Design and Build a Smart Door Lock Using Face Recognition

Rizky Aprylianto Susilo, Dicky Chandra, Abdul Hamid Kurniawan, Hari Subagyo

Dept. Electrical Engineering
State Polytechnic of Samarinda
Samarinda, Indonesia
apriliantorizky86@gmail.com, dickychandra26072001@gmail.com,
abdul.hamid.kurniawan@gmail.com, Harisubagyo63polnes08@gmail.com

Abstract. The door has become an access point to a house where it is used for entering and exiting. Security is one of the crucial factors in a residence. Criminal activities often occur by tampering or breaking the lock system of the house door. Currently, the security of house doors generally still relies on wooden supports, handle locks, and sometimes the use of padlocks. Now, door security systems can be obtained through various methods, one of which is by implementing technology. Therefore, a smart lock door system was created using face recognition technology, specifically utilizing the ESP32-CAM module, integrated into the system, allowing the door to be unlocked using one's face as the password. Additionally, the smart lock door incorporates the assistance of a Telegram application, which serves to store detected images and act as a real-time monitor of the situation in front of the house. The methodology employed was a literature review, utilizing written sources to gather information, and a consultation method involving interactions with advisors and individuals possessing relevant knowledge or experience. The testing results indicate that the ESP32-CAM can be effectively utilized as a detector for the smart lock door system.

Keywords: ESP32-CAM, Microcontroller, Smart Door Lock, Technology, Telegram.

1. Introduction

In today's era, crime has become an inseparable part of everyday life. Criminal acts can occur anytime and anywhere when the perpetrator seizes the opportunity, one of which is house burglary. Burglaries often occur by damaging or bypassing the locking system on doors, which serves as an entry and exit point for the house. There are even cases of burglary that occur when the homeowner is inside the house. Despite the door being locked, thieves can still unlock it using a wire and a screwdriver.

Typically, door security commonly involves the use of wooden wedges, handle locks, and some even use padlocks. Nowadays, door security can be obtained through various means, one of which is by implementing technology. The application of technology in the field of security has advanced rapidly, ranging from conventional methods to high-

M. U. H. Al Rasyid and M. R. Mufid (eds.), *Proceedings of the International Conference on Applied Science and Technology on Engineering Science 2023 (iCAST-ES 2023)*, Advances in Engineering Research 230,
https://doi.org/10.2991/978-94-6463-364-1_92

tech solutions. In its implementation, there are numerous types of security methods used. Some security methods for house doors involve the use of combinations of numbers, letters, fingerprints, and even retina scans as their passwords.
Among the door security methods mentioned in the previous paragraph, some are less effective in reducing break-ins at residences. Often, using numbers as a password for house doors can be less effective due to the risk of forgetting the registered numbers. The incorporation of the ESP32-CAM module into the system allows the door to be unlocked using the face as its password. The face used as the password must be registered in the system beforehand. The ESP32 CAM was chosen for its provision of more effective security.
This system can differentiate between the homeowner's face and an intruder, thereby reducing the likelihood of a break-in through the house door. In addition, both the homeowner and the security personnel will receive notifications in the form of images sent to Telegram regarding the matter. Meanwhile, when a guest arrives, the system will send an image to Telegram, allowing the homeowner to monitor whether the guest is known or unknown, thereby eliminating any hesitation in opening the door.
The door security system created by the author, entitled "Design and Build of a Smart Lock Door Using Face Recognition," utilizes the ESP32-CAM as a face detection tool for security. This device uses a face detection system to send a scanned image to Telegram, which is then processed to obtain Personal Identity. With the registered identity of the homeowner's face, the homeowner can gain access. This, in turn, reduces direct contact with humans and minimizes the occurrence of house burglaries.

2. Ease Of Use

2.1. ESP32-CAM Module

The ESP32-CAM camera module comes equipped with wifi and bluetooth features at an affordable price, making it a popular choice for many. This module is highly suitable for systems utilizing the Internet of Things (IoT) and can be used for a variety of IoT applications such as smart home devices, industrial wireless control, wireless monitoring, wireless QR identification, wireless positioning systems, and more. Therefore, the ESP32-CAM is an ideal solution for IoT applications [1]. The following is the form of the ESP32-CAM Module in figure 1.

Fig. 1. ESP32-CAM Module[1]

2.2. USB to TTL Module

The FTDI Breakout Module is a product from the company Future Technologies Devices International (FTDI), which enables Serial to TTL communication for programming Integrated Circuits (ICs). By using this module, it is easy to program ICs such as AVR, PIC, and others [3]. The following is the form of the Fig. 2. USB to TTL Module in figure 2.

Fig. 2. USB to TTL Module[3]

2.3. Relay 5v Module

A relay is an electrically operated switch and is an electromechanical component consisting of two main parts, namely the coil and a set of contactors. Relays operate based on the principle of Electromagnetism, where a small electrical current (low power) is used to actuate contacts that can conduct electricity with higher voltage. For example, the use of a relay with a 5V electromagnet and a current of 50 mA can activate the relay's armature (which functions as a switch) to allow electricity to flow with a voltage of 220V and a current of 2A. Figure 2.6 shows the display of a 5V 1-channel relay module [4]. The following is the form of the Relay 5V Module in figure 3.

Fig. 3. Relay 5V Module[4]

2.4. Selenoid

The solenoid is an electromagnetic component consisting of a large coil made of copper wire with an armature (a piece of metal) in the center. When the coil is energized, the metal piece will be attracted into the coil. When given a voltage of 9-12VDC, the metal piece will be pulled in, preventing anything from protruding, and the door can be opened [5]. The following is the form of the Selenoid in figure 4.

Fig. 4. Selenoid[5]

2.5. Battery 18650

The 18650 battery is a type of lithium-ion battery commonly used. Lithium-ion batteries are classified as secondary batteries and rechargeable batteries. This battery has a cylindrical shape with a diameter of 18 mm and a height of 65 mm, and has a voltage of 3.7 V with varying capacities [7]. The following is the form of the in 18650 battery figure 5.

Fig. 5. Battery 18650[6]

2.6. Telegram

Telegram is a messaging application that focuses on speed and security aspects. Users can access this application on various working devices connected simultaneously, allowing sent messages to be synchronized on a phone, tablet, or computer [2]. The following is the form of the in 18650 battery figure 6.

Fig. 6. Telegram[2]

2.7. LM2596 DC-DC Adjustable step down

LM2596 is an integrated component that is highly suitable for designing a simple and safe step-down switching regulator (buck converter). This module is capable of delivering currents up to 3A using a voltage regulation method. LM2596 is a power converter module with a switch mode system that has significantly higher efficiency

compared to commonly used three-terminal linear regulators. LM2596 operates at a switching frequency of 150 kHz, allowing for smaller-sized filter components [6]. The following is the form of the in LM2596 DC-DC Adjustable stepdown figure 7.

Fig. 7. LM2596 DC-DC Adjustable step down[7]

3. Research Design Method

3.1. Design Steps

The design steps undertaken include several stages that begin with planning, such as preparing the necessary tools and materials. Then, to facilitate the creation of the tool, we use a laptop for the design of the smart lock door. After that, it proceeds to the stage of creating the tool and is supplemented with programming in the Arduino IDE. The program created includes the ESP32-CAM module. The step-by-step design process flowchart can be seen in Figure 8.

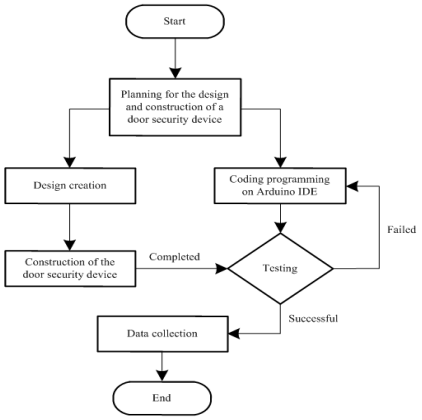

Fig. 8. Design Steps

3.2. Face Recognition Workflow

The workflow of face detection and recognition in the flowchart consists of several stages. First, the face recognition tool is powered on. Next, the ESP32-CAM will detect faces in front of it. Subsequently, the ESP32 will perform face recognition to determine

whether the face is already stored or not. If the face is unrecognized, the image will be sent to Telegram, and the ESP32 will re-scan for a face. However, if the face is recognized, the image will be sent to Telegram, and the solenoid will open for 10 seconds. After that, the solenoid will close again. In the programming itself, there are features expected to work according to the desired mechanics, as follows Opening the door by detecting a face and Sending a notification in the form of an image to the homeowner or security personnel through Telegram connected to the ESP32-CAM. The Face Recognition Workflow flowchart can be seen in Figure 9.

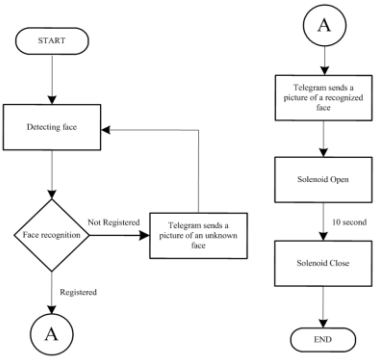

Fig. 9. Face recognition workflow

3.3. The Circuit Design

All components are interconnected where each component has its own functions and tasks. The FTDI Breakout module is used as a serial communication tool to upload programs to the ESP32-CAM, which functions as a face detector. In the circuit, there is an LM2596 DC-DC Adjustable Step Down module that serves to lower the voltage from the 12V battery to 5V and will be used as a power supply for the ESP32-CAM and Relay. Then, the power source for the Relay is connected to the 12V voltage from the battery in series. The following is the form of the wiring diagram in figure 10.

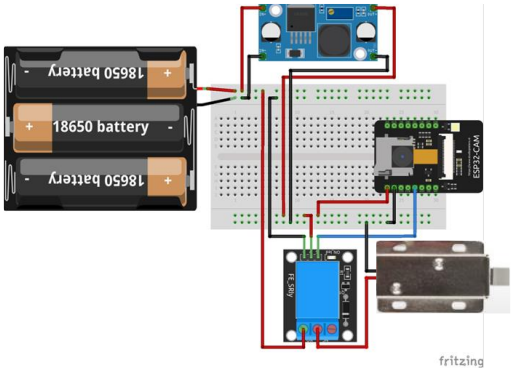

Fig. 10. Wiring diagram

4. Results And Discussion

4.1. The Creation of a Telegram Bot

To create a Telegram Bot, there are several steps that need to be taken as follows:

1. Open the Telegram application.
2. Search for BotFather. BotFather is the official Telegram bot that can assist in creating a new Telegram bot.
3. Start a conversation with BotFather, type and send the message "/newbot" to create a new bot.
4. Provide a name for the bot, such as "notification_esp32".
5. Next, create a username for the bot. Make sure the bot's username ends with the word "bot", for example, "@notification_esp32_19642004_bot".
6. After that, you will receive a reply containing a token that will be used to access the Telegram bot.
7. Once you have obtained the token, search for the Get Id Bot, start a conversation, and it will automatically respond with an ID that will be used in the program created in the Arduino IDE.

4.2. Face Registration Process

To register your face as the password, there are several steps to be followed as follows:

1. Go to Telegram and then press /start to display the menu, press /ip, and you will receive a reply containing a link to access the webcam. Press /face to grant access to the webcam, as shown in Figure 11.

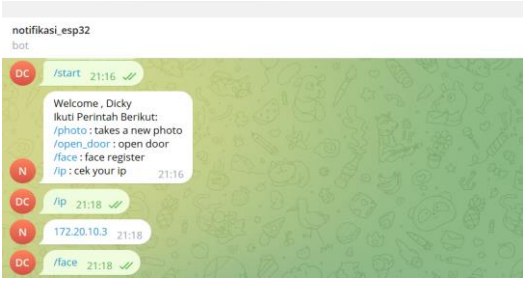

Fig. 11. Chat telegram Bot

2. Go to the link obtained in the TelegramBot chat for the face registration, "http:172.20.10.3,".
3. Then, you will access the camera from ESP32-CAM, press 'Stream Camera' to activate the camera, and then enter the name in the 'Type the person's name here' column as shown in figure 12 below

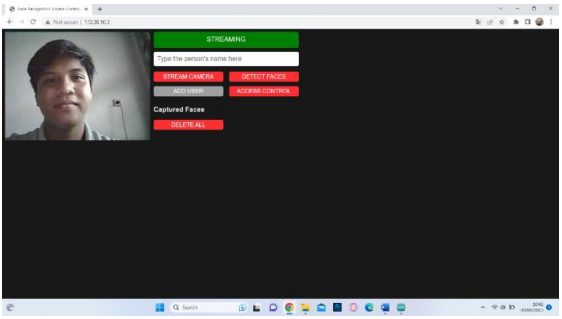

Fig. 12. Web display of ESP32-CAM and Stream Camera

4. The next step is to press the "add user" menu, then the face will begin to be scanned. In the green-colored box, the text "Sample Number 2 for Dicky Chandra" will appear, as shown in the following figure 13, indicating that the face registration process has started.

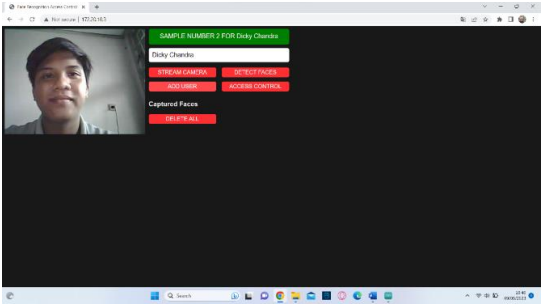

Fig. 13. Add user

5. If the face has been registered, then the created name will be listed in the "Capture Faces" section, the results can be seen in the following Figure 14.

4.3. Telegram Bot Security System

His security system is created to provide security related to the Telegram Bot chat so that not just anyone can access it. The following is the form of the capture face in figure 15.

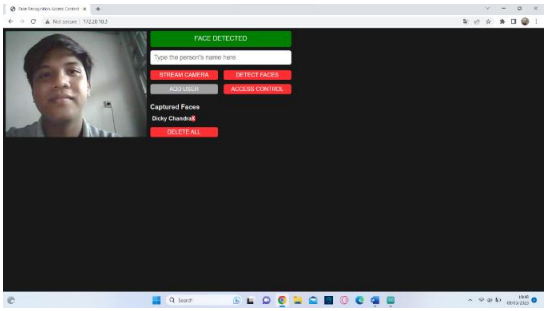

Fig. 14. Capture Face

Fig. 15. The TelegramBot Security System

In the picture, the Telegram Bot security system demonstrates how the Telegram Bot responds to the "/start" message. When a user inputs this message, the bot will reply by sending the message "passwordnya?" (meaning "password?"). If the user enters an incorrect password, the bot will resend the message "passwordnya?" as a request to re-enter the password.

When the user inputs the correct password, the bot will provide a different response. It will send the message "welcome, Dicky Login Accepted...", indicating that the password verification was successful. After the verification process is successful, the user can use the features or menus that have been set up in the program as needed.

4.4. Testing Data for Selenoid

The solenoid test is conducted to determine at what voltage the solenoid can operate. The results of the DC solenoid testing indicate that the solenoid is unable to operate at DC voltages of 3V, 4V, 5V, 6V, and 7V. However, the solenoid successfully operates at DC voltages of 9V, 10V, 11V, and 12V. Therefore, the minimum operating voltage for this DC solenoid is 9V.

Table 1. Solenoid Working Voltage Measurement

No.	DC Voltage (V)	Result
1	3	Not working

No.	DC Voltage (V)	Result
2	4	Not working
3	5	Not working
4	6	Not working
5	7	Not working
6	8	Not working
7	9	Working
8	10	Working
9	11	Working
10	12	Working

4.5. Face Recognition Testing Data

In this face recognition test, various experiments were conducted with the aim of determining whether the face can still be detected under different conditions.

Table 2. Face Recognition Testing (Registered)

Test Result	
Input Data	Recognized face (registered)
Expected Outcome	The smart lock door system will activate the relay and unlock the door (Solenoid is functioning), then the detected image will be sent to Telegram.
Outcome	The relay is functioning and the door is unlocked (Solenoid is functioning).
Conclusion	Accepted.

Table 3. Unknown Face Testing (Unregistered)

Test Result	
Input Data	Unknown face (unregistered)
Expected Outcome	The smart lock door system will not activate the relay to unlock the door (the solenoid is not functioning), then the detected image will be sent to Telegram.
Outcome	The relay is inactive and the door is not open (the solenoid is not working).
Conclusion	Accepted.

Table 4. Unknown Face Testing (Unregistered)

Test Result	
Input Data	Face with accessories

Expected Outcome	The smart lock door system will not activate the relay to open the door (the solenoid is not working), then the detected image will be sent to Telegram.
Outcome	The relay is inactive and the door is not open (the solenoid is not working).
Conclusion	Accepted.

Table 5. Facial Testing Using Photos

Test Result	
Input Data	Face using a photo
Expected Outcome	The Smart Lock Door system will not activate the relay to unlock the door (the solenoid is not functioning), then the detected image will be sent to Telegram.
Outcome	The relay is inactive, and the door is not open (the solenoid is not working).
Conclusion	Accepted.

Table 6. Left-Facing Facial Testing

Test Result	
Input Data	Face slightly turned to the left
Expected Outcome	The smart lock door system will activate the relay and unlock the door (the solenoid will work), then the detected image will be sent to Telegram.
Outcome	Face not detected
Conclusion	Not accepted

Table 7. Right-Facing Facial Testing

Test Result	
Input Data	Face Slightly Turned to the Right
Expected Outcome	The smart door lock system will activate the relay and unlock the door (the solenoid will work), then the detected image will be sent to Telegram.
Outcome	Face not detected
Conclusion	Not accepted

Table 8. Upward-Facing Facial Testing

Test Result	
Input Data	Face Upwards

Test Result	
Expected Outcome	The smart door lock system will activate the relay and unlock the door (the solenoid will work), then the detected image will be sent to Telegram.
Outcome	Face not detected
Conclusion	Not accepted

Table 9. Downward-Facing Facial Testing

Test Result	
Input Data	Face Downward
Expected Outcome	The smart lock door system will activate the relay and unlock the door (the solenoid will work), then the detected image will be sent to Telegram.
Outcome	Face not detected
Conclusion	Not accepted

4.6. Face Testing Data

This testing is conducted to evaluate the performance of the smart door lock system. The testing is carried out by performing several experiments using facial data that has been registered in the system.

Table 10. Multiple Face Testing

No.	Name	Test Result
1	Chandra	Detected
2	Arief	Detected
3	Fahrizal	Detected
4	Rahmadiva	Detected
5	Rifky	Detected

From the results of the conducted tests, it is evident that all five registered facial data can be read and detected accurately. This indicates that the testing has yielded positive outcomes in detecting and recognizing faces within this smart door lock system. The results also demonstrate a high likelihood of success in facial recognition with just one attempt under sufficiently good lighting conditions.

4.7. Face Testing Data

The ESP32-CAM module has a replaceable camera sensor. In this test, the ESP32-CAM module uses the OV2640 camera sensor with a resolution of 320x240 and a framesize of QVGA. Therefore, a test is conducted to determine the detectable range by the camera sensor on the ESP32-CAM module.

Table 11. Face Recognition Distance Testing

No.	Distance (cm)	Detection Results
1	30	Good
2	40	Very good
3	50	Enough
4	60	Enough
5	70	Enough
6	80	Enough
7	90	Enough
8	100	Not detected
9	110	Not detected
10	120	Not detected

After conducting tests, it was found that the camera sensor distance on the ESP32-CAM module can detect faces within the range of 30 cm to 90 cm. However, at distances of 60 cm to 90 cm, sometimes multiple attempts are needed before the face is successfully detected at that distance. Furthermore, even though a face has been detected within the range of 60 cm to 90 cm, the face recognition system sometimes fails to recognize registered faces. This can be attributed to various factors, such as face size and environmental lighting. Faces beyond a distance of 100 cm cannot be detected at all.

5. Conclusion

After designing and creating the smart lock door device using face recognition, followed by conducting several experiments and tests, several conclusions can be drawn as follows:

1. The ESP32-CAM can be used as a detector for a smart door lock system, and it works quite well, as seen in the test results.
2. This smart door lock utilizes a Telegram application to store detected images and can also serve as a monitor for the situation in front of the house at that time.
3. The optimal range for detecting and recognizing faces with good accuracy on the ESP32-CAM module is 40 cm.
4. The ESP32-CAM module can only perform face recognition when the face is facing forward.

REFERENCES

1. N. Yudistira, "Design of ESP8266-based miniature smart gate parking," A.Md. thesis, Electrical Engineering., State Polytechnic of Samarinda., Samarinda., East Kalimantan, (2021).
2. Y. Fauzan, "IoT-based package receiver box using ESP32-CAM module," S.Kom. thesis, Informatics Engineering., Syarif Hidayatullah State Islamic University., Jakarta, (2020).
3. Nurjaman, "Design of security monitoring system using Telegram application based on internet of things and web for rental of Seikou Mulia car garage," S.Kom. thesis,

Informatics Engineering., Computer University of Indonesia., Bandung., West Java, (2021).
4. W. P. Bahari and A. Sugiharto, "Design of IoT-based fire detection tool," J.Electrical Engineering, vol.9, pp.1-8, Aug. (2019).
5. M. A. R. Pramadita, "Planning and creation of biometric face image-based door security system," A.Md. Final Project, Electrical Engineering., Sepuluh Nopember Institute of Technology., Surabaya., East Java. (2017).
6. F. Fatkhurrozak, D. Prasetio, and N. A. Ariyanto, "Design of 48 V 50 AH lithium battery pack," J.Energy Engineering, vol.18, pp. 1-9, Jan. (2022).
7. R. Muwardi and R. R. Adisaputro, "Door security system design using Face," J.Electrical Technology, vol.12, pp. 120-128, Sep. (2021).
8. D. Misransyah, "Automatic home door security system, the guardian and notifier to the homeowner," Tourist Companion., Paringin., Balangan, South Kalimantan, Nov. (2020).