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Smart Door System using Face Recognition Based on Raspberry Pi

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Abstract

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A smart door system is a door with a smart digital lock system where someone can open the door or give permission to enter the house by authenticating the user. Basically, the technology used for smart door implementation uses a microcontroller as its controller and is combined with identification in the form of a password. The technology can be combined with other techniques, such as using facial recognition. This is done because data security using alphanumeric combination passwords is no longer used, so it is necessary to add security that is difficult to manipulate by certain people. The type of security offered is facial recognition biometric technology which has different characteristics. This study will design a smart door system that is built using Raspberry Pi-based facial recognition as a controller. The facial recognition algorithm will interact with the webcam and solenoid lock using the Raspberry Pi.Based on the results of the study, it was found that the smart door system with facial recognition can be done well and obtains an accuracy of 94%. The application of the smart door system proposed in this study is considered capable of increasing home security which can be controlled automatically using facial recognition.

Keywords: smart door, facial recognition, home security, Raspberry Pi

1. Introduction

The development of the times requires humans to always innovate in making equipment to make work easier. One of these innovations is applied to the security system applied to smarthomes, namely smart doors. A smart door system is a door with a smart digital lock system where someone can open the door or give permission to enter the house by authenticating the user.[1]. This system is needed for home security, especially in elite housing that implements smarthomes. Security is something that is often overlooked by most people and think it's safe, but in fact someone can still lose their valuables[2]. The main function of a home security system that implements a smart door is to prevent crimes such as theft of valuable items. Besides that,the benefits of smart doors for owners who have multiple keys for their apartments, houses or doors, will maintain access only to authorized personnel. Smart doors reduce the costs required for key fabrication, duplication and distribution and maximize security in the event of a key being lost[3].

Home security systems have become an important research where the latest technology has been used for smart door systems[4]. There are many technologies used in implementing smart door systems for home security. One of the technologies used is Bluetooth, because it is available on all mobile phones such as smartphones which helps users to disable or operate the door lock easily[1]. In addition, another technology used is IoT (*Internet of Things*), where *smart door*can be controlled and monitored remotely using an Android-based smartphone[5]. Basically, the technology used for smart door implementation

uses a microcontroller as its controller and is combined with identification in the form of a password. With the development of current microcontroller technology, security systems can be carried out using electronic devices instead of conventional key security systems[6].The technology can be combined with other techniques, such as using facial recognition. This is done because data security using alphanumeric combination passwords is no longer used, so it is necessary to add security that is difficult to manipulate by certain people. The type of security offered is facial recognition biometric technology which has different characteristics. Face recognition is a method used to identify faces based on the feature values contained in facial images and can be applied in various systems, such as attendance, room security access and application or device logins.[7].

Face recognition is the process of identifying faces using computational methods and comparing them with previously stored facial data (databases).[8]. This system consists of parts of image processing, face detection, feature extraction and classification[9]. The main function of facial recognition is to validate that the person doing the recognition has access rights to a system. The system is said to be reliable if the face validation can be done correctly during the recognition process[10]. Facial recognition is widely used for human identification because of its ability to measure facial points and recognize identities in an unobtrusive and difficult-to-manipulate manner. The application of facial recognition systems can be applied to surveillance at home, work and campus[11].

Based on the previous explanation, this research will design a smart door system that is built using Raspberry Pi-based facial recognition as a control. The facial recognition algorithm will interact with the webcam and solenoid lock using the Raspberry Pi. Raspberry Pi is a series of mini-sized computers or low-cost ARM-based computers capable of computing facial recognition[12].Everyone who has access rights will have their face image taken and stored in the database. This system will work to open the door for people who are recognized as the owner of the house or who have access automatically when the face is in front of the webcam. Instead, this system will maintain the security of the door for people who do not have access and will sound an alarm in an effort to provide more security for homeowners.

2. Method

2.1 Materials

Smarthome is a technology or system found in electronic devices at home to improve comfort, energy efficiency, privacy and security of its residents[13]. Smarthome enables the entire home to be automated which provides a comfortable life as well as additional benefits for individuals with disabilities[14]. One of the devices contained in a smart home is a smart door, where this device is built to provide security to the house by giving someone access rights to enter the house. Smart door systems can be built with the help of various technologies, such as android applications and Bluetooth. This system will detect the person at the door using a webcam and with the help of Bluetooth will notify the person at the door and give permission to enter the house if the owner has allowed the door to be opened. In addition, to access the door, you can also use an ID-card with the ID process being stored permanently in the database[1]. Variations in security and control of key systems with various technologies applied have their respective weaknesses. Some of them are forgetting the password so that the locking system cannot be operated or losing the device used to control the locking system, so that it can be taken over by irresponsible people.[15]. Therefore, more protective technology is needed, such as implementing facial recognition for smart door systems.

Face recognition is a process to identify facial images with computational methods and compare them with facial data stored in the database for the recognition process.[8]. Various benefits of facial recognition, such as crime, room access systems, criminal search and human interaction with computers. In the process of recognizing faces, facial images can be taken from a great distance for the person to be

identified. Face recognition has three processes, namely: face detection, feature extraction and face image classification or face recognition. In general, the architecture in face recognition can be seen in Figure 1 below[10].

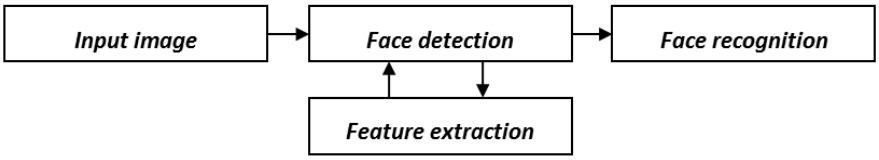

Figure 1.Face recognition process

1. Input image, is an image obtained from the acquisition process (image taking) using a camera or webcam.
2. Face detection, is a detection process carried out to take the position of the face in the recognition process.
3. Feature extraction is the process of obtaining characteristic values from an image using image processing techniques.
4. Face recognition is the result of identification from the previous input image. This process will compare the characteristic values of the input image with a collection of images stored in the database.

Face recognition is appropriate for home security systems because each face has different characteristics from one another. The security system built with this technology is very likely to be an alternative in implementing smarthomes. Facial recognition combined with microcontroller technology makes security systems a priority for homeowners. Homeowners don't have to worry about their homes being theft as long as this system works well. Everyone who has access rights will have their faces captured and stored in the database. The door will open automatically when the person is in front of the door while taking pictures using the webcam[16] .

One method in facial recognition that is quite accurate is*Eigenface*. The Eigenface method can be used as a means of facial recognition between the access owner and other people in real-time[9]. Eigenface is a face recognition algorithm based on Principle Component Analysis (PCA).[17]The workings of the Eigenface method can be seen in Figure 2 as follows[18].

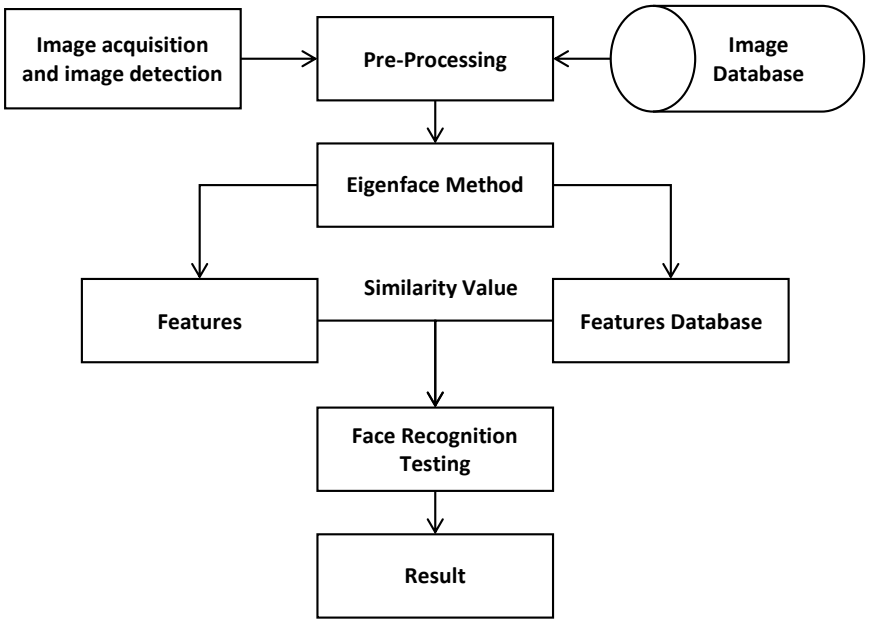

Figure 2.Face recognition with Eigenface

In Figure 2 describes the face recognition process starting with face capture until the recognition results. The face detection stage is carried out using the method*Viola Jones*and then the process will be carried out*preprocessing*. This process has the aim of preparing the image to obtain an image that will be processed in the calculation*Eigenface*optimally. Furthermore, calculations are carried out using the Eigenface method to obtain*eigenvalue*and*eigenvector*. The recognition process will find the shortest distance between the values of*eigenfaces*stored in*database*with value*eigenfaces*from the calculation*realtime*use*Euclidean Distance*. Mark obtained must according to the applicable provisions to display face data, otherwise the face is not recognized.

On the smart door system using Rasspberry PI-based facial recognition, gThe face image that has been carried out by the Eigenface process will be stored in the database. When the system detects a new face image, the system will compare the image with the existing image in the database. If the new image is in the database, thenThe Raspberry Pi turns on the relay andprovides output to the door lock solenoid to open the door. When the image is not in the database, the system does not recognize the face and the door will remain closed and there will be a notification on the LCD display that the face is not recognized.

2.2 Block Diagram of Smart Door

This section will discuss the block diagram of the general working principle of the system built on smart doors and hardware design (prototype). The design of a smart door system with facial recognition will be described first before hardware design is carried out. In Figure 3 it can be seen the working process of the smart door system in general as follows.

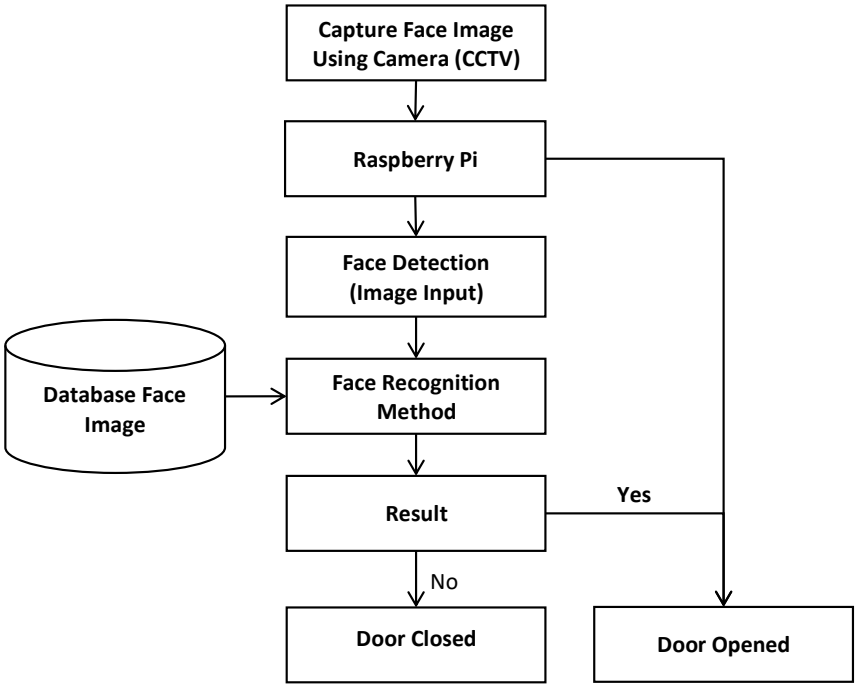

Figure 3. The proposed of the smart door system architecture

The steps for a smart door system using facial recognition can be explained as follows:

1. Image capture, is the process of taking facial images using a webcam. Image capture is done when someone brings their face closer to the webcam that has been provided.
2. Rassberry Pi, is a mini computer that controls to take and store an image of a person's face and where the computing process takes place. In addition, this device is also used as a control to open or close the door based on the results of facial recognition.
3. Face detection is the process of detecting the presence of a face. During the image-taking process, not only the face is taken. Other body parts such as hair, ears and neck will also enter into the image. Members other than this face will of course be discarded so that the recognition process can be accurate. The method used to detect faces is Viola-Jones, where this method will capture only the face for processing.
4. Face Recognition, is a facial recognition method used. This section is an algorithm used for a smart door system using facial recognition. This method will match the facial image taken with the facial image contained in the database.
5. Result, is the result obtained when the matching method or face recognition is performed. If the captured face is in the database, the Rasppberry will instruct the lock to open the door. On the other hand, when the captured face is not in the database, Rassberry will still lock the door and issue a notification that the face is not recognized.

The prototype design of the proposed smart door system can be seen in Figure 4 as follows.

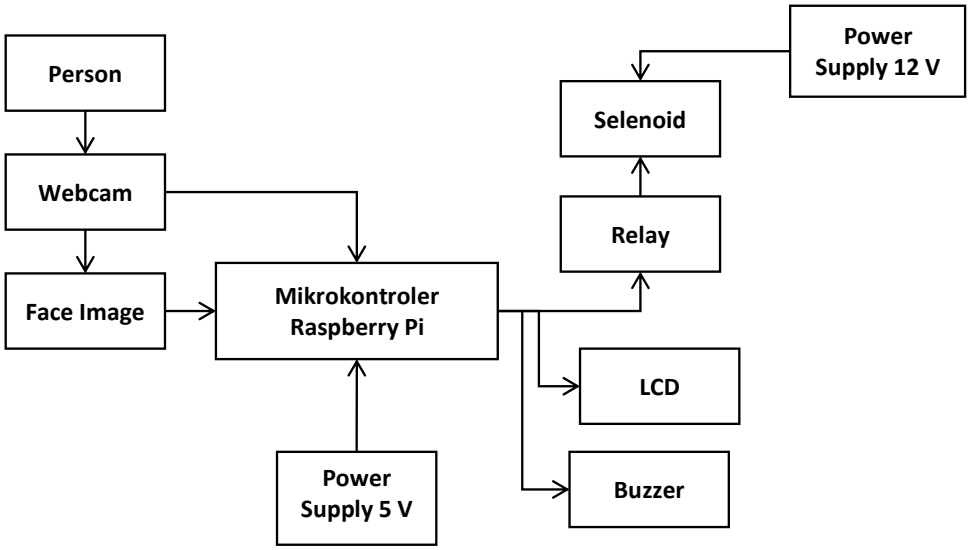

Figure 4. The proposed of the smart door system prototype

In Figure 4, the block diagram is the working principle of the prototype of the built smart door system, namely:

1. The webcam will capture a person's face according to the algorithm commands found on the Raspberry Pi. When a face has been detected, the capture process will be carried out and generate a face image as system input.
2. The captured face data will be processed on the Raspberry Pi using a facial recognition algorithm. Furthermore, the data will be compared with the stored data (database) for the authentication process.
3. When the captured face is in the system (database), the Raspberry Pi will give a command to activate the relay and open the solenoid lock, so the door will open.
4. When the captured face is not in the system (database), the Rasberry Pi still closes the solenoid lock, so the door remains closed. In addition, the Rasberry Pi will notify via the LCD that the face is not recognized and activate the buzzer that an unknown person is at the door.

3. Results and Discussion

3.1 Devices Used

The smart door system in this study has a device requirement in the form of hardware and software used. The tools needed in the design of this system include:

1. Raspberry Pi
2. Webcam
3. Solenoid Lock
4. 5 volt buzzer
5. Relay Module
6. 5 V and 12 V . batteries
7. Open CV
8. Python

3.2 Data Used

The data used in this study is facial image data taken from 14 students. Each student will perform the authentication process on the system that was built 10 times with different distances and directions of faces. The total number of experiments obtained is 140 and then the recognition accuracy and system functionality will be calculated. The data used in this study can be seen in Table 1 as follows.

Table 1. Data used

No.	Name	Face Image
1	Person 1	
2	Person 2	
3	Person 3	
4	Person 4	
5	Person 5	
6	Person 6	
7	Person 7	
8	Person 8	
9	Person 9	
10	Person 10	

11	Person 11	
12	Person 12	
13	Person 13	
14	Person 14	

3.2 Results and Discussion

This section will explain the important parts during the facial recognition process for a smart door system. Everyone who has access rights to operate the door will have their face image taken for the database needs of the system. The facial image that has been taken will be processed using the Eigenface method described previously. The result of this method is feature extraction in the form of numeric data that will be used for identification needs in the smart door system that has been designed. The test begins with the process of capturing faces through a webcam installed in front of the door. The resulting image is an image of the face only generated from the Viola-Jones method. The image will be processed to produce feature extraction in the form of numerical data using the Eigenface method. The image is a new image that will be entered into the system for face recognition. Furthermore, the processed data will be compared or matched with previously stored data and the result is a face that is recognized or not.

This study tested the granting of access to 14 students through the face capture process for storage in the database. Furthermore, each student will perform the authentication process 10 times by re-capturing his face via the webcam. This process is carried out with different directions and distances to determine the performance of the system that has been designed. The results of the experiment can be seen in Table 2 as follows.

Table 2. Smart door system test results

No.	Name	Number of Correct	Number of Wrong	Accuracy
1	Person 1	10	0	100%
2	Person 2	8	2	80%
3	Person 3	10	0	100%
4	Person 4	10	0	100%
5	Person 5	7	3	70%
6	Person 6	10	0	100%
7	Person 7	10	0	100%
8	Person 8	9	1	90%
9	Person 9	10	0	100%
10	Person 10	8	2	80%
11	Person 11	10	0	100%

12	Person 12	10	0	100%
13	Person 13	10	0	100%
14	Person 14	9	1	90%
Average Accuracy				**94%**

In Table 2, the average test accuracy obtained is 94%. The resulting accuracy is the number of successful trials divided by the number of trials multiplied by 100%. These results are the results of testing with 10 trials for each student in the authentication process. The face capture distance is 25 cm to 75 cm and the face orientation angle is 45 degrees. The smart door system designed has as many as two conditions that have been described previously. If the face is recognized, then the algorithm gives a command to the Raspberry to activate the relay and open the solenoid lock that has been installed. When the solenoid is open, the door will open and automatically the person who has made the identification is the person who has access rights to enter. If the face is not recognized, then the algorithm will give a command to the Raspberry to notify that the entered face is not recognized. In addition, the Raspberry will also activate a buzzer to notify that someone is trying to log in.

4. Conclusions

Based on the results of the study, it was found that the smart door system with facial recognition can be done well and obtains an accuracy of 94%. The application of the proposed smart door system is considered capable of increasing security in order to maintain home security which can be controlled automatically. The use of facial biometrics in smart door systems is very well used to limit people who want to enter a room that is not easily broken into or manipulated. The use of smart doors is also very useful to be applied in various government institutions to ensure the security of documents stored in a room from people who do not have the authority.

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