

DEVELOPMENT OF A FACE RECOGNITION AND GEOFENCING BASED ATTENDANCE INFORMATION SYSTEM USING THE PROTOTYPING METHOD

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ABSTRACT

An attendance information system is a crucial component in managing attendance in educational institutions and organizations. This research aims to develop an attendance system that integrates face recognition and geofencing technology to improve the accuracy and efficiency of the attendance recording process. Face recognition technology recognizes users' faces in real-time, while geofencing ensures users are within a designated area when taking attendance. The system development method used is prototyping, allowing the design process to be carried out iteratively by involving direct feedback from users. The results of this research are a mobile and web-based attendance information system that can automatically detect faces and locations, and store attendance data securely and structured. The developed system is expected to be an innovative solution in realizing a more modern, accurate, and reliable attendance process.

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INTRODUCTION

The management of lecturer attendance in higher education institutions is an important aspect that affects the effectiveness of academic administration and the quality of learning. The Faculty of Computer Science faces significant challenges in its lecturer attendance system, which still uses fingerprints and is carried out in one of the rooms in the Faculty of Economics. This situation has caused various operational problems, particularly related to the considerable distance between the faculties and the unsuitability of the attendance location for faculty members daily activities. The distance of approximately 50 meters between the Faculty of Computer Science and the Faculty of Economics means that lecturers have to move locations just to take attendance, which in reality often causes them to forget or be late in taking attendance when leaving. This results in inaccurate attendance data and inefficiency in academic administration management. Additionally, the fingerprint system used also has limitations in terms of real-time attendance validation and does not support more advanced verification mechanisms such as facial biometrics.

The current phenomenon shows that conventional attendance systems are unable to meet the flexibility and security requirements of modern academic environments. Computer Science Faculty lecturers need a solution that allows them to take attendance easily, quickly, and accurately without

having to travel long distances. Additionally, the attendance system must also be able to ensure the authenticity of faculty attendance with more complex biometric validation, such as face recognition equipped with biological movement detection like eye blinks and mouth opening to prevent data manipulation. This system must also be able to utilize geofencing technology to ensure that attendance can only be recorded within a predetermined radius, namely a maximum of 5 meters from the valid area, thereby increasing the accuracy and reliability of attendance data.

The development of a face recognition and geofencing-based attendance application used prototyping as an effective approach. This method enables iterative system development by directly involving users in the evaluation and improvement process [1]. With the prototyping approach, the needs of lecturers as the main users can be accommodated more precisely and the system can be dynamically adjusted to field conditions. Several previous studies have demonstrated the success of using the prototyping method in the development of biometric-based attendance systems [2].

Previous research by Arizal, L., Pravitasari, shows that the development of a biometric-based attendance system and location technology can provide a more effective and efficient solution compared to conventional methods [3]. One study developed a prototype of a fingerprint-based student attendance system integrated with a wireless network, making the attendance process more flexible and reducing the potential for attendance fraud. Another study applied the geofencing method to an Android-based attendance application, which allows attendance to be taken only within a certain radius of a valid location, thereby increasing accuracy and preventing fraud. In addition, a web-based lecturer attendance system with student validation has also been proposed to ensure real-time lecturer attendance in class, increasing transparency and accuracy of attendance data.

RESEARCH METHOD

This research methodology is designed to develop a mobile-based attendance system that can meet the needs of lecturers at the Faculty of Computer Science in recording attendance accurately, securely, and practically. This approach integrates face recognition technology with biological movement validation and geofencing to ensure the authenticity and location of attendance [4]. The following are the methodological steps that will be used in this research:

Research Stages

The research began with a literature study to understand the basic concepts of face recognition technology, biological motion validation, and the application of geofencing in attendance systems. This study also included an analysis of software development methods, particularly prototyping methods, as well as a review of relevant previous research [5].

Next, user requirements were identified through interviews and observations with lecturers from the Faculty of Computer Science to understand the constraints of the existing attendance system and determine the required features, such as biological movement validation and location restrictions with a maximum radius of five meters. The results of this requirements analysis were used as the basis for system design.

Application of the Prototyping Method

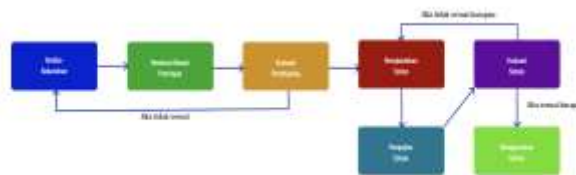


Figure 1. Prototyping Method

The prototyping method is used in system development because it provides flexibility for iterative processes between developers and users. The stages of this method include:

a. System Requirements Analysis

This stage is the initial step, where researchers collect and analyze user needs and system requirements to be developed. In the context of faculty attendance at the Faculty of Computer Science, the analysis was conducted through interviews with several faculty members, observations, and literature studies to understand the constraints faced and the features needed, such as biometric validation with face recognition and location restrictions using geofencing. The results of this analysis form the basis for designing a system that is appropriate and effective [6].

b. Creating a Prototype Design

Once the system requirements have been identified, the next step is to design an application prototype. This design includes creating a mockup of the user interface (UI) and conceptualizing the system flow. This prototype is created to provide an initial overview of the functions and appearance of the application to be developed, as well as to facilitate communication with users to obtain initial input. The prototype design also includes the database structure and application logic to be implemented [7].

c. Prototype Evaluation

The prototype that has been created is then evaluated together with users, in this case lecturers from the Faculty of Computer Science, to test the suitability of features and ease of use. This evaluation aims to identify shortcomings, bugs, or additional needs that have not been met. This process allows for improvements and refinements to the prototype before entering the coding stage, thereby reducing the risk of errors during the implementation stage [8].

d. System Coding

At this stage, the approved prototype is developed into a functional application by programming using the specified technology, such as Flutter for the frontend and Express.js for the backend. Coding includes the implementation of a face recognition feature with biometric validation, geofencing integration, and the creation of an API and database for attendance data storage. This stage also involves the creation of modules that support the overall system operation [9].

e. System Testing

In the system testing stage, the method used is Black Box Testing, which is a software testing technique that focuses on testing system functionality without looking at the internal structure or program code. This testing is carried out by providing certain inputs into the application and observing the outputs produced, then comparing them with the expected results according to the system specifications [10].

f. System Evaluation

After testing, the system is evaluated based on the test results and user feedback. This evaluation covers both technical aspects and user satisfaction with the application. The evaluation results are used to make final improvements and determine the application's readiness for wide implementation. This stage also forms the basis for future system development and maintenance [11].

g. System Usage

The final stage is the official implementation of the application and its use by Computer Science Faculty lecturers in their daily activities. At this phase, the system is fully operational and supports the real-time attendance process with biometric validation and location restrictions [12]. Effective use of the system will improve the efficiency of attendance administration and provide accurate and reliable data for the faculty.

RESULTS AND DISCUSSION

The process in this research, the system development process was carried out using the Prototyping method. Prototyping is an approach in software development that focuses on creating an initial model (prototype) of the system to be built. This model is used to demonstrate basic functionality to users so that they can understand and provide direct feedback before the system is fully developed. In this study, the Prototyping method was applied with the following procedures:

Requirement Analysis

1. System Analysis

b. Activity Diagram

Activity diagrams visualize the flow of activities within a system. Starting from the initial point, activities continue with possible decisions that affect their course. Finally, each activity path ends, signifying the completion of the activity.

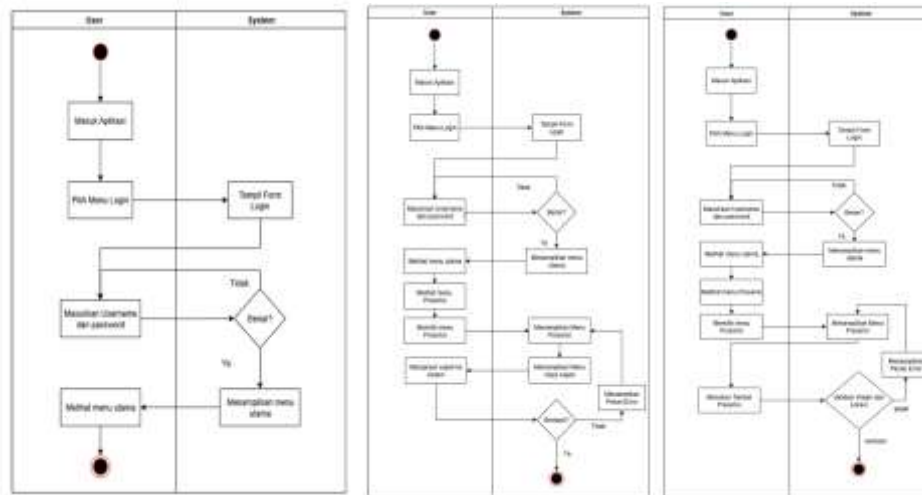


Figure 3 Lecturer Login, Register Lecture Attendance Validation, Perform Attendance Activity Diagram

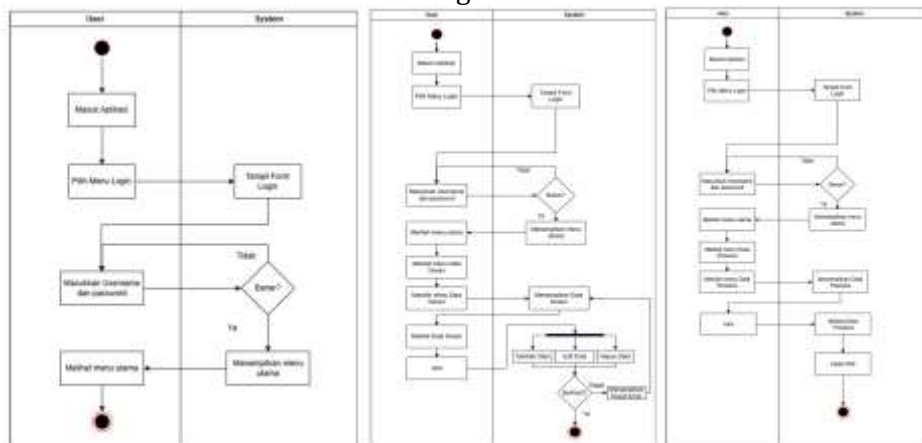


Figure 4 Admin Login, Manage Lecture Data, View and Print Lecture Attendance Data Activity Diagram

c. Sequence Diagram

Sequence Diagram is a type of diagram in UML that describes the interaction between actors and systems in a specific sequence of time. This diagram shows how objects in the system communicate with each other through the exchange of messages to complete a process or activity.

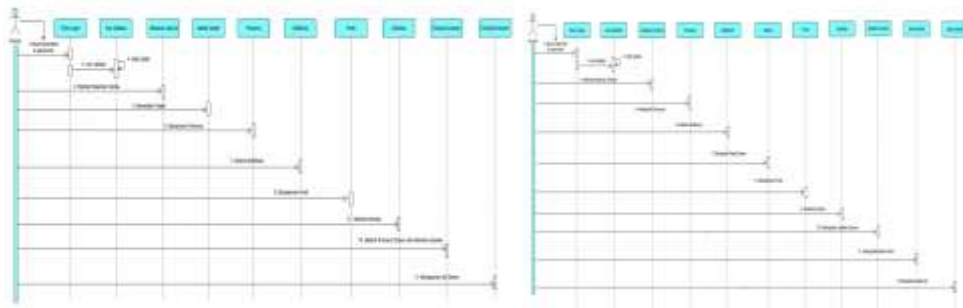


Figure 5 Lecture Sequence Diagram **Figure 6** Admin Sequence Diagram

d. Class Diagram

Class Diagram is a type of diagram in UML that is used to model the static structure of a system. This diagram depicts the classes in the system along with attributes, methods, and relationships between classes. Class Diagram helps in understanding the design and relationships between components in software development.

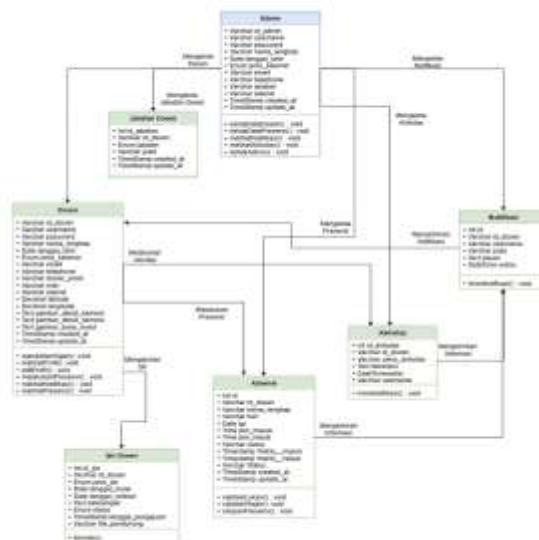


Figure 7 Class Diagram

Database Design

A database is a complete arrangement/collection of operational data from an organization/company that is organized/managed and stored in an integrated manner using specific methods and computers so that it can provide the information needed by its users. Database design is the process of designing the data structure that will be used to store, manage, and access information in a system [15].

1. Creating a Prototype Design

The User Interface is an integral element of a system that facilitates interaction between users and the system. It includes screen displays that enable navigation within the system, forms for collecting data, and reports generated by the system. The design of the user interface determines how users will interact with the system, including the types of input accepted and output generated by the system.

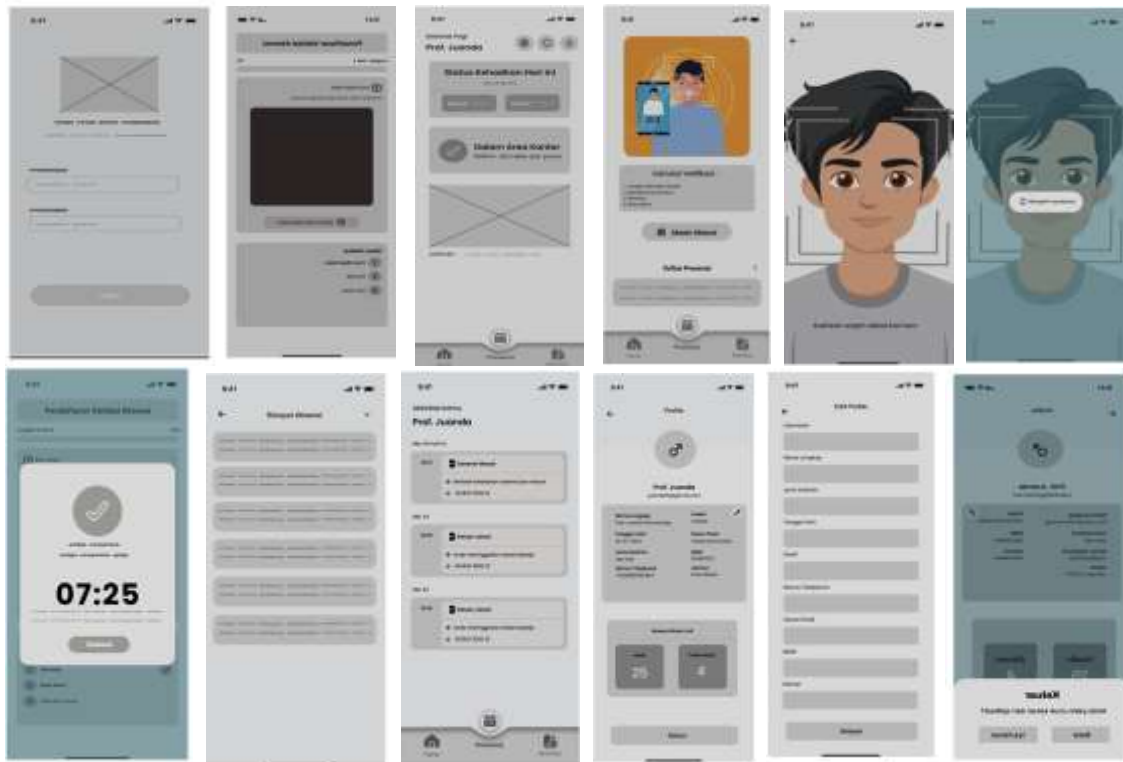


Figure 8 Lecturer Interface



Figure 9 Admin Interface

2. Prototype Evaluation

The prototype evaluation stage was conducted after the initial design of the face recognition and geofencing-based attendance system for lecturers was successfully built in prototype form. This evaluation aimed to obtain input from end users, in this case lecturers and administrators at the Faculty of Computer Science, Santo Thomas Catholic University, regarding the suitability of the system's appearance, usage flow, and functionality to actual needs in the field.

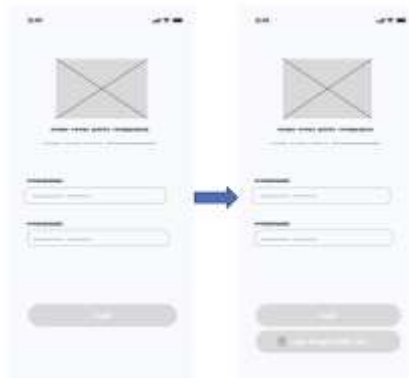


Figure 10 Login Interface Design Before and After Evaluation



Figure 11 Home Interface Design Before and After Evaluation



Figure 12 Lecturer Attendance Interface Design for Deans & Vice Deans before and after Evaluation



Figure 13 Lecturer Attendance Interface Design before and after Evaluation

3. System Coding

This subsection describes the coding process for the system that has been developed in accordance with the prototype agreed upon in the previous stage. Coding includes the application of programming languages, application directory structures, and the description of the main modules in the system. Each part of the code is arranged based on the results of the interface design, process logic, and system requirements that have been analyzed previously. Coding is carried out with attention to efficiency, code readability, and ease of maintenance in the future.



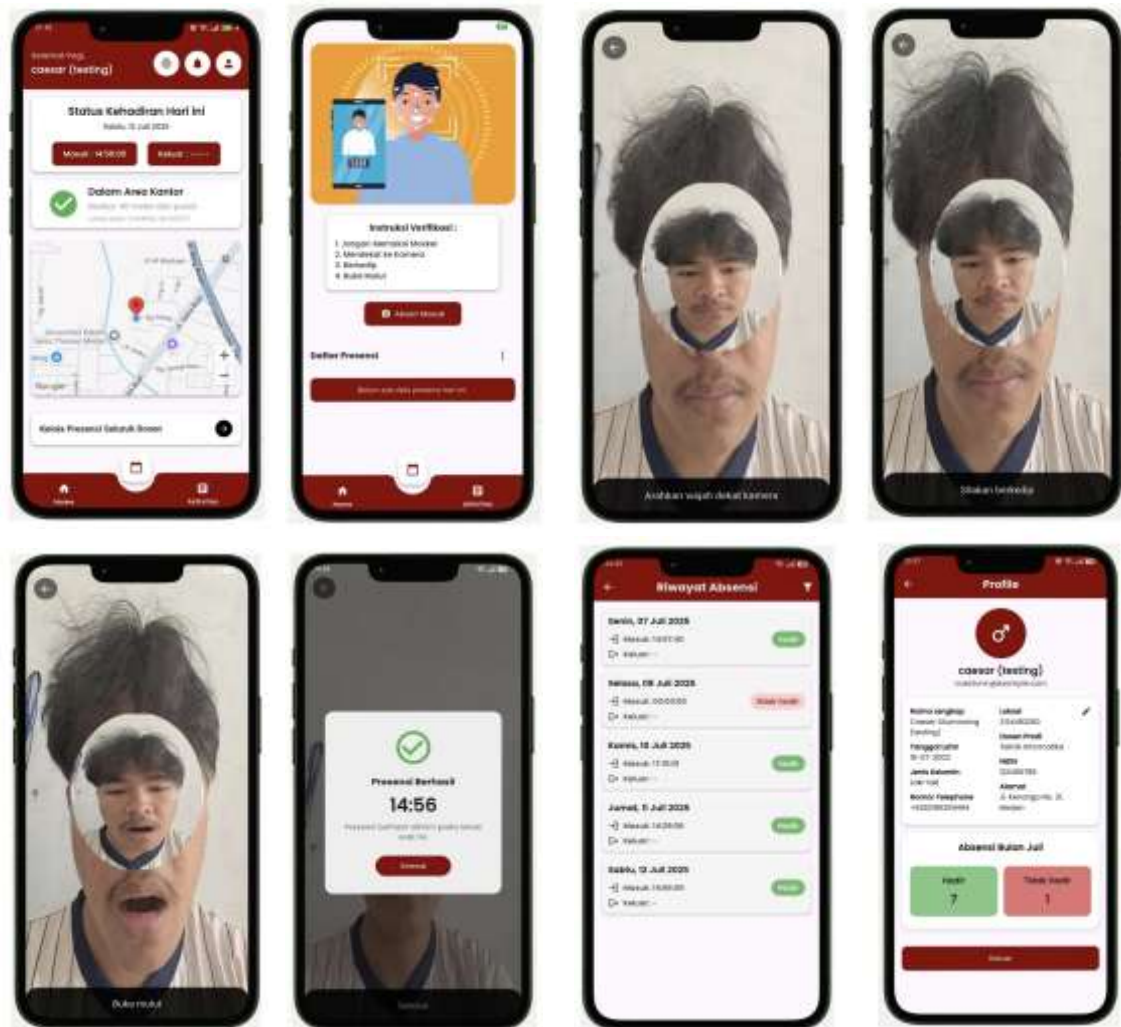


Figure 14 Implementation of the Lecturer Interface

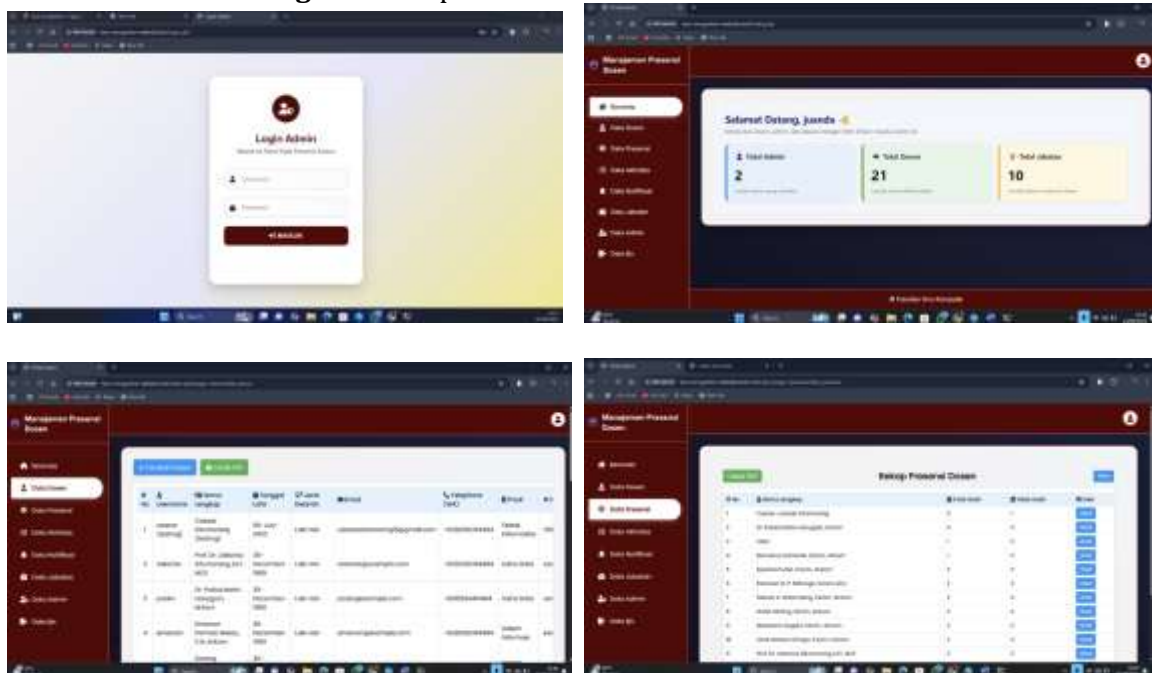


Figure 15. Admin Interface Implementation

4. System Testing

After the system has been successfully developed and implemented, the next step is to conduct testing to ensure that the system runs as expected. At this stage, testing is carried out using the Blackbox Testing method, which is a testing method that focuses on system functionality without regard to the internal structure of the program code. In other words, this testing only checks the input and output of the system, as well as how the system responds to various usage scenarios, both normal

and extreme. Each module is tested based on specific inputs to see whether the output results are as expected. The results of this testing will be described in a table that shows the success or failure status of each feature that is tested. This testing is an important part of ensuring the quality and reliability of the system before it is fully used by users.

Table 1. Lecture Login Testing

No.	Scenario Testing	Test Case	Expected Results	Test Results	Conclusion
1.	Leave the Username and Password fields blank, then click the login button	Username: (Blank) Password: (Blank)	The system will reject it and display the message "username and password must be filled in"	As expected	Success
2.	Type in your username and password, leave the password field blank, then click the Login button	Username: (caesar) Password: (Blank)	The system will reject and display the message "username and password must be filled in."	As expected	Success
3.	Type in your username and password, but if the password you entered is incorrect, click the Login button	Username: (caesar) Password: (123456)	The system will reject it and display the message "Incorrect Password."	As expected	Success
4.	Enter the correct username and password, then click the Login button	Username: (lian) Password: (123456)	The system will reject it and display the message "Username not found"	As expected	Success
5.	Type in the correct username and password, then click the Login button	Username: (admin) Password: (admin1234)	The system will accept the login access and then display the main page for lecturers.	As expected	Success
6.	Log in using your fingerprint, but your fingerprint has not been registered yet	Click the fingerprint login button	The system will reject it and display the message "Fingerprint not yet registered."	As expected	Success
7.	Log in using your fingerprint once your finger has been registered	Click the fingerprint login button	The system will accept the login access and then display the main page for lecturers	As expected	Success

Table 2. Attendance Validation Registration Testing

No.	Scenario Testing	Test Case	Expected Results	Test Results	Conclusion
1.	When on the face attendance validation page near the camera, step 1/3 is at 0%	Go to the face validation page near the camera	The system will display step 1/3 at 0%	As expected	Success
2.	When you click the face validation button near the camera	Click the validation button	The system will save the data and redirect you to the validation page.	As expected	Success
3.	When the attendance validation page flashes, step 2/3 is at 50%	Go to the validation page	The system will display step 2/3 at 50%	As expected	Success
4.	When the validation button flashes	Click the validation button	The system will save the data and redirect you to the validation page.	As expected	Success
5.	When on the face attendance validation page, open your mouth 3/3 at 100%	Go to the validation page, open your mouth.	The system will display step 3/3 at 100%	As expected	Success
6.	When you click the validate button, open your mouth	Click the validate button	The system will save the data and redirect you to the location validation page	As expected	Success
7.	When you click the location validation button	Click the validate button	The system will save the data and display a pop-up saying "successfully completed validation."	As expected	Success

Table 3. Navigation Testing on Lecturer Home Page

No.	Scenario Testing	Test Case	Expected Results	Test Results	Conclusion
1.	Disable network connection	Go to the home page	The system will display loading in all features	As expected	Success
2.	Active network but turn off the server	Go to the home page	The system will display loading in all features	As expected	Success
3.	Activate the server and network then	Taking cell phones outside the campus	The home page will display the message "you	As expected	Success

	exit the campus location 50 meters away	location	are outside the office area"		
4.	Activate the server and network then exit the campus location 50 meters away	Taking cell phones outside the campus location	The system will display maps showing where the cell phone is located	As expected	Success
5.	All navigation buttons	Click the fingerprint button, notifications, profile, attendance and activity	The system will display the page according to what is clicked	As expected	Success

Table 4. Lecturer Attendance Testing

No.	Scenario Testing	Test Case	Expected Results	Test Results	Conclusion
1.	Enter the attendance page	Click the clock in or clock out	The system will record the lecturer and give instructions when approaching the camera, blinking, and opening the mouth	As expected	Success
2.	The sequence of instructions for attendance is to approach the camera, blink, and open your mouth	Enter the attendance page for clocking in or clocking out.	The system will give instructions when you bring your face close to the camera, blink, and open your mouth	As expected	Success
3.	Once you have successfully checked in or out	Log in to the attendance page for lecturers	The system will display today's attendance list based on the day, date, time of arrival and time of departure if you have already signed out	As expected	Success
4.	When outside the campus location	Go to the faculty attendance page and check in or out	The system will display the message "failed to send attendance, make sure you are in the right location."	As expected	Success

Table 5. Fingerprint Management Testing

No.	Scenario Testing	Test Case	Expected Results	Test Results	Conclusion
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1.	When registering a finger that is not registered on the device	Click register finger and insert finger	The system will display the message "finger not found in the device"	As expected	Success
2.	When adding fingers that have the same	Click register finger and insert finger	The system will display the message "finger double"	As expected	Success
3.	When registering more than one finger and already registered on the device	Click register finger and insert finger	The system will save and display the message "fingerprint successfully added."	As expected	Success

Table 6. Admin Login Test

No.	Scenario Testing	Test Case	Expected Results	Test Results	Conclusion
1.	Username and Password are not filled in then click the login button	Username: (Blank) Password: (Blank)	The system will reject and display the message "username and password must be filled in."	As expected	Success
2.	Type in the username and password (leave blank if you don't have one) then click the Login button	Username: (admin) Password: (Blank)	The system will reject and display the message "username and password must be filled in"	As expected	Success
3.	Type in your username, and password, but if the password you entered is incorrect, then click the Login button	Username: (admin) Password: (123456)	The system will reject and display the message "Password incorrect."	As expected	Success
4.	Type in the wrong username and password, then click the Login button	Username: (lian) Password: (123456)	The system will reject and display the message "Username not found."	As expected	Success
5.	Type in the correct username and password, then click the Login button	Username: (admin) Password: (admin1234)	The system will accept login access and then will display the main admin page	As expected	Success

Table 7. Home Admin Testing

No.	Scenario Testing	Test Case	Expected Results	Test Results	Conclusion
1.	Click the faculty data management menu to enter the Faculty Data page	Click Menu Management Lecturer Data	The system will display a message on the faculty data management page	As expected	Success
2.	Click the attendance data management menu to enter the Attendance Data page	Click Menu Management Attendance Data	The system will display a message on the attendance data management page	As expected	Success
3.	Click the data management notification menu to enter the data Notification page	Click Menu Management Data Notifications	The system will display a message on the notification data management page	As expected	Success
4.	Click the activity data management menu to enter the Activity data page	Click Menu Management Data Activities	The system will display a message on the activity data management page	As expected	Success
5.	Click the attendance data management menu to enter the Admin data page	Click Menu Management Data Admin	The system will display a message on the data management admin page	As expected	Success
6.	Click the profile icon to go to the admin profile page	Click the profile icon in the navigation bar	The system will display a message on the admin profile page	As expected	Success

CONCLUSION

Based on the results of research and development of a faculty attendance application based on face recognition and geofencing, it can be concluded that the developed system has succeeded in creating a solution that is more practical, secure, and accurate compared to conventional methods such as fingerprint recognition. By integrating face recognition technology and biological movement validation such as blinking and opening the mouth, the system is able to verify the authenticity of the user's identity in real-time and prevent attendance data manipulation. In addition, the application of geofencing technology with a maximum radius of five meters has succeeded in limiting attendance locations to only predetermined areas, thereby preventing attendance location fraud and increasing the validity of attendance data. The use of prototyping methods in the development process also allows lecturers to provide direct feedback on the prototype being built, making the system more adaptive to user needs and resulting in a responsive and easy-to-use application.

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