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FaceLogix: Face Recognition Employee Attendance System with Redundancy Webcam for MD1010 Engineering

Ahmad Firdaus Ngah[1], Nurul Azma Abdullah[1]*

[1] *Fakulti Sains Komputer dan Teknologi Maklumat,*
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA

*Corresponding Author: azma@uthm.edu.my
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Abstract

Monitoring employee attendance is important for tracking working hours and late arrivals. MD1010 Engineering is one of the subcontractors that do civil engineering, electrical, and telecommunications work. This company is still using outdated attendance systems, such as the punch card system. These methods can lead to fake attendance like proxy attendance and human errors in data entry. Therefore, face recognition is recommended as being more reliable, easier to use, and eliminating the possibility of face attendance and punch card errors. The system captures an employee's face with a webcam and matches it to a database. If it discovers a match, it records their attendance. If the main camera fails, a backup webcam takes over, ensuring that the system operates without interruption. The proposed system employs an object-oriented methodology for its design and implementation. This methodology emphasizes modularity, encapsulation, and reusability, ensuring a robust and maintainable system. The findings shows that the new system will significantly reduce attendance-related errors, prevent proxy attendance, and ensure an efficient employee attendance system of working hours. Key modules developed include registration and login, managing attendance details, add photos and train dataset module, and face recognition with redundancy webcam. Both face recognition and the backup webcam were successfully implemented, and testing confirmed the system's reliability and security. This will lead to improved payroll management and operational efficiency for MD1010 Engineering.

1. Introduction

Attendance systems are required for monitoring and tracking employees' attendance. These systems allows the employer to monitor their employees' working hours and late arrivals. Every organization does this in its own method to mark the attendance of their employees.

MD1010 Engineering is a company capable of carrying out civil engineering, electrical and telecommunication work as well as building, facility, and area maintenance. This company who are used outdated attendance system which is a paper-based system and punch card. According [1][2], these methods are prone to human errors and proxy attendance. Administrative staff manually input this data into the attendance record and leading to potential data entry errors. These human errors might be causing incorrect data and would be affected payroll discrepancies. However, the uses of biometric can eliminate this problem.

One critical aspect of implementing a reliable face recognition attendance system is ensuring its continuous availability. A single point of failure in a traditional system, such as a broken webcam, might cause serious interruptions. The redundancy webcam ensures that the system remains operational at all times, significantly reducing the risk of downtime and ensuring that attendance records are accurately maintained. Maintaining regular employee attendance records and avoiding data loss from hardware failures are made possible by this extra level of reliability. Redundancy webcams allow MD1010 Engineering to create a reliable and fail-safe attendance system, which improves system availability and dependability as a whole.

To sum up, it's critical for tracking employee attendance. Payroll concerns are caused by human error and proxy attendance in MD1010 Engineering's present punch card system. These issues can be resolved by switching to a face recognition mechanism, which is more user-friendly and efficient. Redundancy webcams ensure that the system operates continually, minimizing data loss and downtime. All things considered, MD1010 Engineering now has a more dependable, secure, and effective approach to handle attendance due to this suggested system. The remaining section of the paper is organized as follows: Section 2 discusses the topics related to attendance system management and face recognition method, and comparison of three attendance system. Section 3 will discuss in detail the methodology applied in this project. Meanwhile, the analysis and maintenance will be discussed in section 4. Next, the implementation and testing of the system will be established in section 5. Finally, section 5 will contain the conclusion for this project and highlights in the future work.

2. Literature Review

This chapter reviews the literature for this project. Section 2.1 covers attendance system management and approaches. Section 2.2 introduces face recognition. Section 2.3 discusses face recognition methods, and section 2.4 explains redundancy webcams. Section 2.5 compares existing attendance systems with a table.

2.1 Attendance System Management

Attendance management is an important aspect of organizational operations, and much research has been done over the years to improve the efficiency, accuracy, and security of attendance systems[3]. Manual record-keeping and punch-card, for example, have proven to be prone to mistakes and fraudulent practices. As a result of these issues, technical developments in attendance systems have received a lot of attention. According to research, the use of biometric methods such as facial recognition, fingerprint, and iris scanning are good options for improving the accuracy of attendance taking[4]. These methods not only eliminate inaccuracies, but they also prevent time theft such as proxy attendance. Furthermore, the implementation of automated redundancy for this proposed system. It ensures the continuous operation of the attendance system in the face of hardware failures and disruptions.

2.2 Face Recognition

Face recognition technology has rapidly evolved from a futuristic concept to a pervasive and transformative reality in our modern world. Research has highlighted the facial recognition; a facial recognition system is a piece of computer software that can determine or validate a person by comparing patterns based on their facial characteristics[2].Facial recognition is crucial for understanding human behavior and enhancing user experiences since it has applications from outside security, such as age estimates and emotion analysis. Research has been focused on the creation of methods that secure people's face data while using the possibilities of this technology in response to worries about data privacy and ethics.

As technology advances, this literature review investigates the complex world. It explores the history of face recognition system, the technology concepts, and the confidentiality and environment concerns that come with their widespread use. In order to obtain the maximum this technology, there is much research and development being done in this field. In the upcoming years, a few new applications and research areas will continue to rise[2].

2.3 Face Recognition Methods

Face recognition systems have grown rapidly due to rapid advancements in computer vision and deep learning techniques. The primary objective of these strategies is to accurately identify and authenticate individuals using their distinctive facial features. Convolutional neural networks, or CNNs, are now the industry standard, and deep learning methods offer extraordinarily high levels of efficiency and reliability[5]. According to recent studies, deep learning can perform in face verification at a level comparable to human ability, as the Deep Face model illustrates[6]. CNN deployment has improved face recognition, recommended value accuracy and robustness across a range of challenges.

2.3.1 Local Feature Hybrid Matching

To extract the local features from face images, this method uses a local feature descriptor such as local binary pattern (LBP), scale-invariant feature transform (SIFT), or histogram of oriented gradients (HOG). The approach uses a hybrid matching scheme with two stages which are coarse matching and fine matching. The method reduces the search space and selects the most similar candidate in the coarse matching stage by using a holistic matching method, such as eigenfaces or fisherfaces[7]. The approach uses approach uses a local feature matching method, such as closest neighbor or support vector machine (SVM), at the fine matching step to compare local features of the candidates and the query image and select the best match[8].

2.4 Redundancy Webcam

Redundancy webcams are an important component of face recognition attendance systems, providing backup in case the main webcams fail. This redundancy ensures uninterrupted operation and enhances system reliability. It also adds an extra layer of security, making it more resilient to interference or technical issues. Studies, such as one by [9], have shown that integrating redundancy webcams improves accuracy, security, and reduces the chances of proxy attendance. In conclusion, redundancy webcams are crucial for maintaining the continuous and secure functioning of face recognition attendance systems, contributing to their overall dependability and reliability.

2.5 Comparison of Existing Attendance System

In this section, three types of attendance systems are compared with the proposed system. These systems are used in organizations and educational institutions in Malaysia. The comparison highlights the advantages of the face recognition attendance system over other existing systems.

2.5.1 Face Recognition based Attendance Management

The paper presents a new system for managing attendance in schools and colleges using face recognition technology. This system aims to replace the traditional manual method of taking attendance with more efficient and accurate automated system[10]. The development of this system involves four main phases, including creating a database, detecting faces, recognizing faces, and updating attendance records. The system utilizes Haar-Cascade classifier and Local Binary Pattern Histogram algorithm for face detection and recognition, making it a promising solution for attendance management[10].

2.5.2 Smart Attendance using Fingerprint Recognition

The paper describes the development of a smart attendance and leave management system for students and employees in academic institutions using fingerprint recognition[11]. It aims to replace manual attendance management with a more effective and secure technique of attendance system. Modules for student attendance monitoring, class routine management, personnel attendance and leave management, and information management are included in the proposed system. It is developed in PHP, MySQL, HTML, CSS, and JavaScript and includes features such as sure attendance reports, department-specific attendance reports, and employee leave reports[11].

2.5.3 QR Based Smart Attendance System

The article presents the development of a QR Code Based Smart Attendance System utilizing smartphone technology. The system comprises two Android applications: one for generating QR Codes for students and the other for recording attendance and producing reports[12]. Its primary objective is to offer a more efficient and automated approach to monitoring attendance in educational institutions[12]. The article delves into methodology, software, and hardware requirements, use case, data flow diagram, database, sequence diagram, and flow chart.

2.5.4 Comparison of Existing Attendance System with The Proposed System

Table 1 presents a comparative analysis of three different attendance systems with the proposed system. The table evaluates these systems based on various features and attendance requirements such as continuous operation, hygiene concerns, security, and database requirements. This comparison aims to highlight the strengths and weaknesses of each system that provides a comprehensive overview that can guide the selection of an optimal attendance system.

Table1 *Comparison on Existing System*

Features/System	Face Recognition based Attendance Management System	Smart Attendance Using Fingerprint Recognition	QR based Smart Attendance System	The proposed system
Attendance Approach	Face Recognition	Fingerprint Recognition	QR Code	Face Recognition
Contact Requirement	Contactless	Requires physical contact	Contactless	Contactless
Continuous Operation	No	No	No	Yes
Hygiene Concerns	No	Yes	No	No
Database	Yes	Yes	Yes	Yes
Password and authentication	Highly secure	Secure but may affected by cleanliness	Highly secure	Highly secure with face recognition and redundancy webcam

3. Methodology

This chapter details the implementation of the Object-Oriented Software Development Method (OOSD) and the tasks completed at each phase. Section 3.1 gives an overview of the methodology. Sub-sections 3.2 to 3.6 describe the phases: requirements analysis, design, implementation, testing, and operation and maintenance.

3.1 Object-Oriented Methodology

In order to create an effective and dependable attendance system, structured and modular software design principles are applied in the face recognition attendance system implementation of object-oriented methodology[13]. In order to organize and structure the system and enable the creation of modular and reusable development tools are crucial for the development of a reliable face recognition attendance management system methodology makes use of the principles of encapsulation, inheritance, and polymorphism[14]. The reason this project employs OOM is that it can assist lower the codebase's complexity and provide easier long-term maintenance. The requirements analysis, object, design, implementation, and operation and maintenance phases are the five stages of object-oriented programming as shown in Figure 1.

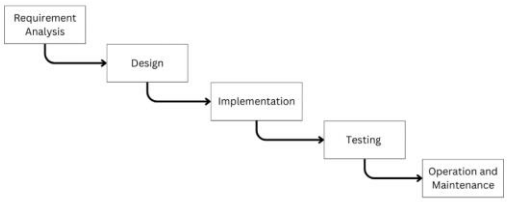

Fig. 1 Object-Oriented Methodology [15]

Based on Figure 1, the object-oriented process starts with requirement analysis, where the system's needs are gathered and examined. Next is the design phase, using the specifications from the previous step. In the implementation stage, the designs are translated into code. Initially, small programs are created and integrated into the system. After coding, the testing phase ensures the product meets the requirements. Finally, during operation and maintenance, the system is used by actual users, who may discover any issues missed during testing.

3.2 Requirement and Analysis

Collect data for attendance system, face recognition algorithm, and functional and non-functional aspects of the system during the requirement phase. The analysis phase then involves determining the problem and the necessary hardware and software by reading through the literature, looking through materials, data, and information about face recognition systems, and determining the needs for the obtained data. Additionally, figure out how to put a redundancy webcam in place for continuous functioning.

3.2.1 Hardware Requirements

The system that is built requires some hardware that is used to support system functionality and performance. As for the hardware, the project uses:

- Integrated webcam
- USB webcam
- Laptop

3.2.2 Software Requirements

The system that is built requires some software that is used to support system functionality and performance. As for the software, the project uses:

- Python
- OpenCV
- Visual Studio Code
- Django Framework
- SQLite

3.3 Design

It designed the system throughout the design phase using flowcharts and Unified Modelling (UML), as well as a thorough analysis of the suggested system based on the requirements. This is the layout and operation of the system that will be used. The design focuses on high-level design, such as what programs are needed and how they will interact with one another, interface design, or how interfaces will look, and data design, or how data will be needed. The enrollment and recognition steps of the face recognition approach are represented in Figure 2.

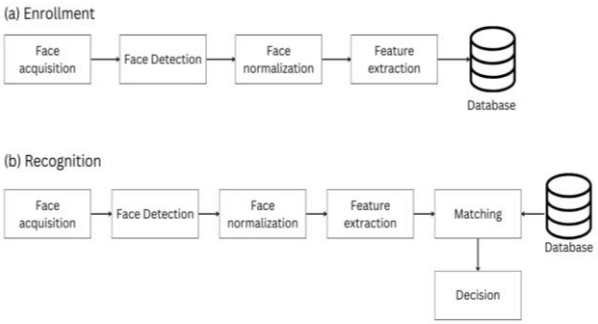

Fig. 2 *The Step Enrollment and Recognition*[16]

The Face Recognition System has seven main modules that follow these processes: In the enrollment phase, the system gathers, identifies, and normalizes a person's face, extracts a feature set, and saves it as a template in the database. During the recognition phase, the system repeats the first four steps with new face photos, compares the new feature set to stored templates, and determines a match based on a similarity score.

3.4 Implementation

During this stage, the designed system is translated into actual code. The above-mentioned Python programming language is used to implement the proposed system according to the object-oriented design. Every object becomes a class, and instances within these classes serve as the system's representation of actual entities. At this step, face recognition algorithms, user interface elements, attendance management logic, and support for redundancy webcam models are coded.

3.5 Testing

In the fourth stage, described as testing, the system is examined over an extended period of time to ensure that its stability and reliability are preserved and that it operates as intended. To make sure the system functions correctly, any errors found during the testing stage will be fixed and debugged. This guarantees that the system operates correctly and that all of its requirements, including functional and non-functional, are satisfied.

When a system is utilized by a user, it will always undergo certain modifications. This is because the user's diverse input differs from the data input during the system's testing. Unexpected data is occasionally entered into the system, leading the system to malfunction. Therefore, the testing phase is critical, since it allows developers to identify extra adjustments that are needed to ensure that the system is error-free.

3.6 Operation and Maintenance

The operation and maintenance phase begins after the proposed system has been tested and put into use. During this continuous stage, the system is updated, bugs are fixed, and enhancements are made as needed. Code flexibility and reusability are prioritized by object-oriented approaches, which facilitate system extension and maintenance over time. Updating the system keeps it secure, resilient, and compliant with changing needs.

4. Analysis and Maintenance

This section presents the system requirement analysis and design for the face recognition project. It covers the overall system design, including functional and non-functional requirements, and uses Unified Modelling Language (UML) diagrams such as use case, sequence, class, and activity diagrams. Additionally, it discusses the user interface design for the face recognition system.

4.1 Functional Requirements

Functional requirements are features that need to be created so that the client or users can utilize the system to fulfill their requirements. It outlines the actions that the system must perform when faced with specific situations. Table 2 displays the functional requirements of the face recognition attendance system.

Table 2 *Functional Requirements*

No	Modules	Functionalities
1	Check-in	• The employee check-in for work by scanning their face in front of the webcam.
2	Check-out	• The employee check-out for work by scanning their faces in front of the webcam.
3	Login	• The employer and employee's login into the attendance management system.
4	Registration	• Employers register the new employees by adding the employees' personal information in the database.
5	Report	• Employee attendances are recorded in the report. • Employer able to view report.
6	Redundancy	• Utilize integrated and USB webcams for redundancy and backup.

Table 2 outlines the functional requirements for the face recognition attendance system. It includes six key modules: Check-in, where employees scan their faces to clock in for work; Check-out, allowing employees to scan their faces to clock out; Login, enabling both employers and employees to access the attendance management system; Registration, permitting employers to add new employees' personal information into the database; Report, which records and displays employee attendance for employers to view; and Redundancy, which utilizes both integrated and USB webcams to ensure backup and continuous operation.

4.2 Non-Functional Requirements

Non-functional requirements explain how a system should function, not focusing on its usefulness but on its usability. These specifications address the overall performance and characteristics of the system. Table 3 provides a list of the non-functional requirements for the face recognition attendance system.

Table 3 *Non-functional Requirements*

No	Modules	Functionalities
1	Performance	• The performance of the system should be fast without uninterrupted.
2	Security	• The system enforces to set the password with at least 8 characters during registration. • The employer may access the system with the correct username and password. • Utilize cryptographic technique.
3	Availability	• This system will available only until the system on which is the system is running. • This system is still available if the main webcam is interrupted and switched to backup webcam.
4	Operational	• The system can generate employee attendance reports.
5	Integrity	• The system will save information properly, ensuring that it is neither corrupt nor unreadable.

Table 3 outlines the non-functional requirements for the face recognition attendance system. The system must perform efficiently without interruptions (Performance). It enforces secure passwords with at least 8 characters and ensures only authorized access through cryptographic techniques (Security). The system's availability is limited to its operating platform but remains operational with a backup webcam if the primary fails (Availability). It should be capable of generating detailed attendance reports (Operational) and must store data accurately to prevent corruption or unreadability (Integrity).

4.3 Use Case Diagram

A use case diagram visually shows how different parts of a system work together. Its purpose is to clarify the relationship between the system's components and how the system is supposed to behave. The emphasis is role in showing interaction between users and the system and providing a preview of the main function depicted in the diagram. Figure 3 shows the use case of FaceLogix Face Recognition Employee Attendance System with Redundancy Webcam.

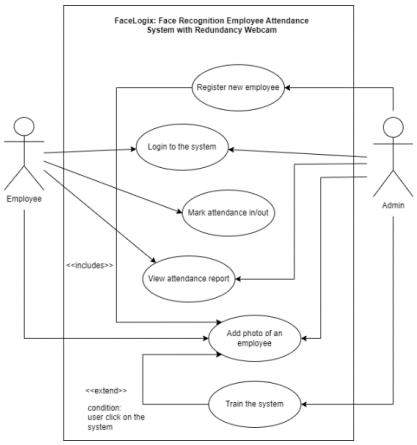

Fig. 3 *Use Case Diagram*

Figure 3 illustrates the interactions between the employee and admin with the face recognition attendance system. Employees log in and mark attendance by using the webcam, which identifies and records their attendance. If the primary webcam malfunctions, a backup webcam is activated. Admins can manage various tasks, such as adding new employees and photos, training the system, and accessing attendance reports.

4.4 Sequence Diagram

The sequence diagram explains how objects interact with each other in specific scenarios of a use case. This section includes three sequence diagrams for the proposed system which are the admin login process, employee login process, and register new user process.

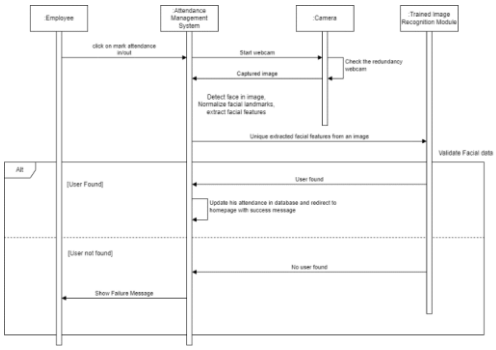

Fig. 4 *Sequence Diagram for Employee Login Process*

Figure 4 shows a more complex login process with face recognition compared to a typical username and password login process. The process begins as the employee enters the homepage, and the system instructs them to click "Mark Attendance In and Out." The primary webcam is activated to capture the employee's face. In case of multiple unsuccessful attempts with the primary webcam, the system automatically switches to the redundancy webcam for another try. Subsequently, the captured image undergoes analysis for facial features and is compared to a database of known faces. If the face matches that of a recognized employee, their attendance record in the database is updated by the system, and they are redirected to the homepage with a success message. If the face does not match any known employee, the system displays a failure message and prompts the employee to try again.

4.5 Class Diagram

A class diagram illustrates the overall framework of a system by presenting classes, properties, methods, and the connections between the components of the system. It proves beneficial for object-oriented systems, as it can convey various aspects of object-oriented programming principles. This is advantageous for other developers and project team members, as it facilitates quicker and more efficient code creation and testing. Figure 5 displays the class diagram for the Face Recognition Employee Attendance System with Redundancy Webcam.

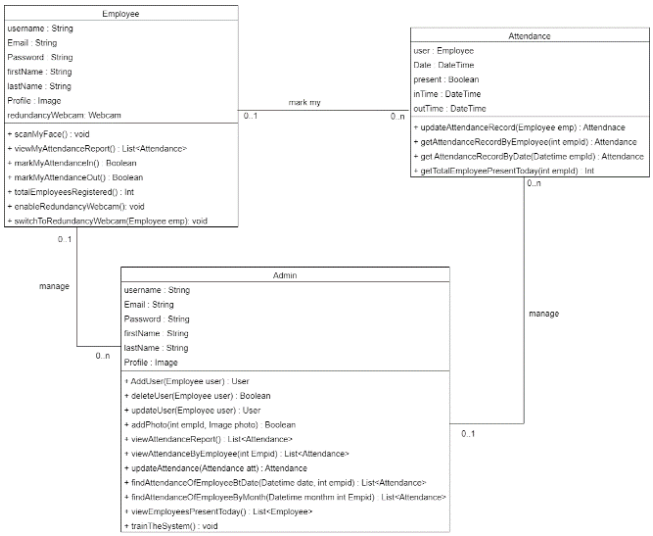

Fig. 5 *Class Diagram of Proposed System*

The central AttendanceSystem oversees user authentication, captures employee faces through a webcam, and conducts face recognition to record attendance. It communicates with the Employee class to store and retrieve employee details like username, email, and profile picture. Attendance information, encompassing date, time, and presence status, gets stored in the Attendance class. The admin class enables authorized users to handle employees and view attendance reports. Moreover, the system can undergo training with new faces through the trainTheSystem method.

4.6 Activity Diagram

Activity diagrams play a crucial role in developing the "FaceLogix: Face recognition employee attendance system with redundancy webcam." They offer a visual depiction of the system's workflow, providing a clear and intuitive understanding of its logical flow. Figures 6 display the activity diagram for the "FaceLogix: Face Recognition Employee Attendance System with Redundancy Webcam".

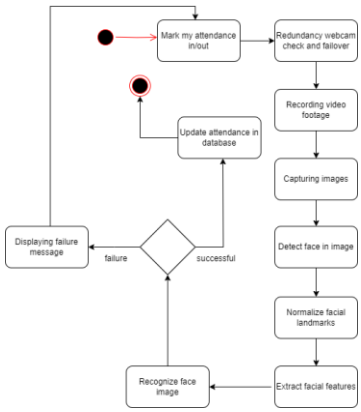

Fig. 6 *Activity Diagram of Proposed System*

In figure 6, the system starts by face recognition process, which is recoding video footage, capturing images, detect face in image, normalize facial landmarks, and extract facial features. Then, the system will check the webcam and verify the status of the main webcam. If the main webcam is corrupted or failure, the system will continue to backup webcam to the recognize face image stage. It then identifies the employee by matching the captured image against a database of known faces. If a match is found, the system records the employee's attendance for that day and displays a success message. If the face isn't recognized, the system prompts the employee to try again.

4.7 Class Diagram

The class diagram is a system diagram that shows the connection between the entity and its data. It's a modeling method used to visually represent the information structure of an organization's entity and the interactions among entities more precisely. Figure 7 displays the class diagram for the face recognition employee attendance system.

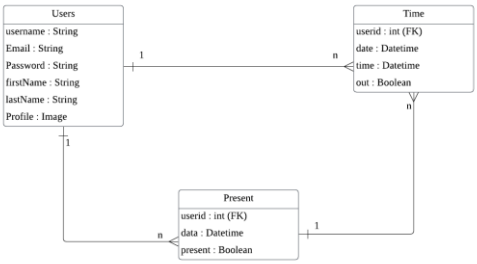

Fig. 7 *Class Diagram of Proposed System*

In figure 7, the class diagram illustrates a system for face recognition designed to monitor employee attendance. The system retains details about employees, such as their username, email, password, first name, last name, and profile picture. Additionally, it stores information regarding attendance events, including the date, time, and whether the employee was present or absent. The system operates by capturing an image of the employee's face using a camera. Subsequently, the system compares this image to a database of known faces to identify the employee. If the identification is successful, the system records their attendance for that day.

4.8 Data Dictionary

A data dictionary plays a crucial role in database design by serving as a central repository of metadata that explains the attributes and elements of the data within the database. It acts as a comprehensive catalog, detailing data definitions, types, relationships, and constraints, providing valuable understanding of the database's structure and meaning. This section specifically addresses three tables: the user table, the attendance table, and the time log table.

Table 4 *User Table*

No	Field name	Data type	Required	Unique	PK/FK	Ref. table
1	UserId	Int	True	True	PK	-
2	Email	String	True	True	-	-
3	Name	String	True	False	-	-
4	Password	String	True	False	-	-
5	CreatedAt	DateTime	True	False	-	-
6	UpdatedAt	DateTime	True	False	-	-

Table 5 *Attendance Table*

No	Field name	Data type	Required	Unique	PK/FK	Ref. table
1	AttendnaceId	Int	True	True	PK	-
2	Date	DateTime	True	False	-	-
3	UserId	String	True	False	FK	User
4	Present	Boolean	True	False	-	-

Table 6 *Time Log Table*

No	Field name	Data type	Required	Unique	PK/FK	Ref. table
1	TimeLogId	Int	True	True	PK	-
2	Date	DateTime	True	False	-	-
3	UserId	String	True	False	FK	User
4	Time	DateTime	False	False	-	-
5	Out	Boolean	True	False	-	-

Tables 4, 5, and 6 present the database structure for the face recognition attendance system. Table 4 (User Table) includes fields for UserID, Email, Name, Password, CreatedAt, and UpdatedAt, with UserID as the primary key. Table 5 (Attendance Table) comprises fields for AttendanceID, Date, UserID, and Present, with AttendanceID as the primary key and UserID as a foreign key referencing the User Table. Table 6 (Time Log Table) contains fields for TimeLogID, Date, UserID, Time, and Out, with TimeLogID as the primary key and UserID as a foreign key referencing the User Table. These tables ensure efficient data management and integrity within the system.

4.9 System Interface Design

The user interface is created to present a clear visual representation of the pages that will be integrated into the system, serving as the point of interaction between humans and computers. Figures 8 and 9 showcase the user interface for the FaceLogix: Face Recognition Employee Attendance System with Redundancy Webcam.

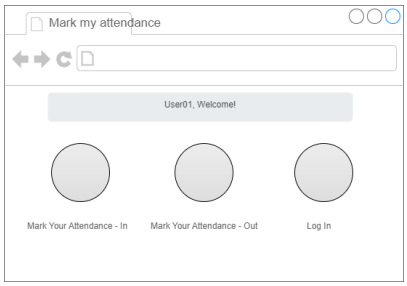

Fig. 8 *Homepage*

Fig. 9 *Scanning Face Process*

Figures 8 and 9 depict the user interface of the face recognition attendance system. Figure 8 shows the homepage, where users can choose to mark their attendance (in or out) or log in. It welcomes the user by displaying their username. Figure 9 illustrates the face scanning process, which activates when users select to mark their attendance. The system captures the user's face for verification to record their attendance accurately. This streamlined interface ensures a user-friendly experience for both employees and administrators.

5. Implementation and Testing

This chapter will delve into the implementation and testing of the FaceLogix: Face Recognition Employee Attendance System with Redundancy Webcam for MD1010 Engineering. Section 5.1 covers the implementation details of each module, including algorithm segments and explanations. Following this, section 5.2 presents the testing results, encompassing unit testing, integration testing, system testing, and user acceptance testing.

5.1 Registration and Login Module

This module handles the registration of new employees, system, and management of employee's profile details. The admin can use this module to register new employees, and both the admin and employee can log in using their username and password.

Step 1: Check if the user is logged in and if the username is admin. If not, redirect to 'not-authorised' page.
Step 2: If the request method is 'POST', create a UserCreationForm with the data from the request.
Step 3: If the form is valid, save the form which adds the user to the database.
Step 4: Show a success message "Employee registered successfully!" and redirect to 'dashboard'.

Fig. 10 *Algorithm for Register*

Figure 10 illustrates the algorithm for the view function responsible for user registration. This function restricts access to logged-in users, permitting only the admin to register new employees. If accessed for the first time, it displays the registration form. The function employs the 'UserCreationForm' class to validate and save the new employee's data to the database. Success and error messages are displayed accordingly. Upon successful registration, the admin is redirected to the dashboard.

Step 1: Display the login form and handle the login action.
Step 2: When a request is received, check if the user is locked out. If the user is locked out, show a lockout response.
Step 3: If the form is invalid, increment the login attempt count. If the login attempt exceed the maximum limit which is 3 attempts, lock the user out for 30 seconds and show a lockout response.
Step 4: If the form is valid, log the user in and redirect them to a 'Dashboard'.
Step 5: If the user is locked out, render a page showing that the user is locked out.

Fig. 11 *Algorithm for Login with Lockout Mechanism*

Figure 11 describes the 'LoginView' class, which manages user login with security features designed to prevent brute force attacks. After three failed login attempts, it enforces a 30-second lockout period. The 'dispatch' method checks the cache to determine if the user is locked out. If so, it displays a lockout message; otherwise, it proceeds with the login process. If the form is invalid, the 'form_invalid' method increments the login attempt count and locks the user out after the limit is exceeded. A successful login redirects the user to the Dashboard.

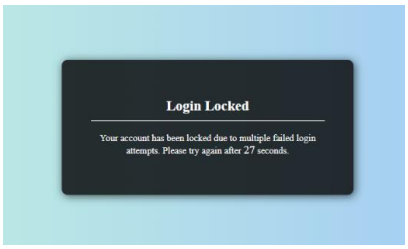

Fig. 12 Login Locked Message

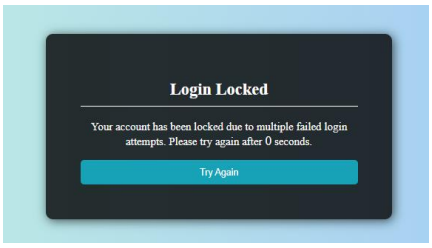

Fig. 13 Try Again Button

The images depict two variations of a login lockout message. In Fig. 12, the message informs users that their account is locked due to multiple failed login attempts, advising them to try again after 27 seconds. After 30 seconds, a similar message appears, but with a "Try Again" button that becomes clickable after the lockout period ends, allowing users to reattempt logging in after 0 seconds as shown in figure 13. These images illustrate a user interface designed to enhance security by temporarily blocking access after several unsuccessful login attempts, thus preventing potential brute-force attacks.

5.2 Manage attendance Details

This module manages employee attendance. Employees can record their presence, as well as their time-in and time-out, in the system. Administrators can view detailed reports for each employee, while employees have access to their own attendance reports. The system includes filters for viewing attendance based on employee, date, and month.

Step 1:	Check if the user is logged in and if the username is admin, if not, redirect to 'not-authorised' page.
Step 2:	If the request method is 'POST', create a DateForm with the data from the request.
Step 3:	If the form is valid, get the date from the form and filter the 'Time' and 'Preset' objects for that date.
Step 4:	If there are any 'Time' or 'Present' objects for the selected date, call the 'hours_vs_employee_given_date' function and render the 'recognition/view_attendance_date.html' template with the form and queryset.
Step 5:	If there are no 'Time' or 'Present' objects for the selected date, show a warning message 'No records for selected date', and redirects to 'view-attendance-date'.
Step 6:	Step 6: If the request method is not 'POST', create an empty 'DateForm' and render the 'recognition/view_attendance_date.html' template with the form.

Fig. 14 *Algorithm for Attendance Report by Date*

Figure 14 describes the 'view_attendance_date' function, which allows admin users to view attendance records by date. The function first checks if the user is logged in as an admin; if not, it redirects to the unauthorized page. For POST requests, it processes the submitted 'DateForm'. If the form is valid, it retrieves the date and queries the 'Time' and 'Present' models for matching records. If records are found, it calculates and displays the attendance data. If no records are found, it shows a warning message and redirects back to the form.

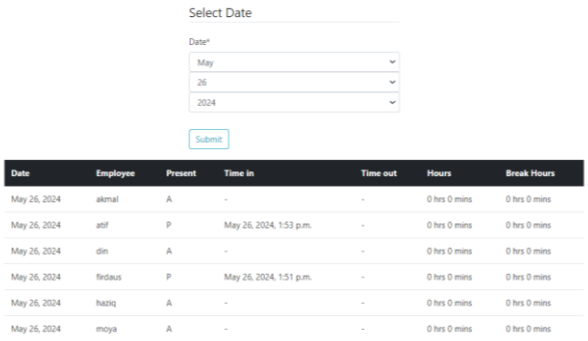

Fig. 15 *User Interface for Attendance Report by Date*

5.3 Add Photos and Train Dataset Module

This module manages features related to employee profiles. During registration, the admin can add a photo of a newly registered employee. Additionally, the admin can instruct the system to train the model, generating data to uniquely identify each employee.

Step 1: Verify if the user is an admin. If not, they are redirected to a not-authorised page.
Step 2: If the request method is POST, process the form data.
Step 3: Extract the username from the form data.
Step 4: Check if the username exists. If it does, proceed to the next step. If not, display a warning message and redirect to the dashboard.
Step 5: Create a dataset for the given username.
Step 6: Send a success message indicating that the dataset has been created and redirect to the add-photos page.

Fig. 16 *Algorithm for Enrollment*

Figure 16 describes the 'add_photos' function, which allows an admin to create a photo dataset for an employee. The function first checks if the user is logged in as an admin; if not, it redirects to an unauthorized page. For POST requests, it retrieves the username from the submitted form. If the username exists, the function calls create_dataset(username) and displays a success message. If the username does not exist, it shows a warning message and redirects to the dashboard. This function ensures that only authorized users can create datasets for registered employees.

Step 1: Verify if the user is an admin. If not, they are redirected to a not-authorised page.
Step 2: Extract the username from the form data.
Step 3: Check if the username exists. If it does, proceed to the next step. If not, display a warning message and redirect to the dashboard.
Step 4: Create a dataset for the given username for 300 photos.
Step 5: Send a success message indicating that the dataset has been created and redirect to the add-photos page.

Fig. 17 *Algorithm for Create Dataset*

Figure 17 discusses the 'create_dataset' function, which captures 300 photos for a specific username using a webcam. The function first checks if a directory for the user exists, creating it if necessary. It then loads the face detector and shape predictor models and starts the video stream. In a loop, the function captures frames from the webcam, resizes them, and converts them to grayscale. It detects and aligns faces in each frame, saving them to

the user's directory. This loop continues until 300 photos are captured. Finally, the video stream stops, and all OpenCV windows close.

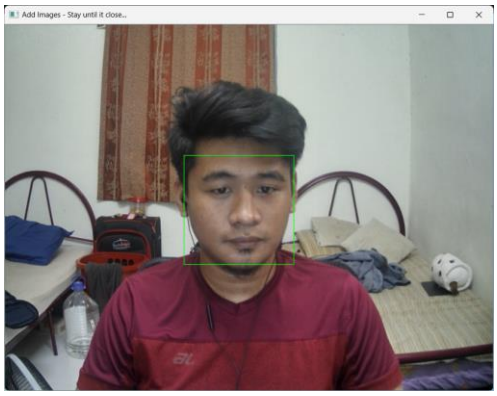

Fig. 18 *The Process of Enrollment*

Figure 18 demonstrates the enrollment process for adding a new employee's photos to the face recognition system. The system captures 300 images of the employee from various angles and expressions to create a comprehensive dataset. During this process, the employee sits in front of the webcam while the system detects, aligns, and saves each image. This extensive dataset is essential for training the face recognition model, ensuring it can accurately and reliably identify the employee in different conditions.

5.4 Face Recognition with Redundancy Webcam

The face recognition system in this application is used for tracking employee time-in and time-out. During training, the system captures multiple images of each employee, extracts unique facial features using the "face_recognition" library, and stores these features with labels. For real-time attendance, a webcam captures the employee's image and compares it with the stored data to identify the employee. The system includes a redundancy feature with two webcams: a primary and a secondary. If the primary webcam fails, the system switches to the secondary webcam to ensure continuous operation and accurate attendance tracking, preventing missed records due to hardware issues.

Step 1:	Load the face detector and shape predictor models.
Step 2:	Load the saved classifier model.
Step 3:	Set up the face aligner and load the classes for the label encoder.
Step 4:	Set up variable for face encoding, counts, presence flags, log times, and start times.
Step 5:	Start the primary and secondary video streams.
Step 6:	Begin a loop to continuously read frames from the active video stream.
Step 7:	If an error occurs while reading a frame, switch to other video stream.
Step 8:	Detect faces in each frame.
Step 9:	For each detected face, align the face, draw a rectangle around it, and predict the user's identity using the classifier.
Step 10:	If the prediction is no -1 (unknown), update the count, presence flag, and log time for the predicted person. If the count reaches a certain threshold within a certain time, reset the count and mark the user as present.
Step 11:	Show the processed frame with the marked attendance and the user's name.
Step 12:	If the 'e' key is pressed, break the loop.
Step 13:	Stop the primary and secondary video streams.
Step 14:	Update the attendance in database based on the presence flags.
Step 15:	If an exception occurs, stop the video streams, close all windows, and redirect to the homepage.

Fig. 19 *Algorithm for Mark the Attendance*

Figure 19 discusses the 'mark_your_attendance' function, which uses face recognition to mark attendance by capturing images from a webcam. It loads the necessary models and encoders and initializes two video streams: one for a USB webcam and one for a built-in webcam. The function starts with the primary webcam and switches to the secondary stream if the primary fails. It captures frames, detects faces, aligns them, and identifies the person using the SCV model. If the prediction is valid, it logs the person's presence and time, displaying messages on the frame. This process continues until the 'e' key is pressed. The function then stops the video streams, updates the attendance records in the database, and redirects to the homepage.

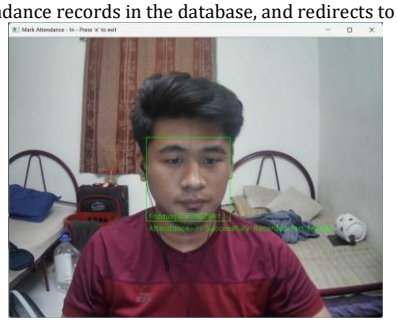

Fig. 20 *The Process of Recognition using Primary Webcam*

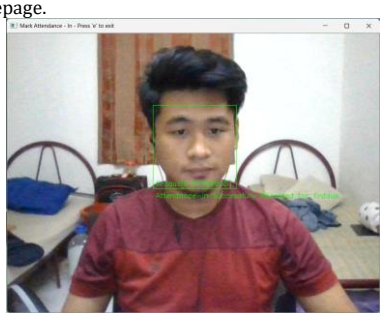

Fig. 21 *The Process of Recognition using Secondary Webcam*

```
Error reading frame from active stream: Frame not available
Primary stream failed. Switching to secondary stream in 2 seconds...
[ WARN:2] global C:\Users\appveyor\AppData\Local\Temp\1\pip-req-build-
eoio(MSMF): can't grab frame. Error: -2147483638
```

Fig. 22 *The Logs Entry of Switching Webcam*

Figures 20, 21, and 22 illustrate the redundancy feature of the face recognition system, which utilizes both primary and secondary webcams. Figure 20 shows the primary webcam capturing and recognizing an employee's face, successfully logging their attendance with a confirmation message displayed on the frame. Figure 21 demonstrates the system's response when the primary webcam fails, automatically switching to the secondary webcam to continue capturing the employee's photo and successfully logging their attendance. Figure 22 presents the log entry documenting the failure of the primary webcam ("Frame not available") and the subsequent switch to the secondary webcam within 2 seconds. This seamless transition ensures continuous operation and reliable attendance tracking, highlighting the system's robustness in handling hardware failures.

5.5 Functional Testing

Functional testing is crucial for ensuring a software application's reliability and quality. It helps identify problems, enhance user experience, and verify that the system meets its functional requirements. The employee attendance system will be thoroughly evaluated in all aspects.

Table 7 *User Testing for Admin*

No	Description	Expected Result	Actual Result
1	Admin able to login and logout to the system	Admin successfully logs into the system and logs out, ensuring session management functions correctly.	Pass
2	Admin able to add employee	System adds the new employee to the database and confirms the addition.	Pass
3	Admin able to add photo of employee	System saves at files local host.	Pass
4	Admin able to view list employees	System displays a complete list of all employees, with options to view details for each.	Pass
5	Admin able to train the dataset	System processes the dataset for training, updating the model as necessary and confirming the completion.	Pass

Table 7 outlines a series of tests conducted to verify the functionality of an administrative system. The tests include various tasks that an admin should be able to perform, such as logging in and out of the system, adding new employees, uploading employee photos, viewing a list of employees, and training the dataset. Each task has an expected result detailing the proper functioning of the system when the task is performed. The actual results show that all these tasks were successfully completed, confirming that the system operates as intended in each tested scenario. The consistent "Pass" outcomes suggest a robust and reliable system for administrative use.

Table 8 *User Testing for Employee*

No	Description	Expected Result	Actual Result
1	Employee able to login and logout to the system	Employee successfully logs into the system and logs out, ensuring session management functions correctly.	Pass
2	Employee able to reset password via email	The system sends a password reset link to the employee's registered email address, allowing secure reset.	Pass
3	Employee able to view attendance report	System generates and displays the requested attendance report based on specified criteria.	Pass
4	Employee able to mark attendance In and Out	System records the attendance information, including date and time and confirms the entry.	Pass

Table 8 summarizes the results of user testing for an employee system. It includes four tests: logging in and out, resetting passwords via email, viewing attendance reports, and marking attendance. Each test had expected results, such as successful login and logout, receiving a password reset email, displaying attendance reports, and recording attendance accurately. All tests passed, indicating the system functions correctly as intended.

5.6 Test Plan

User testing helps identify usability issues, validate design decisions, and ensure the system meets the needs and expectations of its users. Admin and employees are two users of this system. Table 9 show the redundancy webcam testing plan and Table 8 show the security testing plan.

Table 9 *Test Plan for Redundancy Webcam*

No	Description	Expected Result	Actual Result
1	Verify the primary webcam captures images correctly.	The primary webcam captures images without errors	Pass
2	Verify the secondary webcam activates when the primary webcam fails.	The secondary webcam activates automatically if the primary webcam fails.	Pass
3	Verify the secondary webcam captures images correctly.	The secondary webcam captures images without errors.	Pass
4	Test face detection using images captured by the primary webcam.	The system detects faces correctly using the primary webcam images.	Pass
5	Test face detection using images captured by the secondary webcam.	The system detects faces correctly using the secondary webcam images.	Pass
6	Simulate primary webcam failure during image capture and ensure smooth switch to secondary webcam.	The system switches to the secondary webcam seamlessly during image capture.	Pass
7.	Verify that attendance data is logged correctly during a switch from primary to secondary webcam.	Attendance data is logged accurately without interruption during the webcam switch.	Pass
8.	Test if the system provides log entry when switching webcams.	The system provides a log entry indicating the switch from primary to secondary webcam.	Pass
9.	Ensure the system continues to operate without interruption when switching between webcams.	The system operates continuously without interruption during webcam switch.	Pass

Table 9 *(cont)*

No	Description	Expected Result	Actual Result
10.	Measure system performance and response time during the switch between primary and secondary webcams.	The system performance and response time remain stable during the webcam switch.	Pass

This test plan ensures that a backup webcam system works seamlessly. It includes ten tests to check if both the primary and secondary webcams can capture images properly and if they can detect faces accurately. The plan also tests what happens if the primary webcam fails, making sure the system smoothly switches to the secondary webcam without missing a beat. It verifies that important data, like attendance logs, is recorded correctly during this switch and that the system continues running smoothly without any interruptions. All tests were successful, confirming the system's reliability.

Table 10 *Test Plan Security*

No	Description	Expected Result	Actual Result
1	Username must be 150 characters or fewer and contain letter, digit and @/./+/-/_ only – **user enters "firdaus***"**	System validates the username format, ensuring it meets the specified criteria before saving	Pass
2	Username can't be same to another username – user enter "firdaus"	System check for duplicates and prompts a user with that username already exists.	Pass
3	Password can't be too similar to your other personal information – user enters password "firdaus"	The system evaluates the password against personal information and prompts user if the password is too similar.	Pass
4	Password must contain at least 8 characte – user enters "daus"	System validates the password length, ensuring it meets the minimum character requirement.	Pass
5	Password can't be a commonly used password – user enters "password"	System checks the password against a list of commonly used passwords and prompts "This password is too common."	Pass
6.	Password can't be entirely numeric – user enters "123"	System validates that the password contains a mix of characters and is not entirely numeric.	Pass
7.	The Password will be salted and hashed before stored into database.	The system applies salting and hashing to the password before storing it in the database for enhancing security.	Pass
8.	Forgot password link will be sent through an email.	System sends a password reset link to the user's registered email address, allowing them to reset their password securely.	Pass
9.	Switching primary camera to secondary camera during Mark Attendance – In and Out process.	System successfully switches from primary to secondary webcam, allowing continued attendance marking.	Pass
10.	Account lockout after 3 unsuccessful login attempts for 30 seconds.	System lock the account for 30 seconds after 3 unsuccessful login attempts, preventing further attempts during this period.	Pass

This test plan is designed to make sure a system's usernames and passwords are secure. It includes nine checks to confirm everything works as it should. First, it ensures usernames are unique and follow specific rules. Next, it tests passwords to make sure they aren't too similar to personal info, are at least eight characters long, aren't common passwords, and contain a mix of characters. It also makes sure passwords are encrypted before being stored, and that users can receive a password reset link via email if needed. Finally, it checks that the system can switch cameras seamlessly during attendance marking. All tests were successful.

6. Conclusion and Future Work

This chapter discusses the development system's introduction, the system's contribution, the advantages and disadvantages of face recognition employee attendance system with redundancy webcam for MD 1010 Engineering, future recommendations, and the chapter summary.

6.1 Result of Develop System

The Face Recognition Employee Attendance System was successfully developed with several key features. It includes secure registration and login and logout functionalities, extensive attendance viewing capabilities, and a redundancy webcam setup for enhanced reliability. Employees can upload photos for recognition and view their attendance records, while administrators can monitor overall employee attendance and statistics. Security features such as password salting and hashing, email-based password resets, and limited login attempts further enhance system robustness. These features collectively ensure that the system is secure, user-friendly, and efficient.

6.2 Advantages of Employee Attendance System

The Face Recognition Employee Attendance System offers several key advantages. Firstly, the redundancy webcams ensure continuous operation by switching to a backup if the primary webcam fails, thus minimizing downtime and enhancing reliability. Secondly, the face recognition technology improves accuracy by reducing errors common with manual methods, thereby ensuring reliable attendance records for payroll processing. Thirdly, the system enhances security through password hashing, salting, and limited login attempts to prevent brute force attacks, while also allowing secure password resets via email. Lastly, the system increases efficiency by automating the attendance process, saving time and reducing the administrative workload for both employees and administrators.

6.3 Disadvantages of Employee Attendance

The several disadvantages of Face Recognition Attendance System which are listed below:

1. The system can mark attendance if an employee's picture is shown, which could lead to misuse.
2. The system requires capturing 300 photos per employee for better accuracy, demanding a significant amount of storage. This could be challenging for larger organizations.
3. The classifier training time takes about 20 seconds per employee. This could result in significant delays for large organizations.

6.4 Future Work

There are a few highlighted potential improvements. The following are examples of future improvements:

1. Implementing an intruder alert feature to enhance security. Images of unknown people can be saved efficiently and displayed for better security.
2. Decrease the number of images needed for training by removing duplicates or similar images, reducing storage requirements.
3. Retrain the classifier only for newly added images to reduce training time.

6.5 Conclusion

The Face Recognition Employee Attendance System was successfully developed, featuring redundancy webcams to ensure continuous operation even if the primary webcam fails. Users are authenticated through unique facial data, enabling access to their profiles and attendance records. The system is secure, user-friendly, and significantly improves attendance tracking efficiency, addressing the challenges of traditional systems. The redundancy webcams enhance reliability, ensuring uninterrupted and accurate attendance tracking. This project modernizes attendance systems and provides a scalable model for MD1010 Engineering.

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References

[1] R. Ravalji, N. Shah, H. Patel, and M. Patel, "Facial Recognition-Based Attendance System Using Python," *International Research Journal Of Engineering And Technology*, 2020, [Online]. Available: Www.Irjet.Net. Accessed October 31, 2023.

Commented [N.1]: Do not separate the references based on category.

[2] M. Aware, P. Labade, M. Tambe, A. Jagtap, and C. Beldar, "Attendance Management System Using Face-Recognition," *International Journal Of Scientific Research In Computer Science, Engineering And Information Technology*, Pp. 336–341, May 2021, Doi: 10.32628/Cseit217370.

[3] N. Ali, A. Alhilali, H. Rjeib, B. Al-Sadawi, and H. Alsharqi, "Automated Attendance Management Systems: Systematic Literature Review," *International Journal Of Technology Enhanced Learning*, Vol. 14, P. 37, Nov. 2022, Doi: 10.1504/Ijtel.2022.120559.

[4] M. Sharif, M. Raza, J. Shah, Y. Mussarat, and S. Fernandes, "An Overview Of Biometrics Methods," 2019, Pp. 15–35. Doi: 10.1007/978-3-030-15887-3_2.

[5] Editorial, "Face Recognition Methods Explained For Beginners." Accessed: Nov. 22, 2023. [Online]. Available: Https://Roboticsbiz.Com/Face-Recognition-Methods-Explained-For-Beginners/. Accessed October 20, 2023.

[6] S. I. Serengil and A. Ozpinar, "Lightface: A Hybrid Deep Face Recognition Framework," In *2020 Innovations In Intelligent Systems And Applications Conference (Asyu)*, 2020, Pp. 1–5. Doi: 10.1109/Asyu50717.2020.9259802. Accessed October 29, 2023.

[7] D. N. Parmar and B. B. Mehta, "Face Recognition Methods & Applications." [Online]. Available: Www.Ijcta.Com. Accessed October 20, 2023.

[8] W. Hariri, "Efficient Masked Face Recognition Method During The Covid-19 Pandemic," May 2021, [Online]. Available: Http://Arxiv.Org/Abs/2105.03026. Accessed October 20, 2023.

[9] A. M. Sudhan and S. Kumar. Sharma, "Webcam Based Computerized Attendance System Using Face Recognition Algorithms," *Int J Eng Adv Technol*, Vol. 9, No. 3, Pp. 859–863, Feb. 2020, Doi: 10.35940/Ijeat.C5329.029320.

[10] P. S. Smitha and A. Hegde, "Face Recognition Based Attendance Management System," 2020. [Online]. Available: Www.Researchgate.Net/Publication/326261079_Face_Detection_ Accessed October 29, 2023.

[11] M. Humaun Kabir, S. Roy, M. Tofail Ahmed, and M. Alam, "Smart Attendance And Leave Management System Using Fingerprint Recognition For Students And Employees In Academic Institute," *Article In International Journal Of Scientific Research*, 2021, [Online]. Available: Www.Ijstr.Org. Accessed October 15, 2023.

[12] X. Wei, A. Manori, N. Devnath, N. Pasi, and V. Kumar, "Qr Code Based Smart Attendance System," *International Journal Of Smart Business And Technology*, Vol. 5, No. 1, Pp. 1–10, Mar. 2017, Doi: 10.21742/Ijsbt.2017.5.1.01.

[13] E. Colbert, "The Object-Oriented Software Development Method: A Practical Approach To Object-Oriented Development," In *Proceedings Of The Conference On Tri-Ada '89: Ada Technology In Context: Application, Development, And Deployment*, In Tri-Ada '89. New York, Ny, Usa: Association For Computing Machinery, 1989, Pp. 400–415. Doi: 10.1145/74261.74291.

[14] I. Adjabi, A. Ouahabi, A. Benzaoui, and A. Taleb-Ahmed, "Past, Present, And Future Of Face Recognition: A Review," *Electronics*. 2020. Doi: 10.3390/Electronics9081188.

[15] K. Dudeja and A. Kharbanda, "Object-Oriented Approach And Waterfall Model: A Review," *International Journal Of Research*, Vol. 2, Pp. 180–184, 2015, [Online]. Available: Https://Api.Semanticscholar.Org/Corpusid:55552323. Accessed October 20, 2023.

[16] Z. Akhtar and A. Rattani, "A Face In Any Form: New Challenges And Opportunities For Face Recognition Technology," *Computer (Long Beach Calif)*, Vol. 50, Pp. 80–90, Nov. 2017, Doi: 10.1109/Mc.2017.119.