

Increasing Security of Boarding House Door Access with QR-Code Technology and Fisherface-Based Face Recognition

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Abstract— This study aims to design and implement a boarding house gate security system based on QR-Code and Face ID using the Fisherface method. The system was developed to improve the security of boarding house resident access through dual authentication integrated with Internet of Things (IoT) technology. The Fisherface method is used as the main facial recognition algorithm because it can recognize facial patterns under different distance and lighting conditions. The system is designed using an ESP32 microcontroller, a cellphone camera, and an Android application as the user interface. Testing was carried out on three users with distance parameters of 20 cm, 40 cm, and 60 cm, facial attribute conditions without accessories, wearing glasses, and wearing a helmet, and lighting conditions ranging from normal light of approximately 360–423 lux, very bright light above 1500 lux, and low light of 15–21 lux. The results show that the system works optimally at distances of 20–40 cm and under normal lighting conditions, where authentication was successfully performed. The system still functioned up to 1823 lux but failed at 1928 lux due to overexposure, while all tests under 15–21 lux failed. Overall, the proposed system improves access security through an efficient two-layer authentication process.

Keywords— Face ID, QR-Code, Fisherface, ESP32, Security, IoT

I. INTRODUCTION

Security is a vital aspect in people's lives, especially in residential environments such as boarding houses. The use of conventional security systems such as manual locks often have loopholes that can be exploited by irresponsible parties. Therefore, modern security technology based on biometrics and IoT (Internet of Things) has begun to be implemented to improve the security of restricted access areas [1].

The Fisherface method is known to be effective in recognizing faces in various lighting conditions and expressions. Research by [2] shows an 80% success rate in implementing this method. However, the use of one authentication method still has security gaps, so the combination with QR-Code is a safer alternative [3], [4].

The use of ESP32 microcontrollers is becoming more common in IoT-based security systems. Research [5] demonstrated its successful implementation in locker and smartlab systems. In addition, ESP32-CAM was shown to be able to support real-time facial recognition with certain limitations on lighting [6]. The system integration with Android applications strengthens the practical side, while the effectiveness of QR-Code and integration with Firebase has been discussed showing that the ESP32 is able to manage dual authentication efficiently [7].

Based on the study, this research proposes a boarding house gate security system based on QR-Code and Face ID with the Fisherface method, which is integrated with ESP32 and an Android application as a practical and secure dual authentication solution [8]. On the other hand, QR-Code technology is used as a fast authentication method that does not require direct connectivity between the user and the physical system [9]. Users only need to show the QR-Code generated by the Android application, and the system will perform verification. The effectiveness of using QR-Code as an alternative authentication [10].

ESP32 is the primary choice in modern security system research because it has WiFi connectivity, sufficient processing capacity, and is compatible with various camera modules [11], [12]. Research shows that ESP32 can be used in web-based and Telegram-based door monitoring systems with a high success rate [13], [14].

Current security systems are mostly manual security systems in the form of padlocks or conventional keys. People often forget to lock doors [15]. Furthermore, a parking lot is a situation where a vehicle is temporarily left by its owner. In boarding house areas, parking is a facility that must be fulfilled because this facility plays an important role in comfort and security [2].

On the other hand, the Fisherface algorithm is a method in facial recognition that has proven effective in identifying individuals based on their facial features [16]. This facial recognition system works by comparing input data with classification data stored in the database to find a facial match that corresponds to the stored facial data. Fisherface is one method that can be used for facial recognition processing. With the Fisherface method, faces that have been trained can be recognized with facial objects in the database [17].

II. METHOD

The research method used in this study consists of several systematic stages, starting from literature study, system design, and the selection of hardware and software components. The literature study was conducted to obtain theoretical references related to QR-Code technology, Fisherface-based face recognition, Internet of Things (IoT), and electronic door access security systems. After that, the system design stage was carried out to determine the overall architecture, workflow, and interaction between the Android application, facial recognition process, QR-Code authentication, ESP32 microcontroller, and door lock mechanism. The next stage was collecting the

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required hardware and software components to ensure that all system requirements could be fulfilled before implementation.

After the design and component preparation stages were completed, the research continued with hardware assembly and application development. In this stage, the ESP32 microcontroller, electronic lock system, Android application, QR-Code scanner, and face recognition feature were integrated into one access control system. The system was then evaluated through a feasibility checking process to determine whether the hardware and software integration worked properly. If the system was not feasible, improvements were made by returning to the previous design or development stage. However, if the system was feasible, the process continued to testing and analysis. The testing stage was conducted to evaluate system performance based on several parameters, such as face distance, facial accessories, and lighting conditions. Finally, the results of the testing and analysis were used to draw conclusions regarding the effectiveness of the proposed boarding house door security system.

A. Block Diagram

The block diagram of the system is shown in the Fig. 1 below:

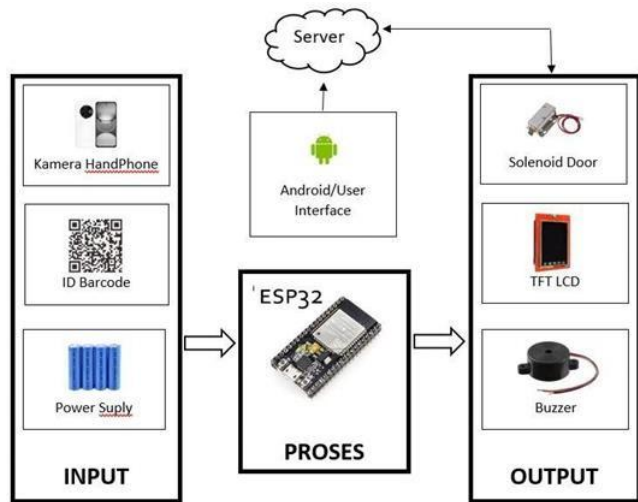


Figure 1. Diagram Block

The input section consists of a cellphone camera, barcode ID, and power supply battery. The cellphone camera is used by the user to scan barcodes or perform facial verification through the Android application. The barcode ID serves as a unique identity for each user and is used as one of the authentication methods for system access. Meanwhile, the power supply battery is used to provide electrical power to the ESP32 module and all other supporting electronic circuits. In the process section, the ESP32 functions as the main microcontroller and serves as the center of data processing. The ESP32 receives data from the Android application through Firebase, verifies the data in the form of barcode and Face ID information, and then controls the output devices according to the verification results.

The output section consists of a solenoid door lock, buzzer, and TFT LCD. The solenoid door lock functions as a door-locking actuator that will activate or open when the verification process is successful. It can also remain locked or be locked again if the verification fails or the system is no longer in use. The buzzer functions to provide an audible signal as a notification of success or failure during the verification process.

Meanwhile, the TFT LCD is used to display status information such as “Access Granted” “Invalid ID” or user data.

B. Hardware Planning

In this research, the design of the tools used was meticulously planned to meet the desired system requirements. This design, as shown in the Fig. 2 below, illustrates the main components and their functions within the system.



Figure 2. Hardware Design

The image shows the arrangement of the main components of the boarding house door security system, designed compactly and integrated. The first component is the ESP32, which is the main microcontroller that manages the entire system. The ESP32 functions as a controller for communication between the camera module, relay, and Android application, as well as processing facial recognition data and Wi-Fi connectivity. Next to it is the relay module, which acts as an electronic switch to regulate the electrical current to the solenoid door lock. Commands from the ESP32 will activate or deactivate the relay according to the user's authentication results.

The system's power source is obtained from a battery-based power supply that can maintain system performance even during power outages. This component is designed to provide stable and continuous power to the entire electronic circuit. Meanwhile, the buzzer is used as an audible indicator to provide notifications to the user, such as when authentication is successful, failed, or when the system is in a certain process. All these components are assembled in one module with an efficient layout, making it easy to install and maintain this QR- Code and Face ID-based security system.

The implementation of the tools and placement of the system includes the installation of the buzzer, ESP32, toggle button, Solenoid door lock, Relay, Power Supply, and LCD components. Fig. 3 shows the circuit implemented for the security system.

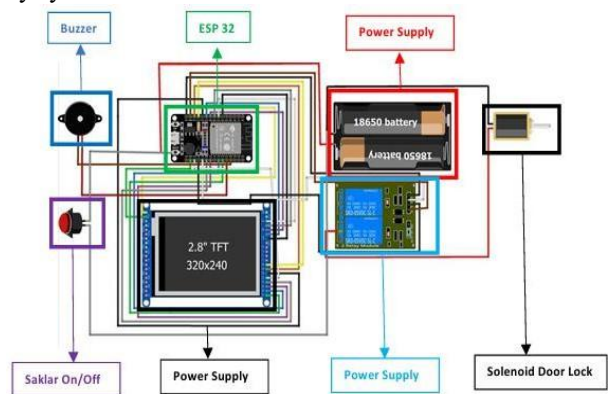


Figure 3. Cable Component

C. Software Planning

The software plan is shown in Fig. 4 below.

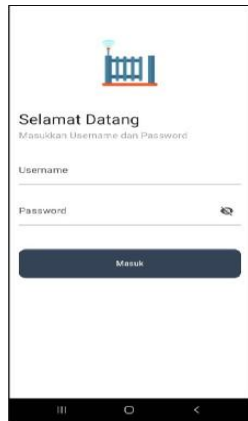


Figure 4. App Planning

The password field also has an "eye closed" icon, which usually functions to hide or show password characters when tapped. After users enter their username and password, they can tap the "Masuk" (Login) button to proceed with the login process.

III. RESULTS AND DISCUSSION

A. Hardware Circuit Result

The following figures shows the hardware circuit used in this research.



Figure 5. Hardware Inside Result



Figure 6. Hardware Outside Result

Figures 5 and 6 show the results of the hardware that has been successfully assembled as part of the QR-Code and Face ID-based boarding house door security system. This hardware includes the ESP32 microcontroller as the system's control center, a relay module as an actuator controller, and a buzzer as an audible indicator. These components are organized into a single module, supported by a battery-based power supply to ensure power stability. This circuit is designed to operate independently and connect to the facial recognition system and mobile application.

All functional tests have been conducted to ensure that the system can authenticate users, automatically activate the door lock, and provide real-time system status notifications. The physical form of the hardware has also been adjusted to be easily installed in the boarding house door area without requiring much space and remaining secure from external interference. The final results show that this hardware design is capable of functioning as intended and supports the entire system workflow optimally.

B. Application

This system is integrated with an Android application that functions as a user interface for QR-Code authentication and real-time door status monitoring. Through this application, users can enter registered accounts, scan QR-Codes, and receive notifications if access is granted or denied.

On this login page, as shown in Fig. 7, users must fill in the username and password that have been registered previously. If there is an error in one of the fields, the user will not be able to log in.

However, if the credentials entered are correct and match the registered user data, the application will continue to the home page according to the user role, as shown in the Fig. 9. The home page displays the main menu of the application after the user has successfully logged in. In this page, the system shows the active user identity, namely "Bayu Andika" with the role as Admin.

Several main features are provided in the form of menu cards, including "Buka Akses Gerbang" for opening gate access, "Daftar Pengguna" for managing registered users, and "Ubah Password" for changing the user password. Each menu is designed with a clear icon and label to help users access the available functions easily. This page acts as the main navigation interface that allows the admin to manage access control and user data efficiently.

Figure 8 shows the barcode scanning and face recognition pages used in the proposed boarding house door access system. After selecting the “Buka Akses Gerbang” menu, the user is directed to the QR-Code scanning page to perform the first authentication process. The system scans and validates the QR-Code to ensure that the access identity is registered and authorized. Once the QR-Code is successfully verified, the application proceeds to the selfie page for face recognition.

In this stage, the user’s facial image is captured through the smartphone camera and compared with the registered face data using the Fisherface method. The combination of QR-Code technology and Fisherface-based face recognition provides a layered security mechanism, reducing the possibility of unauthorized access and improving the reliability of the boarding house door access system.



Figure 8. Page Notification

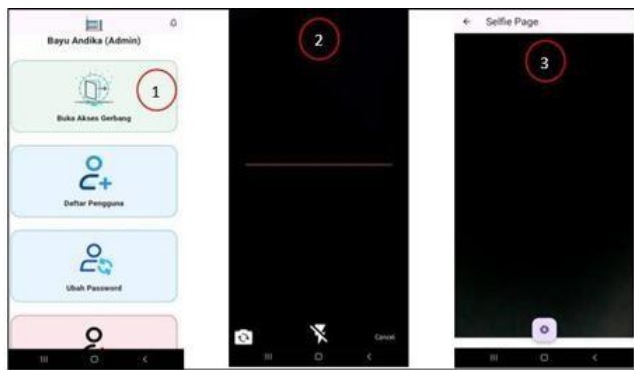


Figure 7. Page Scan Barcode and Face Recognition

If both verification stages are successfully completed, the system will grant access to the boarding house door and display a notification page, as shown in Fig. 9. This notification informs the user that the authentication process has been successful and that the gate has been opened. The message “Sukses” and “Gerbang telah dibuka” indicates that the QR-Code scanning result and Fisherface-based face recognition result have both been validated by the system.

This notification page serves as immediate feedback for the user after completing the layered security process. By displaying a clear success message, the application confirms that the access request has been approved and the door control mechanism has been activated. Therefore, the notification page becomes the final confirmation stage in the proposed boarding house access system, ensuring that users know whether the gate access process has been completed successfully.

C. Test Result Without Accessories

The test was conducted without using any additional accessories to evaluate the performance of the QR-Code and Face Recognition-based security system under normal conditions. Three users, namely Bayu, Melda, and Yulio, participated in the test. The system was tested at three different distance variations: 20 cm, 40 cm, and 60 cm. This test aimed to determine the system’s ability to recognize QR-Code and facial identity simultaneously without the influence of external accessories. The test results are presented in the Table I.

TABLE I
TESTING WITHOUT ACCESSORIES

No	Test Result	Face Recognition	Qr Code	Information
1	Bayu (20cm)	V	V	Succes
2	Melda (20cm)	V	V	Succes
3	Yulio (20cm)	V	V	Succes
4	Bayu (40cm)	V	V	Succes
5	Melda (40cm)	V	V	Succes
6	Yulio (40cm)	V	V	Succes
7	Bayu (60cm)	V	V	Succes
8	Melda (40cm)	V	V	Succes
9	Yulio (60cm)	X	X	Fail

In Table 1, at a distance of 20 cm and 40 cm, the system showed very good performance. The three users were successfully authenticated using both the face recognition method and QR- Code scanning. This shows that at this distance, the quality of the facial image captured by the camera is clear and accurate enough to be processed by the Fisherface algorithm, and the QR-Code can be read quickly. However, at a distance of 60 cm, there was one case of authentication failure on a user named Yulio. The system failed to recognize the face or scan the QR- Code, which is marked with an "X" on both methods and the information "Fail". This failure is most likely caused by two factors

light.

D. Test Result With Accessories Sun Glasses

The test was conducted using sunglasses as an additional accessory to evaluate the performance of the QR-Code and Face Recognition-based security system under partially occluded facial conditions. Three users, namely Bayu, Melda, and Yulio, participated in the test. The system was tested at three different distance variations: 20 cm, 40 cm, and 60 cm. This test aimed to determine the system's ability to recognize QR-Code and facial identity simultaneously when the user wears sunglasses. The test results are presented in the Table II.

TABLE II
TESTING WITH ACCESSORIES SUN GLASSES

No	Name	Distance	Face Recognition	Qr Code	Information
1	Bayu	20 cm	V	V	Succes
2	Melda	20 cm	V	V	Succes
3	Yulio	20 cm	V	V	Succes
4	Bayu	40 cm	V	V	Succes
5	Melda	40 cm	V	V	Succes
6	Yulio	40 cm	V	V	Succes
7	Bayu	60 cm	V	V	Succes
8	Melda	60 cm	V	V	Succes
9	Yulio	60 cm	X	X	Fail

At a distance of 20 cm and 40 cm, all users successfully authenticated using Face Recognition and QR-Code. This shows that wearing glasses is not a significant obstacle to the system as long as the user's face is still clearly captured by the camera. The Fisherface method is able to adjust to the difference in the appearance of a face wearing glasses, so that the main features The main thing is still recognized accurately. QR-Code reading also runs smoothly because the distance is still within the effective limit for the camera. The main thing is still recognized accurately. QR-Code reading also runs smoothly because the distance is still within the effective limit for the camera.

E. Test Result With Accessories Helmet

This test was conducted to evaluate the performance of the security system when the user is wearing a helmet, which is an attribute with a wide coverage of the facial area. Based on the test results, it is known that at a distance of 20 cm, all three users successfully passed the authentication process using Face Recognition and QR-Code without any problems. However, starting from a distance of 40 cm to 60 cm, the authentication process using Face Recognition failed for all users, while the QR-Code method was still able to function properly for most cases, except for one user (Yulio) at a distance of 60 cm. The test results are presented in the Table III.

TABLE III
TESTING WITH ACCESSORIES HELMET

No	Name	Distance	Face Recognition	Qr Code	Information
1	Bayu	20 cm	V	V	Succes
2	Melda	20 cm	V	V	Succes
3	Yulio	20 cm	V	V	Succes
4	Bayu	40 cm	X	V	Fail
5	Melda	40 cm	X	V	Fail
6	Yulio	40 cm	X	V	Fail
7	Bayu	60 cm	X	V	Fail
8	Melda	60 cm	X	V	Fail
9	Yulio	60 cm	X	X	Fail

The failure of facial recognition is caused by the covering of most of the important facial features due to the use of a helmet, so that the camera cannot capture the main features needed by the Fisherface method for the identification process. Additional factors such as light reflection from the helmet visor or shadows on the face also contribute to this failure. However, the QR-Code can still be read well at a distance of 40 cm to 60 cm, as long as its position is within the camera's range and is not obstructed by the helmet.

However, in certain cases such as user Yulio at a distance of 60 cm, both authentication methods failed. This is most likely due to the instability of the QR-Code position or inadequate lighting, which exacerbates the interference from the helmet. These results indicate that the system has limitations in dealing with large attributes such as helmets, especially in facial recognition. QR-Code proved to be a fairly reliable authentication alternative in this condition, although it still requires appropriate positioning and lighting adjustments to function optimally.

F. Testing Angle Parameters

Testing for angle parameters was carried out on five angle samples, namely: 0 degrees, 45 degrees, 90 degrees, 270 degrees, and 315 degrees, as shown in Table 4 below.

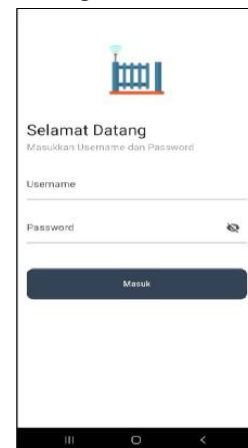


Figure 9. Login Page

TABLE IV
TESTING ANGLE




No	Test Result	Face Recognition	Angle	Information
1	Bayu	V	0 Degrees	Succes
2	Bayu	V	0 Degrees	Succes
3	Bayu	X	45 Degrees	Fail
4	Bayu	X	45 Degrees	Fail
5	Bayu	X	90 Degrees	Fail
6	Bayu	X	90 Degrees	Fail
7	Bayu	X	270 Degrees	Fail
8	Bayu	X	270 Degrees	Fail
9	Bayu	X	315 Degrees	Fail
10	Bayu	X	315 Degrees	Fail

This test was conducted to determine the effect of facial viewing angle on the success of the Face Recognition system using the Fisherface method. The test was focused on one user (Bayu) with several variations of facial rotation angles, namely 0°, 45°, 90°, 270°, and 315°. Each angle was tested twice to ensure consistency of the results. From the results obtained, the system successfully recognized faces only at an angle of 0 degrees, where the face faces straight at the camera. In this position, the main features of the face such as the eyes, nose, and mouth are detected intact and symmetrically, so that the Fisherface method can recognize faces accurately and the authentication process is declared successful. On the other hand, at angles of 45°, 90°, 270°, and 315°, the system failed to perform face recognition. This failure was caused by changes in the visual appearance of the face due to the extreme tilt angle. The Fisherface method, which is based on Linear Discriminant Analysis (LDA), is less flexible in recognizing faces with tilted or sideways orientations. Important facial features become completely illegible or distorted, so that the system cannot match facial data with stored data

G. Testing With Light Parameters

The following Table V presents the results of the lighting intensity test used to evaluate the performance of the Fisherface-based facial recognition system under different environmental illumination levels. This test was conducted to determine the extent to which lighting conditions affect the performance of the Fisherface-based facial recognition system. Lighting is one of the crucial factors in the facial image acquisition process because the quality of lighting affects the clarity of facial features captured by the camera.

TABLE V
LIGHT INTENSITY

No	Light intensity	Documentation
1	Bright: 1740 lux	
2	Dim: 471 lux	
3	Dark: 28 lux	

In this test, the system was evaluated under three different lighting conditions, namely bright light, dim light, and dark light, with measured intensities of approximately 1740 lux, 471 lux, and 28 lux, respectively. Each condition was documented to observe how variations in light intensity influence the camera's ability to capture facial details and support accurate recognition by the system. Therefore, this test provides an important reference for assessing the reliability of the proposed boarding house door access system in real usage environments with varying lighting conditions.

This test was conducted to determine the extent to which lighting conditions affect the performance of the Fisherface-based facial recognition system. Lighting is one of the crucial factors in the facial image acquisition process, because the quality of lighting will affect the clarity of facial features captured by the camera. In this test, the system was tested in three different lighting conditions, namely bright (normal daylight), very bright (overexposure), and dark (low light). The result of light parameter testing is shown in Table VI.

TABLE IV
TESTING OF LIGHT PARAMETERS

No	Name	Light Intensity	Face Recognition	Information
1	Bayu	1928 lux	V	Succes
2	Bayu	1823 lux	V	Succes
3	Bayu	1755 lux	V	Succes
4	Bayu	1676 lux	V	Succes
5	Bayu	1531 lux	V	Succes
6	Bayu	423 lux	V	Succes
7	Bayu	402 lux	V	Succes
8	Bayu	384 lux	V	Succes
9	Bayu	380 lux	V	Succes
10	Bayu	362 lux	V	Succes
11	Bayu	21 lux	X	Fail
12	Bayu	20 lux	X	Fail
13	Bayu	18 lux	X	Fail
14	Bayu	16 lux	X	Fail
15	Bayu	15 lux	X	Fail

Based on the test results, the system was tested in three light intensity ranges, namely normal light at around 360–423 lux, very bright light at more than 1500 lux, and dim or dark light below 25 lux. At normal light intensity ranging from 360 to 423 lux, the system showed excellent performance, where all authentication attempts were successful. This indicates that the Fisherface method works optimally under standard lighting conditions, where facial features can be clearly captured and recognized by the camera.

Furthermore, under very bright light conditions with an intensity between 1531 and 1928 lux, the system could still work properly up to 1823 lux. However, when the intensity reached 1928 lux, the system failed to perform face recognition. This failure was most likely caused by overexposure, where excessive light made facial details appear too bright or unclear, resulting in the loss of important facial contours required for identification.

On the other hand, under dark lighting conditions ranging from 15 to 21 lux, all authentication attempts failed. Low light intensity caused the facial image captured by the camera to appear too dark, making facial features difficult to recognize. This result confirms that the proposed system has limitations in low-light environments because the camera cannot capture sufficient visual information for analysis using the Fisherface method.

IV. CONCLUSION

Based on the research conducted under the title “Boarding House Door Fence Security System in the Form of QR-Code and Face ID Using the Fisherface Method,” it can be concluded that the proposed system is able to function properly as a layered security mechanism for boarding house door access. The system combines QR-Code authentication as the first verification stage and Face ID using the Fisherface method as the final verification layer. This combination provides a more secure access control process because users are not only required to scan a registered QR-Code, but also to verify their facial identity before access is granted. The testing results show that the distance between the user’s face and the camera affects the performance of the facial recognition system. The system provides the best recognition results at distances of 20 cm and 40 cm, while the accuracy

begins to decrease at a distance of 60 cm. This condition indicates that the farther the face is from the camera, the lower the recognition accuracy becomes, because the facial features captured by the camera become less clear and less detailed. Therefore, an ideal face-to-camera distance is needed to ensure that the Fisherface method can process facial features optimally. In addition, the condition of the user’s face also influences the recognition results. A face without accessories produces the most accurate recognition performance because all facial features can be clearly captured by the camera. When the user wears glasses, the system is still able to recognize the face, although there is a slight decrease in accuracy. However, the use of a helmet significantly reduces the performance of the facial recognition system because a large part of the facial area is covered. As a result, important facial features cannot be detected properly, which leads to the weakest recognition accuracy. Environmental lighting is also one of the most influential factors in the facial recognition process. Stable and balanced lighting conditions support better facial image acquisition, allowing the system to recognize facial features more accurately. On the other hand, very bright lighting can cause overexposure, making facial details appear too bright and reducing the clarity of facial contours. Meanwhile, dark lighting conditions make facial features difficult to capture because the camera does not receive enough visual information. Both excessive and insufficient lighting conditions significantly reduce the accuracy of the Fisherface-based facial recognition system. Overall, the boarding house gate security system based on QR-Code and Face ID using the Fisherface method has been successfully implemented and has performed well under standard conditions. The system is able to process QR-Code data and recognize user faces according to its intended function. The authentication process runs quickly and responsively when the face distance, face condition, and lighting environment are within suitable ranges. These results indicate that the integration between hardware and software has functioned optimally, and the proposed system can improve the security of boarding house door access through a two-layer authentication mechanism.

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