Image Processing Technique for Smart Home Security Based On the Principal Component Analysis (PCA) Methods

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***Abstract*— Smart home is one application of the pervasive computing branch of science. Three categories of smart homes, namely comfort, healthcare, and security. The security system is a part of smart home technology that is very important because the intensity of crime is increasing, especially in residential areas. The system will detect the face by the webcam camera if the user enters the correct password. Face recognition will be processed by the Raspberry pi 3 microcontroller with the Principal Component Analysis method using OpenCV and Python software which has outputs, namely actuators in the form of a solenoid lock door and buzzer. The test results show that the webcam can perform face detection when the password input is successful, then the buzzer actuator can turn on when the database does not match the data taken by the webcam or the test data and the solenoid door lock actuator can run if the database matches the test data taken by the sensor. webcam. The mean response time of face detection is 1.35 seconds.**

Keywords—face recognition; PCA; Raspberry pi; smart homes

I. INTRODUCTION

Smart Home is an integration of technology and services over a network to improve the quality of one's life. A smart home is one application of a pervasive computing branch of science. Some terms that refer to the smart home include smart house, home automation, intelligent home, adoptive home, and aware home. Three categories of smart homes, namely comfort, healthcare, and security. Comfort with Healthcare can walk remotely as well as locally in the house. While Security focuses more on User Authentication and Device Authentication[1].

Security is a challenging research area and it is fast growing in the latest research trends. Security plays an important and key role in protecting data, devices, and networks from intruders, through effective and efficient protocols and technology to safeguard data and also to control and control incorrect data access[2]. The security system is a part of smart home technology that is very important because the intensity of crime is increasing, especially in residential areas. In the smart home security system, there are mainly three parts. First, password protection from Central Lock to protect the entrance from unknown parties/people. For this use the EPROM function of the microcontroller, keypad, and LCD 16 * 2. Second, a fire safety system that includes a fire alarm and fire protection using a smoke detector and temperature sensor (LM35) to detect fires. The system also adds an alarm and a solenoid valve that is directly connected to the water supply used to extinguish the fire. Third, anti-theft alarm uses touch sensors around the house as an anti-theft system[3].

The problem that occurs is that criminals already know the technicalities of the security systems installed, for example, criminals can quickly eliminate traces of their crimes by destroying the CCTV storage media. Image processing systems allow humans to retrieve information from an image, home security systems using image processing can be collaborated with the PCA (Principal Component Analysis) method [4]. The PCA method is a factor analysis technique in which several factors will be formed in the form of latent variables that cannot be determined before the analysis is carried out, this method allows the speed of facial recognition on the computer to be faster and the implementation of the PCA method can recognize the facial images of the residents in real time[5]. PCA is a technique used to simplify data by transforming it linearly to form a new coordinate system with maximum variance. PCA can be used to reduce the dimensions of data without significantly reducing the characteristics of the data [6]. PCA is the optimal linear scheme for compressing a set of high dimensional vectors into a set of lower-dimensional vectors and then restructuring the original set[7].

Facial recognition systems can be created to register users in a smart home system. When the system manages to identify registered users, the members can control everything in the house, such as controlling electronic devices. this system is

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believed to be a system that is more energy-efficient and safer [8]. The web camera used can also be connected to the raspberry pi accompanied by sensors such as Passive Infrared (PIR) and Ultrasonic sensors. When the camera detects the movement of the person in front of the door, the system then performs real-time facial recognition using a local binary pattern (LBP) [9]. There are many face detection methods to choose from in the field of computer vision. Computer vision is a field of study that focuses on extracting important information from digital images. Images are typically captured from cameras or extracted from video and analyzed to provide appropriate responses (for example, activating alarms, sending emails, and making calls) in real-time without human intervention [10]. In the Artificial Neuron Network (ANN) method, once a face is detected, the system preprocesses each face in the image to create a normalized and fixed-size input to the neural network. Artificial neural networks are used as feature extractors to produce low dimensional representations that characterize a person's unique face [11].

This paper has proposed a new security system in smart home technology combined with the keypad, the face recognition system, and the push button. Two-layer protection for the solenoid lock door will improve the effectiveness of the security. PCA method used in the face recognition system will improve the speed of the recognition by Raspberry pi.

II. Research Methodology

The block diagram in Fig. 1 shows that the object will be detected by the webcam camera and processed by the Raspberry pi 3 microcontroller with the Principal Component Analysis method using OpenCV and Python software. The system has an output/actuator in the form of a solenoid lock door and a buzzer.

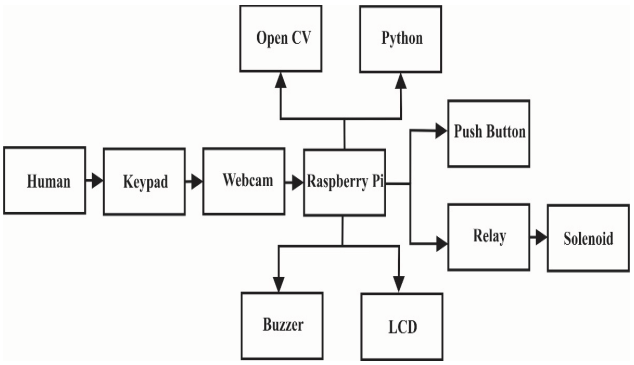

Fig 1. System Diagram.

The face detection system program for home security created using OpenCV in Python involves several processes. In the image capturing stage, as shown in Fig.2 the first step is to enter the identity that will be used as a database then input the number of photos that should be taken, taking this number of photos will affect the speed of the program when facial recognition later. After the number of photos is filled in, the camera will automatically turn on and shoot the image according to the number of photos filled previously. After inputting the name and taking the image successfully, the preprocessing stage is continued where the data will be selected and processed in each document. The next stage is the stage of simplifying the image using the principal component analysis (PCA) method as shown in Fig.3. This process serves to simplify an image so that when the system reads the image, the image will be easily recognized by the system and stored as the home owner's database. In the image recognition stage, password input is performed to open the locked webcam. Image data is taken using a webcam connected to the raspberry pi. In the preprocessing process, the data will be reselected using the principal component analysis (PCA) method after which it enters the identification process to adjust the data previously stored in the database. When the system successfully recognizes the image, the output from the processing on the system will send instructions to open the solenoid lock door. When the face is not recognized, the buzzer will sound.

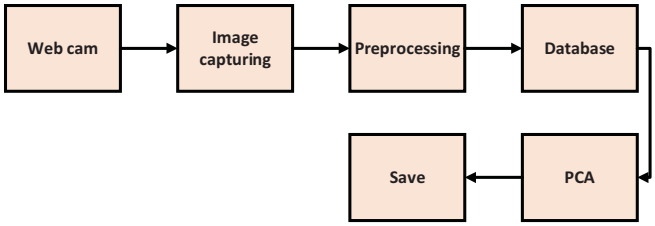

Fig.2 Process in image face capturing.

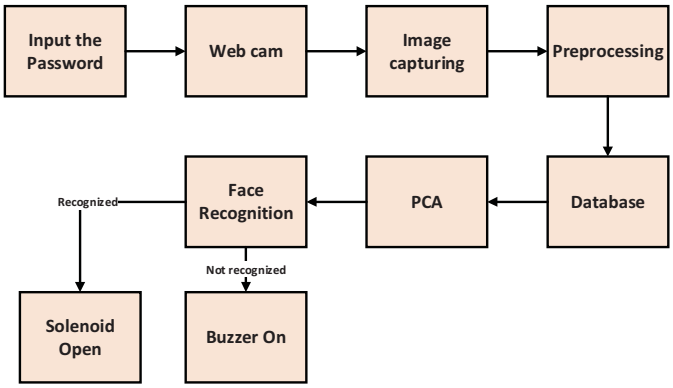

Fig 3. Process in face recognition.

III. System Implementation

The webcam in this study has used USB which can be directly connected to the Raspberry pi via the USB port 1. Raspberry pi can access the webcam and process data, in real-time, the OpenCV module can be used in python because OpenCV has provided the very Image Acquisition Toolbox and Image Processing Toolbox. support the realtime system. For the webcam to work in realtime, the USB webcam must be connected and connected to the Raspberry pi. The hardware implementation used is a keypad that is connected to the Raspberry pi via a USB PIN 1.

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Fig.4 Hardware implementation

The keypad that is connected to the Raspberry pi functions to input the password needed to open a locked webcam. Solenoid door lock that is connected and connected to raspberry pi will give output in the form of instructions when there is a compatibility database from a homeowner who already has a name identity (user ID) and test data in the facial recognition process. Liquid Crystal Display (LCD) functions as display media on the active system in the form of data, or character letters. The push-button is made to open the door from inside the house. Raspberry Pi will give a direct command to the solenoid door lock to open the door when the push button is pressed. The buzzer can produce sound output in the range of 70 dBA numbers, 200 Hz frequency, and 3000 Hz maximum frequency with an input voltage of 3- 24 V. The implementation system is shown in Fig.4.

The Python programming language is needed to create a program that will be embedded in the Raspberry Pi. This program is a command logic gate for the Raspberry Pi when it is run. Raspberry Pi itself already has an Integrated Development Environment (IDE) which is a program for software development. OpenCV is a supporting library for image and image processing systems in python with various existing Image Processing methods such as Haar cascade classifier, Principal component analysis, and viola-jones. OpenCV on the Raspberry pi has a concept that can be directly integrated into the internet network for output results on an image processing system. The program provides commands in Python for facial recognition systems, alarms, door lock solenoid, Liquid Crystal Display, push button, and keypad.

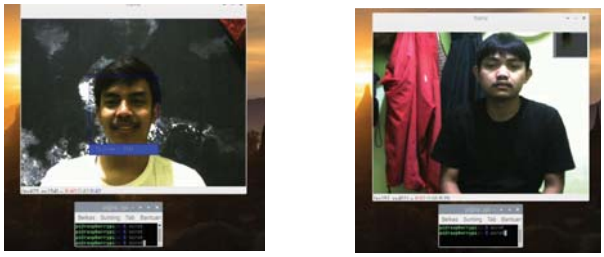
IV. Results and Analysis

This section describes the results and the analysis of testing systems that have been previously designed to get the performance of the system that has been made. This testing includes component testing, Webcam testing, buzzer testing, Solenoid testing, keypad testing, LCD testing, Push Button testing, response time testing, light intensity testing, and overall performance testing.

Testing the Raspberry pi component is done by connecting the Raspberry pi with the monitor screen when the red indicator light on the Raspberry pi lights up and the monitor displays the display menu, indicating that the Raspberry pi and the driver are functioning. In the webcam component testing, it is done by connecting the webcam cable to the laptop's USB port, the yellow indicator light lights up and the webcam can connect to the laptop, indicating that the webcam is working. The buzzer component testing is done by connecting directly to the raspberry pi port, pin 17 - VCC then pin 25 - GND and pin 21 - I / O when the Raspberry pi is turned on and the buzzer sounds indicating that the buzzer is functioning. The door lock solenoid component testing is carried out by applying a current of 12 volts to the door lock solenoid when the solenoid is shifted indicating the solenoid is functioning. Push-button component testing is carried out by connecting the Raspberry pi directly with the sliding door lock solenoid output when the solenoid shifts it indicates the push button and system driver are functioning. Testing of the keypad and LCD components is carried out simultaneously by connecting the two components on the raspberry pi, when the keypad board inputs the password and the liquid crystal display displays the same letter characters, indicating the components and system drivers are functioning. All of the above test results show the system components are functioning properly.

The next stage is testing the performance of using the keypad. The password that has been set on the system is "1234". the system successfully recognizes correct and incorrect passwords. When the password is wrong, the LCD will ask the user to check the face on the webcam. If the password is wrong, face recognition is not allowed. so this smart home system has 2 layers of security levels, making it safer to use compared to just applying 1 facial recognition system.

The webcam test took place with a webcam distance of 40-60 cm. Testing was carried out on 10 people, including 6 people who have registered and have an ID, 4 people are not registered and do not have ID with the aim of knowing the performance of the webcam and face detection program when accessing the house. The difference display by the recognized ID and unrecognized ID are shown in Fig.5.



(a) (b)

Fig.5. (a) Recognized user (b) Unrecognized user.

When the system recognizes the user's face, the LCD will provide the user name and open the solenoid door. Push-button testing also works well for opening solenoid pints from inside the house.

The response time test aims to determine the average value of time it takes for the system to recognize the face of the homeowner, by calculating the response time directly by the stopwatch. The response time test is carried out when the homeowner has entered a password and presses the Enter key until the LCDs user name information. The average response time was 1.35 seconds.

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V. Conclusion

The face recognition-based home door security system using the Raspberry Pi as the system center and Python as the programming language was successfully created. The test results show that the webcam can perform face detection when the password input is successful, then the buzzer actuator can turn on when the database does not match the data taken by the webcam or the test data and the solenoid door lock actuator can run if the database matches the test data taken by the sensor. webcam. The mean response time to face detection was 1.35 seconds.

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