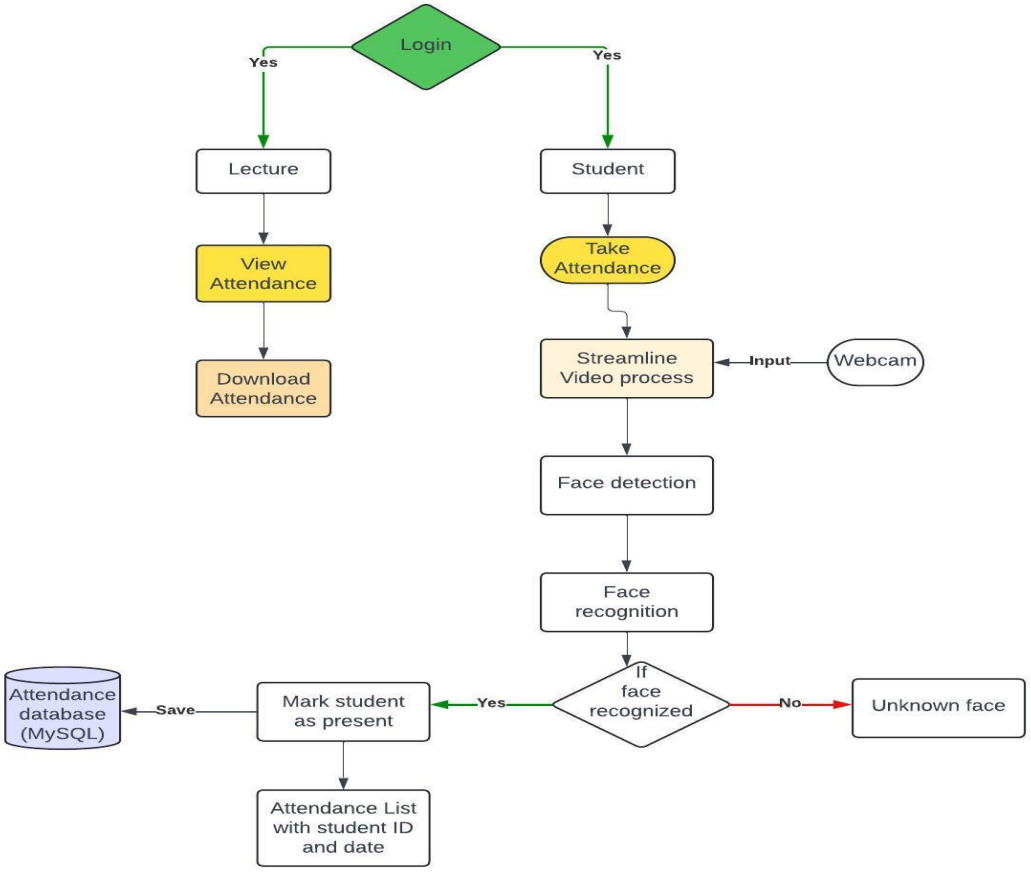

Figure 9.

Proposed System

The proposed system has four main components such as admin, lecture, student component, and database management. However, admin roles are to manage the whole system, such as creating faculty, venue, units, courses, lectures, and

students, thus the student can register themselves allowing students to take their pictures using the web camera of their device, and
Picture will be stored in the database for future attendance marking through face recognition technology by comparing the previously captured picture stored in a database and the detected face via the live video through the web camera. In addition the lectures are allowed to overview the attendance list of the current day and download the attendance list. However, all collected data during the student registration, lectures, attendance list, and courses are stored in the database.

3.2.3 System Workflow

The proposed system aims to provide an accuracy and effective solution to the attendance monitoring system based on facial recognition techniques, however, this system aims to overcome the traditional manual methods applied for managing attendance in educational institutions. Additionally, the process of this proposed system follows such as student registration, lectures, and the creation of courses, faculties, venues, and units.

3.2.3.1 Data Collection

The data acquisition process through the combination of hardware and software to capture students' faces. For instance, the hardware provides a web camera, while the software uses the face-api.js library to process the live video streamline. Figure 10 represent the code snippet for the initialization video stream for data collection.

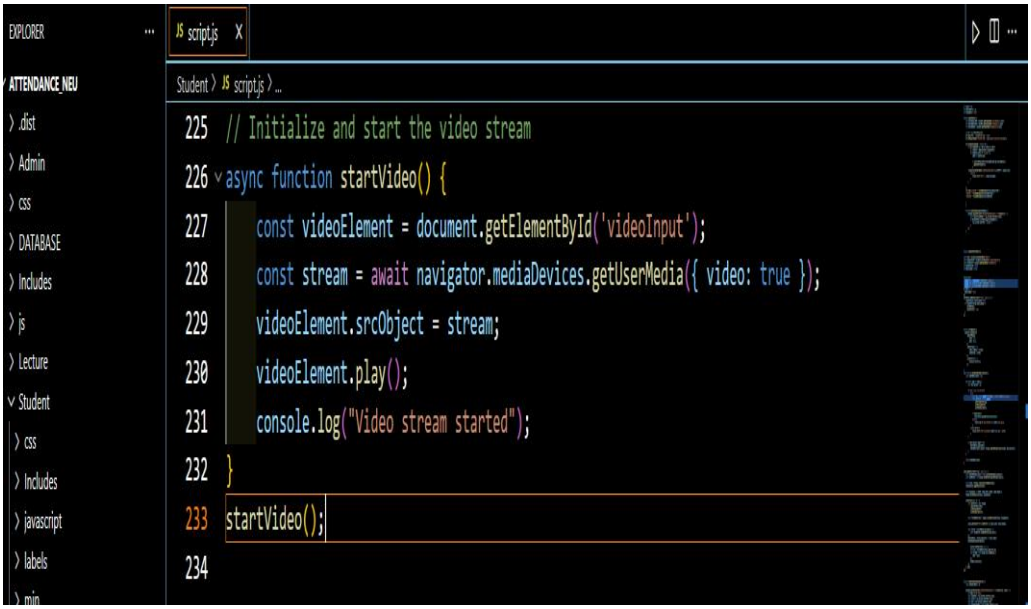

Figure 10.

Initialization of Video Stream for Data Collection

3.2.3.2 Features Extraction

Features extraction concentrates on identifying the unique facial landmarks like nose, mouth and eyes. However, these landmarks represent numerical called face descriptors. This is shown in the figure 11 below.

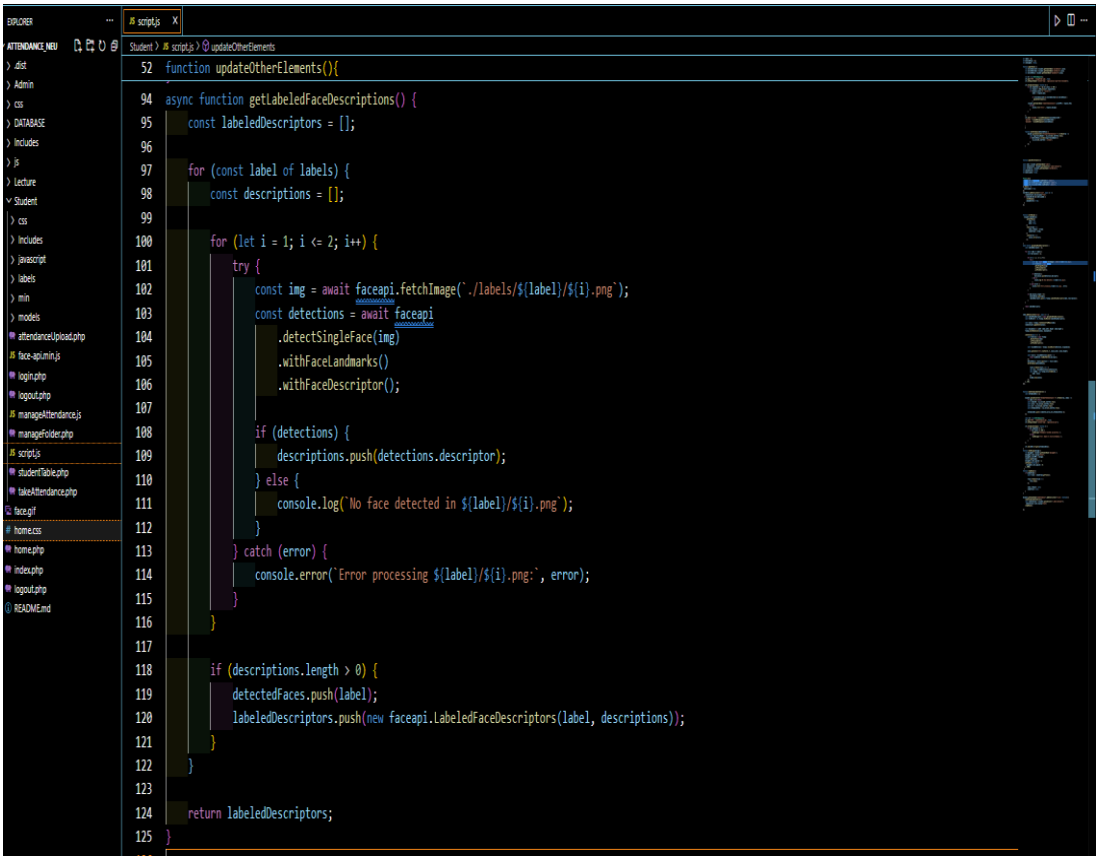

Figure 11.

Code Snippet of Features Eextraction

3.2.3.3 Face Detection

The proposed system detects faces through the live video stream feed. Additionally, bounding boxes are drawn around the detected faces. Figure 12 show the code snippet for facial detection.

Figure 12.

Code Snippet Facial Detection

3.3 Infrastructure for System Development

A stting for development compiles strategies, also tactics for putting a system or piece of software into use, testing it, also troubleshooting it. An important consideration is the development environment, which requires the customer to select from a variety of environmental options and use the one that best meets their demands. Thus, the application will be a complete program made with PHP and JavaScript as the front-end techniques and MySQL as the back-end tool.

3.3.1 Frontend

The foundation of contemporary software engineering is frontend development, which acts as a conduit between users and the underlying features of the system. The frontend component stands out as the canvas that users engage with, explore, and use to get value out of the complex planned facial recognition attendance management system [32]. However using cutting-edge technologies like HTML, CSS, and JavaScript, our frontend aims to produce a smooth and engaging user experience. Because of their adaptability and diversity, these technologies enable us to create interfaces that are not only aesthetically pleasing but also incredibly responsive and user-friendly. Additionally, the dedication to user-centric design concepts is at the core of our frontend development work. The user interface's layout, typography,

color palettes, and interactive features are all carefully designed to promote interaction and make it easier to use. We improve and enhance the frontend to closely match user expectations and preferences through iterative design processes and user feedback loops.

- **HTML**

Primary makup language used to create visual representations on webpages and other platforms that web browsers can view is called Hypertext Markup Language (HTML). There wouldn't be a website without HTML, which is the foundation of all website creation procedures. Using a markup language, ordinary data can be transformed into tables, pictures, links, graghs, also other visual representations [32]. Hypertext is the term used to describe data linkages, also known as hyperlinks that are embedded in the text. The user is directed to another web page when she clicks on the hyperlinked word or phrase. Web browsers work based on viewing HTML files and putting them together to create readable, interactive, or audio-visual webpages. In addition to displaying HTML documents, the web browser employs them to decipher the content of the page. Additionally, we may add HTML links and text-scripts that are presented in JavaScript, which alters the way HTML pages behave and interact.

- **CSS**

The language used for styling in markup language to specify the appearance and design of the documents is called Cascading Style Sheets (CSS). It is frequently used to format HTML and XHTML-based webpages and interfaces. Nearly every website uses CSS for stylesheets to specify its look. CSS is a real web specification. A website's presentation is managed via CSS, which also provides it with a distinctive appearance. It controls style sheets created according to different perspectives, such as screen sizes and device resolutions, and sits on top of other format presentations [32]. The main purpose of CSS is to keep the layout, colour scheme, and fonts of a document distinct from its presentation. Additionally, Content accessibility is enhanced, scalability and flexibility in defining appearance aspects are increased, multiple webpages can share designs, also this separation reduces the complexity and duplication of interaction in a presentational format.

- **JavaScript (JS)**

One of the fundamental components of computer scripting languages is JavaScript (JS). Web pages are commonly used to simply allow web-browser writing for synchronous interactive, user interaction, browser preference control, and document content modification. Additionally, it is employed in coding, server side coding, and the creation of desktop and mobile applications. JavaScript is a scripting language based on prototypes that has numerous helpful features like syntax highlighting. Its syntax is influenced by C. However the semantics of JavaScript and Java are very different, even though JavaScript uses some of Java's vocabulary and identification principles.

3.3.2 Backend Development

Front-end development work is integrated by back-end development tools, which oversee systematic logical operations on the server side. MySQL is used as the backend in the database design. The backend component is in charge of processing data and producing outcomes, whereas the frontend manages user interactions and presentation. APIs (Application Programming Interfaces) and other communication techniques help to facilitate communication between the frontend and backend. Frontend user input is routed to the backend for processing, where face-api.js-based techniques such as the Single Shot Multibox Detector (SSD) based on MobileNetV1 for face detection are used to evaluate the data. Additionally based on the processed data, the backend produces results, which are then sent back to the frontend for the user to see. Efficient processing of user requests and smooth data flow are guaranteed via frontend and backend integration. In addition in the implemented face recognition attendance management system that is put into use, the backend component acts as the foundation of the whole program, managing a wide range of functions from data processing to producing results. For smooth operation and effective user interaction, its frontend integration is essential. The creation of strong channels of communication between the frontend and backend modules is essential to backend integration. Which specify the endpoints and protocols used for data exchange. We guarantee that the frontend can efficiently transmit user inputs and

requests to the backend for additional processing by establishing unambiguous interfaces and protocols. Figure 13 code snippet for sending data to the server.

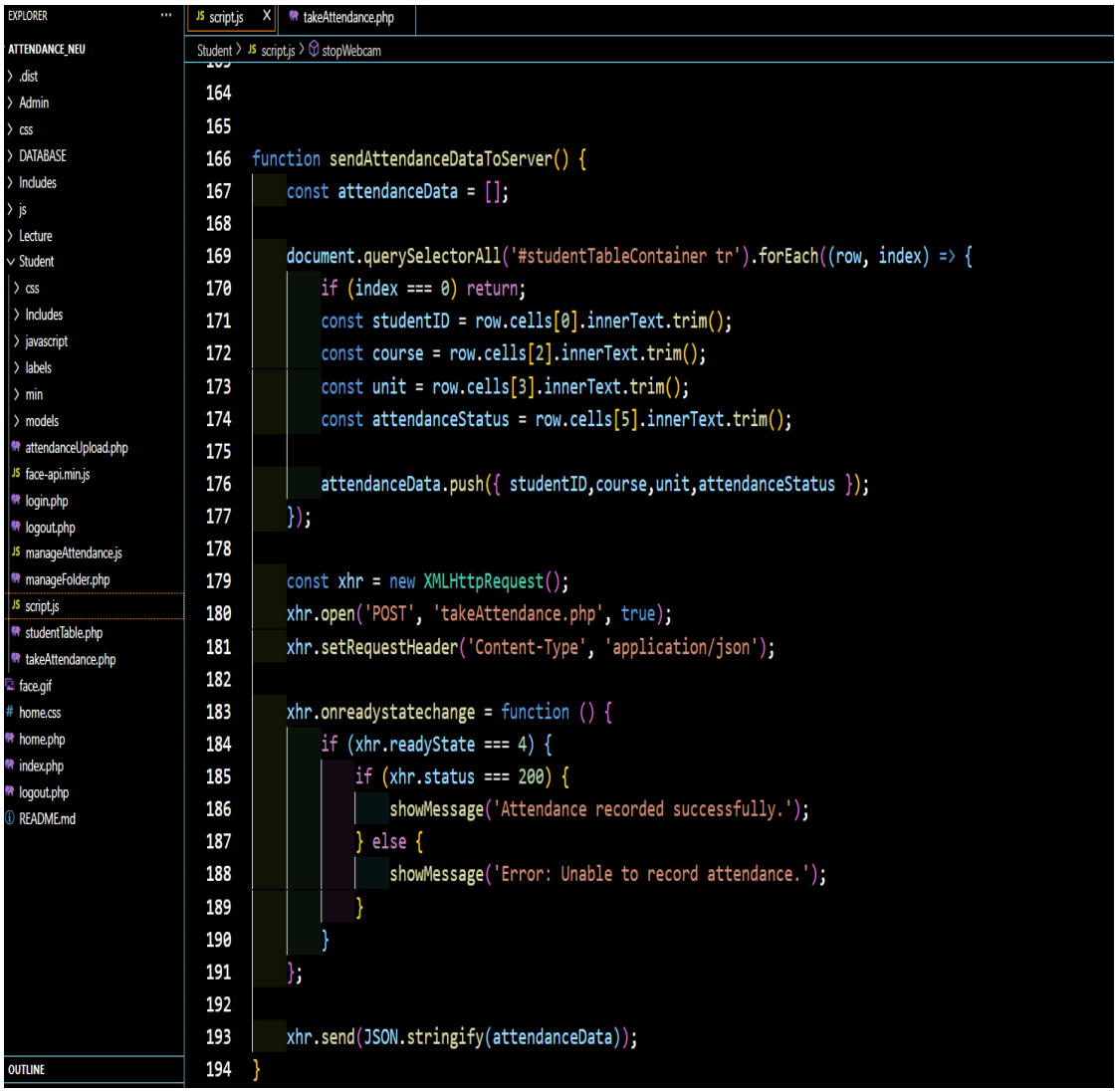

Figure 13.

Sending Data to the Server

CHAPTER IV
Results and Analysis

Using the face-api.js library, which is based on convolutional neural networks (CNNs) and deepFace techniques, this section presents the results of the study and construction of a facial recognition-based attendance monitoring system. However promising results from the evaluation of the facial recognition automatic attendance system showed how well it identified and recorded students' attendance. Additionally the algorithm showed excellent accuracy using a dataset of 2 photos of student taken in a range of lighting and facial expression scenarios. Although this degree of accuracy held steady under various illumination and angle settings, demonstrating the system's dependability in practical situations. Fig 15 show the interface for marking attendance. Additionally evaluate how well face identification techniques work in a range of real-world situations [33]. By testing the models' accuracy, the evaluation focuses on how well the models identify and isolate facial segments within the images. The ratio of accurately identified real faces to all possible faces found by the models is known as accuracy. However the raw footage captured by a camera showing various student entry scenarios inside a classroom make up the experimental input. A list of cropped face images taken from each frame of the raw video file, a video compilation with rectangles enclosing the possible faces the models identified, and statistical data like processing time and accuracy are all included in the models' output.

4.1 Face Enrolment and Recognition process

Students' faces are photographed with a webcam and stored in a database and folder. Additionally each student will have two (2) facial photos taken at registration in order to be recognized it as shown in figure 15 below. In addition the face-api.js package, which is based on a Deepface Neural Network with a pretrained FaceNet 512 model, serves as the foundation for this system's face recognition phase. FaceNet 512 is utilized due to its superior precision [29]. To produce more copies of the faces in the face database, image augmentation is done. The feature extraction module generates facial embeddings and compares them to the facial embeddings of the known faces in the face database once the identified faces are saved into a detected

faces folder. However when the most comparable face is located and the face identity is saved in a MySQL database, attendance is recorded. Every class is different, and attendance is determined by the class. This attendance record can be accessed through an API that verifies each user request. Figure 14 represents the home page of the system. However the figure 16a and 16b, show the attendance Interface for taking attendance.

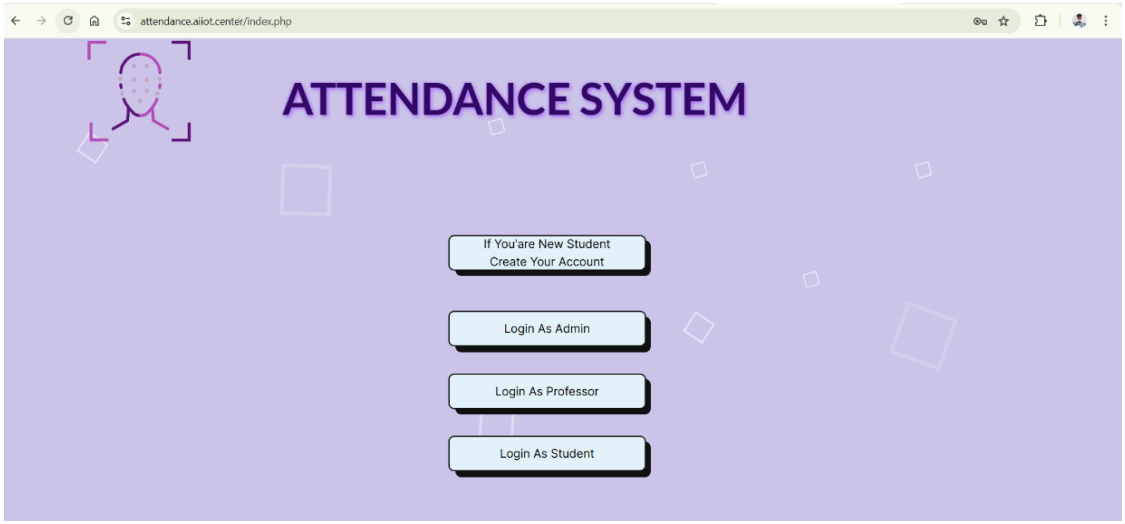

Figure 14.

Home Page of the Application

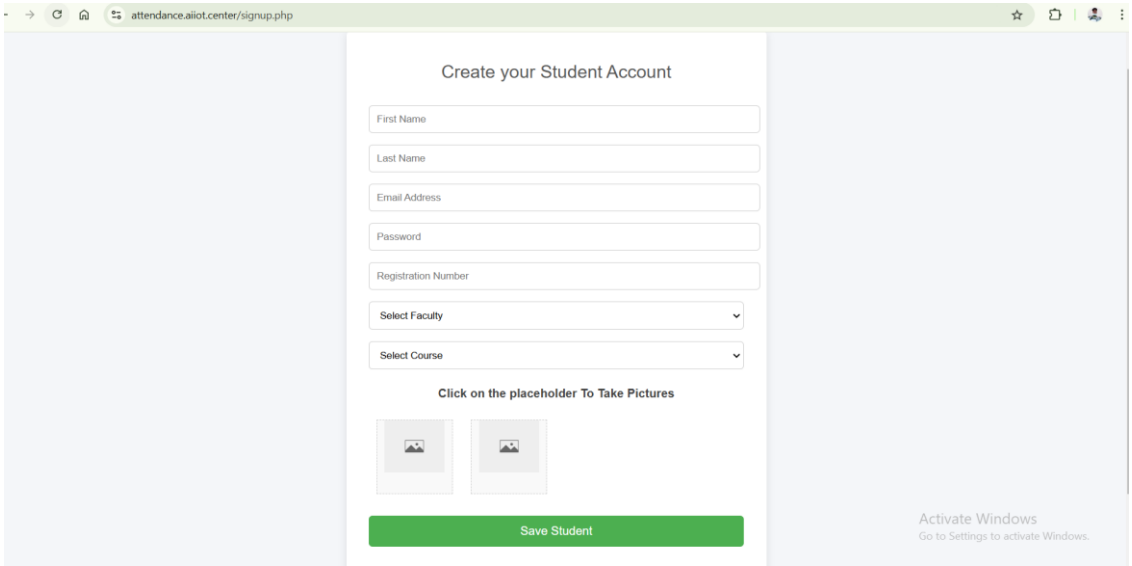

Figure 15.

Student Registration Form.

4.2 Taking and keeping attendance record

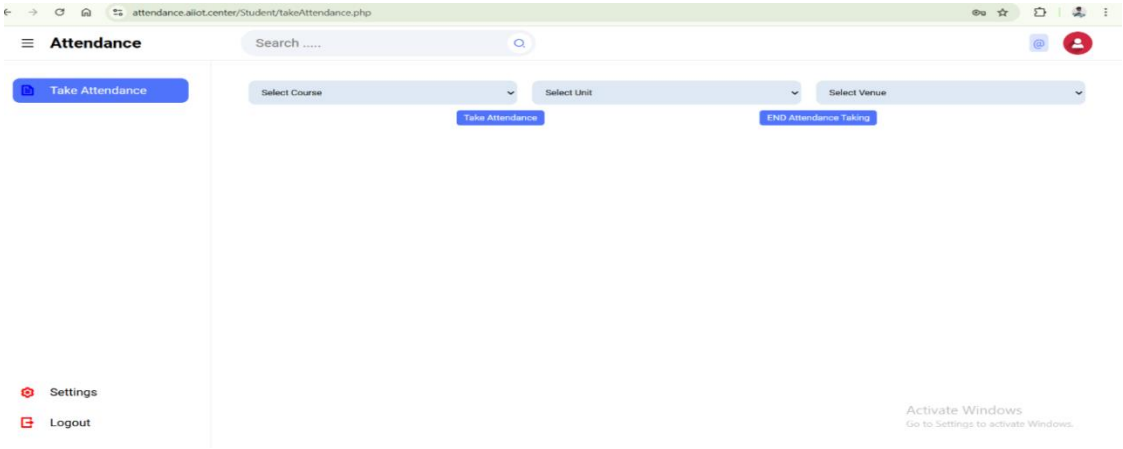

Figure 16a.

Attendance Interface for Taking Attendance

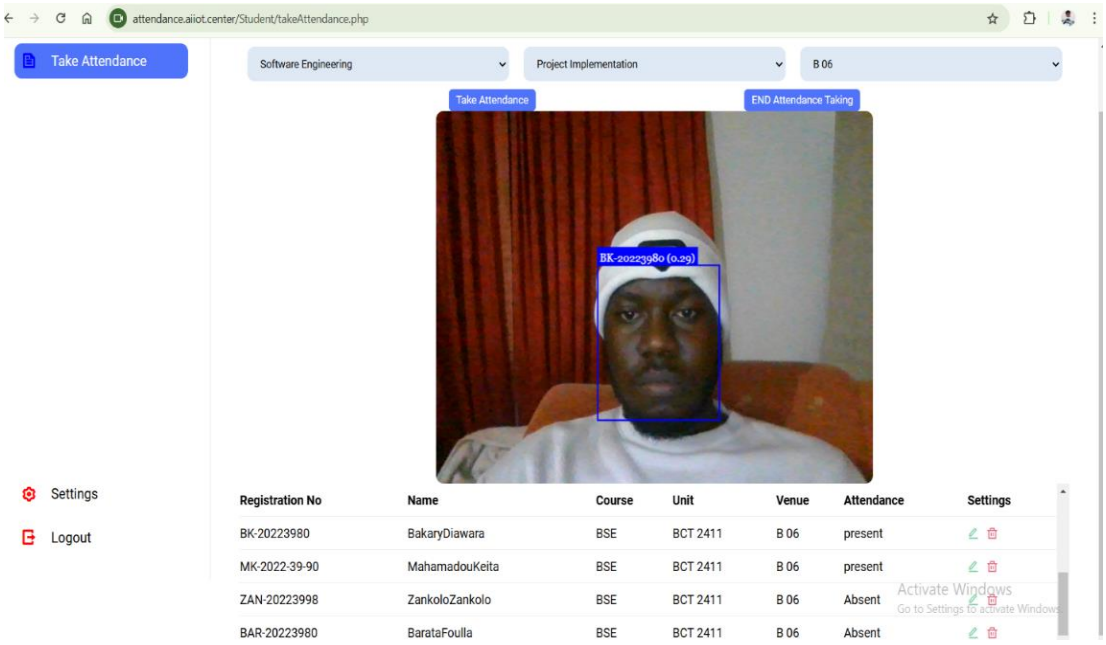

Figure 16b.

Attendance Interface

The results section come up with evidence collected from practicing facial recognition-based student attendance systems in schools and learning organizations. This includes accuracy for attendance, efficiency in administration, improvement of user satisfaction and resource savings. As well as that, questions facing trying to disseminate the project and resolving the arising problems are also addressed**.** Additionally once student faces have been correctly identified, the photos of the faces will be retrieved and entered into the attendance system to record the student's attendance. Figure 17 represent the recorded list of student.

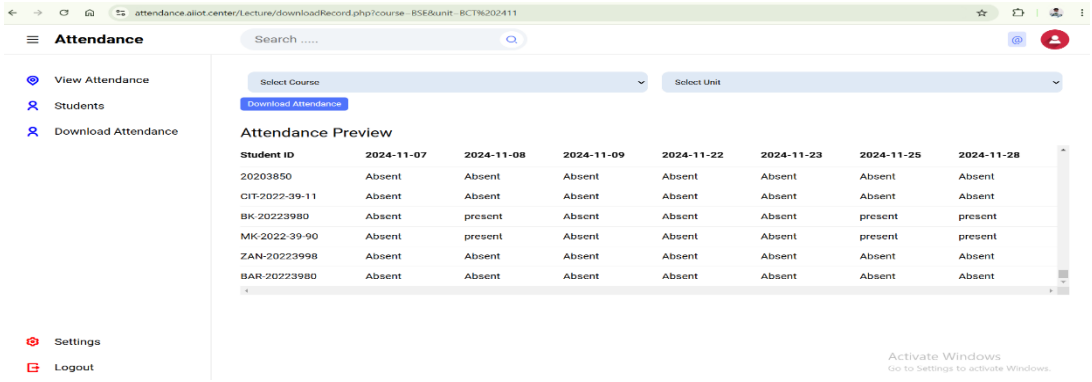

Figure 17.

List of Student's Attendance Record

4.3 Evaluation of Face Detection Methods. The face recognition starts by locating human faces in specific image, the aim of this stage is to identify whether the input image has human faces or not. However the changes of illumination and facial expression which ensure proper face detection [13]. Additionally in order to simplify the method of more facial recognition system and enable it to be more robust, pre-processing are performed. In addition several methods are applied to detected, identify and locate the person face in an image, for instance, Histogram of oriented gradient (HOG), Haar cascade classifier, principal component analysis (PCA) and although there are other techniques used to detect human face through live video, such as OpenCV, face-api.js library, which detect, and recognition human face through web browser. For a human,

identifying a face in a probe image might be easy, but not for a computer. The computer must determine which of the image's pixels belong to the face and which do not [34]. Faces have traditionally been detected using techniques that use regular feature templates, detect face-like colors in circular regions, or concentrate on facial landmarks (such eyes).

4.4 Evaluation of Face Recognition Methods. Facial recognition technology is an essential study issue which spans several areas and domains. Additionally the recognition methods based a computer program that can identify, recognize, and track, otherwise authenticate person faces through a picture, or live streamline video through the web browsers using the web camera. Despite the advancement facial recognition methods is still being constrained by the problems that prevent it from precision on par with or better than that of humans. However these issues include such as lighting conditions, noise, and poor quality of devices camera due that can affect the recognition methods to recognize people's faces. In [35] author applied MTCNN, and OpenCV methods to implement an automated attendance based on face recognition techniques. Although in [27] the authors proposed a technique using LBP method paired with sophisticated image processing techniques like picture blending, constrast modifications, bilateral filters, and histogram equalization. Additionally based on the proposed system the tested system demonstrate that the proposed system based on facial recognition-based attendance monitoring system is effectiveness and accurate, and robust system which can be used in real-life setting. However applying the Local Binary Pattern (LBP) method: The application process starts with the LBPH computational step, which creates an intermediate image that faithfully captures the source image by highlighting face features. The method makes use of the concept of a sliding window and is dependent on the parameters radius and neighbors. The procedure is show in figure 18.

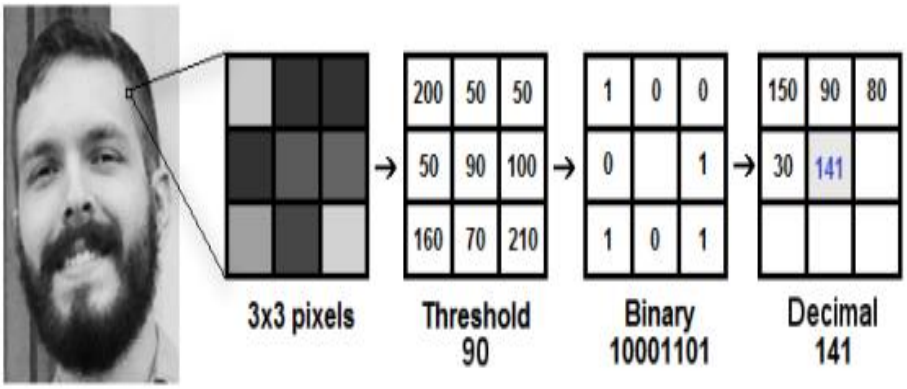

Figure 18.

Local Binary Pattern (LBP) Process

4.5 Measuring algorithm performance with evaluation metrics

In this part, we respond to the following questions:

In terms of accuracy, precision, recall, F1-score, and confusion matrix, how well do the face-api.js models do in tests?

To prove the accuracy of the estimates of probabilities and confidence scores produced by face-api.js algorithms so that educational institutions can reliably carry out interventions.

How can we compare the goodness of such estimates and show that the results are robust?

A secondary check on the significance performance or plausibility of the generated reliable output rates was also conducted using the evaluation metrics such as accuracy, precision, F1-score, and recall, and confusion matrix in comparison to the evaluation metrics of the face-api.js library utilized in this project. The outcomes, which are shown in the tables and graphs below, emphasize the significance of the face-api.js model method and the assessment metrics' performance outcomes.

4.5.1 Confusion Matrix

As the name suggests, Confusion Matrix generates a matrix and emphasizes how well the approach works for model performance in general. Despite not being regarded as a metric, the Confusion Matrix is a vital component that may be used to

assess how well the machine learning classification model is performing. It forms the basis for all other metrics. A two-dimensional table having actual and expected values is called a confusion matrix. For binary classification, it is mostly utilized.

Table 4**.**

An Explanation of the Confusion Matrix

	Correct Predicted	Incorrect Predicted
Actual Correct	TP = 27	FN = 3
Actual Incorrect	FP = 0	TN= 30

4.5.2 Results of the Experiment

The experimental evaluation of the face recognition-base attendance system is centered on two essential metrics such as accuracy and efficiency. However, during testing, these metrics were obtained from the system's performance in real time. Additionally the evaluation of accuracy of the system based on facial recognition methods involves several steps such as measuring True positive (TP), False Positives (FP) and False Negatives (FN), which collectively determine the accuracy and performance of the system.

4.5.2.1 Accuracy

Evaluating the accuracy of the system using face-api.js library based on facial recognition-based attendance system was measured evaluating the system’s capability to correctly detect and identify faces under changing conditions.

- True Positives (TP)

  The system correctly identify and recognized student faces in the dataset.

  For instance, the students were consistently detected and mark present

- False Positives (FP)

There were no cases reported where the system incorrectly identified a face as though it belonged to a student who was registered, but it was not.

- False Negatives (FN)

  There were no cases reported where the system failed to identify a enrolled student's face.

- Accuracy Calculation

  The accuracy was calculate as follow:

$$\textbf{Accuracy} = \left(\frac{(TP+TN)}{TP+FP+TN+FN}\right) * 100$$

$$\textbf{Accuracy} = \left(\frac{(27+30)}{27+0+30+3}\right) * 100 = 95\%$$

4.5.2.2 Precision

Precision in any method refers to the percentage of correctly classified cases out of all instances that are actually classified. The percentage of correct positive forecasts among all the accurate forecasts generated by the program.

$$\textbf{Precision} = \left(\frac{(TP)}{TP+FP}\right)$$

$$\textbf{Precision} = \left(\frac{(27)}{27+0}\right) = 1$$

Because precision measures the classifier's skill and demonstrates how accurately it labels correct predictions, we used it in this project. When False Positives cannot be disregarded but False Negatives must be prevented or are preventable, precision always works well.

4.5.2.3 Recall

When the number of correctly classified cases is divided by the total number of occurrences, the recall value is almost always equal to the correctly classified

instance (CCI). The proportion of true positive forecasts is determined by taking the total number of real positive cases in the dataset.

$$\textbf{Recall} = \left(\frac{(TP)}{TP+FN}\right)$$

$$\textbf{Recall} = \left(\frac{(27)}{27+3}\right) = 0.9$$

Recall, which is calculated by dividing the total number of True Positives by the sum of all True Positives and False Negatives, displays the proportion of accurate positive forecasts among all potential positive estimates. This indicator of missed positive forecasts is provided by recall, which, unlike the accuracy metric we previously covered, evaluates the classifier's performance in predicting all positive cases and displays the number of genuine positive labels it has assigned.

4.5.2.4 F1-Score

The weighted mean of recall and precision is the F1 score, which provides a single statistic to evaluate the algorithm's efficacy. Recall and precision values are used in its calculation (double precision multiplied by recall divided by the sum of recall and precision). The F1score lies between 0 and 1, and it employs the Precision and Recall average of the two harmonic measures.

$$\textbf{F1-Score} = 2\left(\frac{(Presicion*Recall)}{Precision+Recall}\right)$$

$$\textbf{F1-Score} = 2\left(\frac{(1*0.9)}{1+0.9}\right) = 0.94$$

The F1-score calculates their harmonic mean in an effort to strike a compromise between memory and accuracy. It functions as a gauge of test precision, with 1 representing the greatest possible result that denotes perfect recall and accuracy.

The accuracy analysis emphasizes the system accuracy in real-time attendance situations. In addition, the no presence of erroneous negative and positive results that show robustness and system’s precision, which make it suitable for automated

attendance management in educational institutions. Figure 19 shows the Bar chart representation.

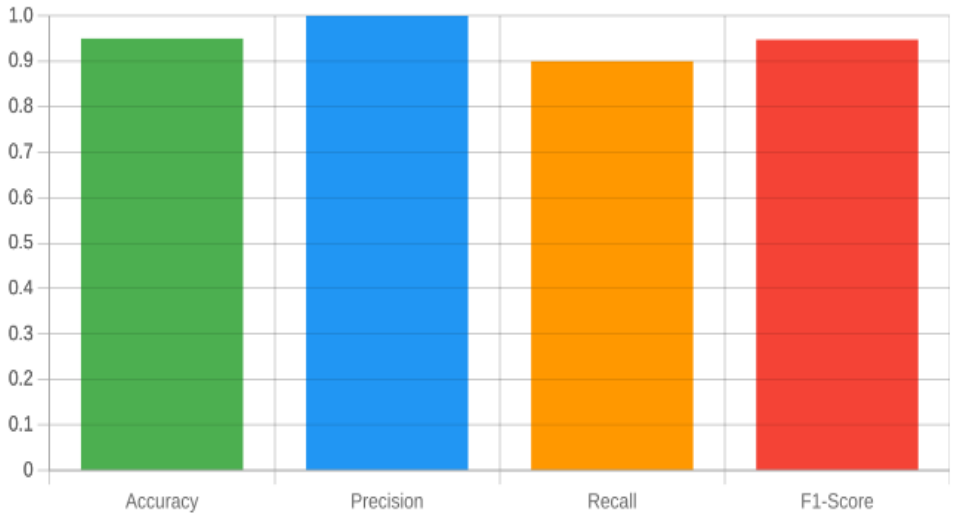

Figure 19.

Bar Chart Representation of the Accuracy, Precision, Recall and F1-score for Face-api.js Model

Table 5.

Performance Metrics of Face-api.js Model

Model	Accuracy	Precision	Recall	F1-Score
Face-api.js	**95%**	**1**	**90%**	**94%**

4.6 Comparatives analysis

A study by Serign Modou Bah et al in Ref [27] they applied Local Binary Pattern (LBP) method to implement an automated attendance system and their got 91% as accuracy. However compare to many studies this proposed method achieved high-level accuracy. Additionally another study by Rin Nurmalasari et al in Ref [18] the author used Haar Cascade combining with OpenCV a computer vision, which makes thier system to achieve 68-.745% of accuracy. Moreover in the terms of accuray compare to the above result our system achieved the high-level of accuray. A

thorough comparison of the examined research articles is shown in the table below, providing information on the various methodologies used in the creation of face recognition-based attendance systems with various technologies. A thorough grasp of the various approaches and technology frameworks examined by each study is provided by the comprehensive overview, which captures the spirit of the research done in this field. Additionally the proposed system have location detection which makes difference from others study.

Table 6.

Comparative Table of Face Recognition Methods for Baseline

Method	Accuracy	Reference
Haar Cascade	68-74%	Rin Nurmalasari et al. (2023)
Local Binary Patterns Histogram (LBPH)	91%	Serign Modou Bah and Fang Ming. (2019)
Cloud Computing with OpenCV and Dlib's ResNet	89%	Sarika Zaware et al (2024)
OpenCV with HOG Algorithm	82%	Arpit Pal et al (2023)
CNN	94%	Md Serajun Nabi et al (2023)
Eigenface and Fisherface	93.70%	Ismail Aliyu et al (2022)
Face-api.js	95-99% (approx)	Proposed Method

CHAPTER V
Discussion

This chapter presents a discussion of the findings from this research and compares them with the methodologies and outcomes from the current literature. Additionally, the main discussion will focus on evaluating the effectiveness and how accuracy, and efficiency of implemented face recognition-based attendance management system applying face-api.js methods and exploring its advantages, challenges, and limitations by comparing to other facial recognition algorithms. However, the facial recognition-based attendance system implemented in this research leverages the face-api.js library, which can be accessed through the browser, and offers browser-compatible, face detection, and face recognition. In addition, the implemented system successfully identified, recognised and marked student attendance with a high level of accuracy under controlled conditions [36]. Moreover, the models applied, particularly pre-trained MobileNetV1-based models, can perform, robustness even with changes in lighting conditions.

Table 4 presents the results of this study's comparisons with earlier research on accuracy across various approaches. This displays an accurate comparison of face detection and identification algorithms, highlighting the more effective approaches. Nonetheless, researchers and scientists have developed several algorithms based on face detection, recognition, and feature extraction to improve areas like security and surveillance. A few years ago, the biometric method gained popularity and became crucial for use in attendance monitoring systems in a variety of settings, including workplaces, organizations, and educational institutions. This enables the implementation of an automated attendance management system using facial recognition technology. Convolution neural networks (CNNs), the local binary pattern histogram (LBPH), the HaarCascade classifier, principal component analysis (PCA), linear discriminate analysis (LDA), support vector machines (SVM), OpenCV, and others are some of the AI-based techniques for putting such an automatic attendance system into practice. To create a reliable, accurate, and effective attendance management system, the researchers also combined two or more

algorithms [7]. Furthermore, a lot of research has employed the Local Binary Pattern Histogram (LBPH) for facial recognition and the HaarCascade classifier approach for face detection in a particular image or live-streaming video. However, the OpenCV library offers the HaarCascade classifier, which employs features of faces and nonfaces to detect faces. The classifier will draw a rectangular face on faces it finds, whether they are in a picture or a video. This classifier is also used to train positive-negative images, where the positive images include faces or other things [2]. For example, when the classifier begins training on positive photos, it must distinguish faces that belong to humans. The classifier is used to train and apply the ROI in an image input for negative images, which are defined as identified images that differ from a human face. Additionally, a different method is used to identify faces whenever the classifier discovers them; this algorithm may be a local binary pattern histogram [37]. On the other hand, the Local Binary Pattern Histogram (LBPH) algorithm is a simple face recognition technique that was utilized to derive histograms from training datasets. Furthermore, the Local Binary Pattern Histogram (LBPH) improves recognition performance on data for classification by addressing the neighbour features of a face image and combining them with the HOG descriptor. Fig. (19) Displays the functions that the LBP operator follows. It specifies the image's 9-pixel values, which are defined after labelling. If the binary value is larger than the centre pixel, it receives 1 or 0; if not, it will be decimal or binary [27]. The face is divided into pixels by the local binary pattern, which also distinguishes between black and white pixels. In contrast to the surrounding neighbour element, every pixel associated with eight neighbor pixels surrounds it. The facial photographs contained in the data store are tested using the Euclidian distance.

In the domains of image processing and computer vision, face recognition functions similarly to object recognition. The two most popular models for feature extraction in face recognition techniques are PCA and LDA, which extract the low dimensional and highly discriminating features from faces [38]. When employed with classifiers, PCA and LDA are contrasted in a variety of real-time scenarios, including varying lighting, unexpected changes in facial features (such as occluded faces), and variations in facial expressions [1]. Additionally, system performance is evaluated in terms of training duration, distance, false positive rate, and recognition rate. Since the image frames are taken when students are seated in the classroom and the facial

region is shrunk, distance serves as a benchmark in this system model. Therefore, capturing the facial region at 1.2 and 2.1 meters may yield superior results.

5.1 System Performance Evaluation

The proposed system-based facial recognition-based attendance management system uses the face-api.js library, which uses convolutional neural networks (CNNs) and DeepFace algorithms. However, the evaluation of the system's performance based on accuracy and efficiency, the system reached a high-level accuracy rate in terms of face recognition and marking student's attendance. Additionally using the face-api.js library to implement this system can resolve some issues such as a lightweight and browser-compatibility solution, which can access through the browser, and provides a solution for real-time face detection and recognition. Moreover, to emphasize the system's performance to evaluate its accuracy and efficiency, the system achieved a considerable high-level accuracy in capturing and tracking student attendance, which is an important outcome in terms of its efficiency for application and deployment. In addition, the use of pre-trained models such as MobileNetV1, allows the system to perform well, under controlled conditions. The system was designed to perform multiple tasks such as an admin control panel to manage lectures and student attendance, in which the admin can add or remove the lectures or students from the system. Additionally, it allows lecturers to track students' performance and download the students' attendance list file from the system and students are only allowed to register on the system and mark attendance for a specific course. However, to perform this task each student must have a device, which has a camera when taking attendance. Shown in Figure 16 is the attendance marking process.

CHAPTER VI

Conclusion and Recommendations

Facial recognition-based attendance management systems represent a significant advancement in the realm of education, by integrating biometric technology which is based on face recognition methods, the system enhances security and simplifies student attendance tracking. Additionally, the implemented system not only aligns with the current trend of digitisation but also ensures a secure and efficient campus environment. However facial recognition-based attendance systems entail a range of advantages that surpass the outdated manual processes such as accuracy, speed, and undoubtedly security. Although these problems may be high in numbers for initial set-up costs and privacy issues, the benefits exceed the drawbacks. Since technology is still developing, human-made AI devices are probably going to become vital equipment for monitoring and restricting attendance rolls in educational institutions, organizations, workplaces and other fields. The authentication system seems to be an AI-based facial recognition technology and it works through the procedure of capturing photos and identification of students afterwards, it relays students' details and it is at last saved in the associated system database. However, one proposed program is to create an online portal whereby those responsible for attendance management can move their manual systems to an automated system. This solution allows removing the need for stationary objects and paperwork to utilize the convenient service of not only keeping but also storing the data. Thus, this solution is simple, and reliable and will result in cost and time savings. Imagined results are that the process is supposed to be quicker and more precise than before. What others could develop from this is that the process can be further enhanced. Indeed, the creation of the biometric attendance system implies a change from the old and inefficient ways based on the use of fingerprints, QR codes, and Radiofrequency Identification (RFDI) to the modern and reliable patterns of attendance keeping as a result of biometric application which is facial recognition technology. Unlike other technologies that are based on traditional ways to implement attendance management systems. Moreover, through the detailed exploration of students’ attendance management systems, it becomes evident that facial recognition methods provide a

holistic approach to detecting and recognising faces and marking students' attendance. In addition, the robustness of the proposed system using facial recognition technology not only fortifies security measures but also ensures a seamless and efficient experience for tracking students' attendance. In the realm of registration, the integration of facial features into the enrolment process streamlines administrative workflows. The creation of unique biometric profiles enhances accuracy, security, and accessibility, contributing to a more organized and responsive educational ecosystem.

6.2 Recommendations and Future Work

This proposed system achieved a great high level in terms of accuracy and efficiency, in spite of the successes of this project, there are many areas for future exploration and improvement. However, refining is one possible path for future study based on face detection and recognition methods. Additionally exploring advanced machine learning methods, like deep learning combined with other complex machine learning algorithms, might lead to more sophisticated and Adaptive recognition skills, especially under difficult circumstances. In addition, we could consider integrating other biometric methods into the existing system such as fingerprint or iris recognition, which could improve and ensure the system's security and reliability. Moreover, the domain of automatic attendance tracking systems based on facial recognition presents a lot of possibilities for future study and development. Focusing on these crucial areas for research and development can provide for the ongoing development and progress of attendance-tracking techniques, which will benefit lectures, students, and educational institutions. The aim of this project in the future is to enhance the reliability of the system and this will be achieved by making the system aware of missing students and the same records will reflect it automatically. This not only makes it possible to send messages to missing students or their parents requesting to explain the causes for absence but it also will make students more disciplined. Rather than relying on an outdated system, the proposed plan hereby brings out temporary responsibility for attendance misconduct and communication

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