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Design of Smart Door Lock Based on Face Recognition Using Rasberry Pi

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Abstract— *Crimes can occur at any time and have a negative impact on the economy or social life, one of which is the action of a robbery who managed to enter in the house. Usually the key used in the house is a fence or chain lock. However, the system is easy for robbers to break, so the robbers managed to enter the house. Therefore, the author wants to apply face recognition technology in a smart door lock system using a rasberry pi for home security. In this system, the door lock can only be opened by users whose faces have been registered in the database. The specifications of this tool include Raspberry PI, webcam, speakers, and magnetic door lock as a door lock. The webcam will receive image information from residents who will enter the house. The system will detect face images using the haarcascade classifier algorithm. Then the face recognition of the resident of the house is carried out using the local binary pattern method by comparing the detection of face images and the face database of the occupants of the house. If the results of face recognition do not match, the speaker will give a warning and the magnetic door lock will close, if the face is successfully recognized, the magnetic door lock will open. Based on the test results, the success rate of the tool is obtained, namely the optimal processing speed is 2.43 seconds with a resolution of 320 x 240. This system can also work optimally with lux values from 10 to 750 lux. For testing the optimal distance in this method is 20 to 200 cm.*

I. Introduction

Crime can happen at any time and have a negative impact on the economy or social life. Crime is an act that violates the law or norms that have been agreed upon in a society [1]. In general, crimes are divided into 4, one of which is crimes against property rights, for example house robbery. Chile is the top country by world robbery rate. In 2016, the robbery rate in Chile was 1,193.6 cases per 100,000 population [2]. While in Indonesia alone in 2018 there were 90,757 robberies [3]

Robbery means an activity to gain unauthorized access to a building with the intent to steal tools or goods. Robberies often occur due to several factors, it can be due to a quiet environment or a weak security system. Many burglars manage to enter empty homes without using sophisticated security. Usually use a fence padlock or chain. Nowadays, smart lock security systems use a lot of fingerprint [4], RFID [5-8] and password alarm [9-10]. Fingerprint is easy to use but has a weakness, namely when the user's finger is injured and when a thief has the fingerprint of the homeowner. While smart lock using RFID has a weakness that is less practical. While smart locks that use alarm passwords also have a weakness when the password is never changed by the owner, it will leave marks on the buttons that have been pressed by the owner. At this time many studies rely on the introduction of biometrics [11-14], but it requires complex calculations. Therefore, the use of smart lock using the face recognition method can cover these shortcomings

There have been many studies related to smartlock technology using the face recognition method, one of which is research in [15] suggesting that many methods can be applied in facial recognition systems. One of them is Eigenface [16-18]. This method works when a face image is projected onto a face space (feature space) which is best defined as a variation of a known test image [19]. However, this tool still uses a PC or laptop as a central processing of facial images, thus making it impractical. Then in [20] the use of raspberries as a central processing of facial images. This study has a weakness when in poor lighting conditions, the algorithm for face identification fails to recognize the target parameters, thus causing a failure to read the required data. In the journal [21] revealed that the use of haar cascade classifier as a face detection method, Local Binary Pattern Histogram (LBPH) as an algorithm for face recognition.

From the background of the existing problems, a smart locking device is made that can identify a person's face and can also be adjusted to the needs of the user. The purpose of this research is to develop a face recognition-based smartlock system using Local Binary Pattern. In addition, the system developed uses a Rasberry Pi so that the tool is more portable. The contribution in this research is a facial recognition system using a local binary pattern for smartlocks with portable devices. This tool will use a camera to take pictures of faces which will later be processed on the Raspberry PI 3. For identification or face recognition, the Image Processing technique is used in OpenCV with the Python programming language base.

II. Method

In this study, the system diagram of the smartlock can be shown in Figure 1. The data collection in this study was by testing several objects and conditions, namely related to lighting, face position, facial expressions, gender. The analysis is done by calculating the error value in each test and comparing the LPH method with eigenface in face recognition.

Based on the system diagram in Figure 1, it can be explained as follows: (a) This web camera is used to detect faces or face recognition will be processed using the Haar Casdade Classifier method then the data is processed on the Raspberry PI. (b) Raspberry PI is used as a microcontroller for processing data from a web camera with programming that uses OpenCV.© OpenCV functions to process images and videos. Then the results at the face recognition stage, the facial images that have been taken will be compared with facial data that are known in the database to determine the identity of people based on the

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processed facial images. (d) Next is the working process of the tool in opening and closing the lock on the door.

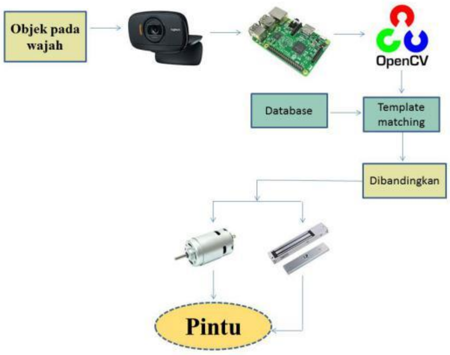


Fig. 1. System Diagram

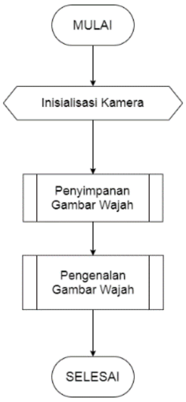


Fig. 2. System Flowchart

Figure 2 is the main flowchart of "Design of Smart door lock Based on Face Recognition Using Rasberry Pi". In the main flow chart, there are several parts of the constituent flow chart, namely the flow chart for storing facial images and the face image recognition flow chart.

III. RESULTS AND DISCUSSION

At this chapter, testing is carried out on "Design of Smart door lock Based on Face Recognition Using Rasberry Pi". The purpose of this test is to determine the results of planning, analyze system weaknesses and compare the test results with what has been planned. Some of the tests carried out include: 1. Testing image resolution on the processing speed of facial recognition programs, 2. Testing the effect of light intensity on facial recognition results, 3. Testing the effect of camera distance to face on facial recognition results, 4. Testing the effect of shooting angles on the results of face recognition, 5. Testing the effect of the shooting angle on facial expressions, 6 Overall testing

Testing of image resolution on the processing speed of face recognition programs

This test aims to determine the speed of the facial recognition process performed by the Raspberry PI 3, so that it can determine the optimal resolution to use. Based on the tests that have been carried out, the data presented in Table 1.

TABLE 1. Resolution test results on data processing speed

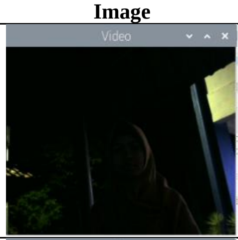
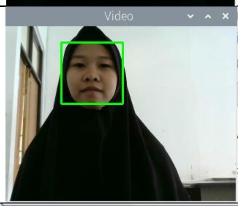
No	Camera Resolution (*pixel*)	Time process (sec)
1	1920x1080	4,51
2	1280x720	4,13
3	720x480	3,04
4	320x240	2,43
5	240x144	2,34

According to the data in Table 1, the most optimal resolution is 320x240 pixels with a processing time of 2.43 seconds, because the smaller the resolution, the more difficult it is to read faces, while the larger the resolution, the longer the processing time. Then the comparison of processing time between 320x240 with a resolution of 240x144 is not too long, namely the difference is only 0.09 seconds compared to a one-level resolution of 320x240, which is 720x480 with a difference of 0.61 seconds.

Testing of effect of light intensity on face recognition results

This test is carried out to determine the range of light intensity so that the program can detect faces. Lighting is an important factor in image processing programs, because the image is a collection of light captured by the camera. The test results are shown in Table 2.

TABLE 2. test results on intensity

No	Intensity (lux)	Image	Condition
1	0		Not detected
2	10		detected
3	42		detected
4	337		detected
5	791		Not detected

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Based on Table 2, it can be seen that the light intensity range for facial recognition programs can work, which is between 10 lux to 750 lux. For other than that range, the facial recognition program cannot work because of the limitations of the camera, which can only capture light within the light intensity range.

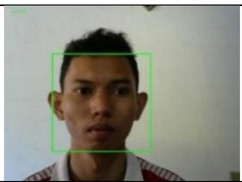
Testing of effect of camera-to-face distance on facial recognition results

This test is carried out to find out what is the optimal distance between the face and the camera for the face recognition program to detect the user's face. In this test the light intensity is 200 lux. In this test the author also compares with other detection methods, namely by using the object eigen method. The test results are shown in Table 3.

TABLE 3. Test results on distance

No	Distance(cm)	LBP	Eigen Object
1	10	Not detected	Not detected
2	20	detected	Not detected
3	50	detected	Not detected
4	100	detected	detected
5	150	detected	detected
6	200	detected	Not detected
7	250	Not detected	Not detected
8	300	Not detected	Not detected

TABLE 4. Face position test results

No	The distance of face from camera	Result	Condition
1	2 cm (left)		detected
2	22 cm (below)		Not detected
3	18 cm (top)		Not detected
4	16 cm (left)		Not detected
5	17 cm (right)		Not detected

Based on the data in Table 3, 8 experiments have been carried out. The minimum distance for the program to recognize faces is 20 cm and the maximum distance is 2 m from the camera to use the LBP method. Meanwhile, to use the object eigen method using a narrower range of values. This is because the object eigen method is very sensitive to the stored face size database.

Testing of effect of shooting angle on face recognition result

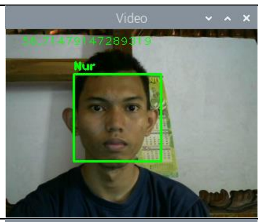
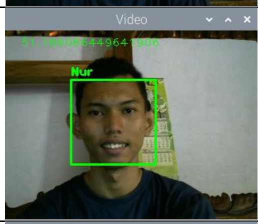
This test was conducted to determine the effect of the shooting angle on the results of the facial recognition program. This test was carried out with a light intensity of 200 lux and a distance of 70 cm. The test results are presented in Table 4.

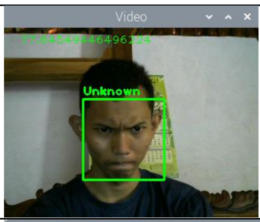
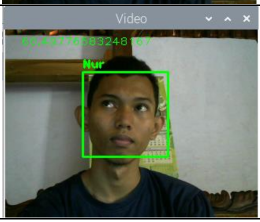
Based on Table 4, the tests that have been carried out show that shifting the position of the face affects the results of face recognition. This is shown in Table 4 numbers 2 to 5. When a face or part of a face passes through the image capture range, the face is not detected. However, when the face is shifted within the image capture range, the face can be detected as shown in Table 4 number 1.

Test identification of faces with various expressions

This test was conducted to determine the effect of various expressions in the face identification process. The test results are shown in Table 5. Based on the data in Table 5, it can be seen that the tests that have been carried out with several facial expressions that are not in the database show failed results even though the faces of the people used for testing are in the database. The new identification process is successful if the expression from the user is the same as what is in the database.

TABLE 5. Expression test results

No	Face expression	Condition
1		Detected
2		Detected
3		Detected

4		Not Detected
5		Detected

Test identification of faces with various expressions

This test aims to determine whether all components of the tool function properly as a unit. Is there an error that occurs when all components are combined.

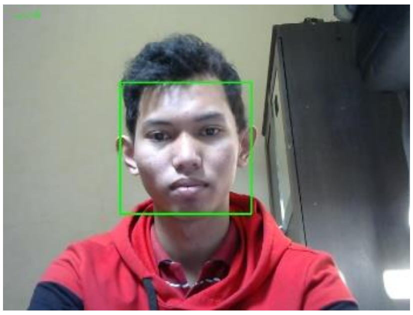


Fig. 3. Face detection

From the overall test that has been done, the results are as desired. The overall test results that have been carried out are shown in Figures 3 to 6.

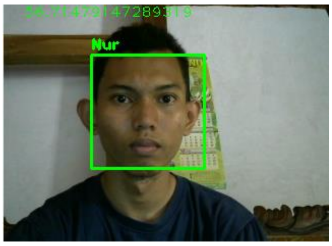


Fig. 4. Identified face

Fig. 5. LCD

In Figure 3, the detectable face portrait is the result of the face detection process using the haar cascade classifier method. The data in Figure 4 is the result of the face identification process using the eigenface method which shows success. The data in Figure 5 shows the LCD display when the face identification process is successful.

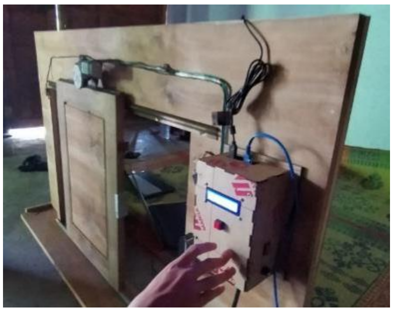


Fig. 6. Smartdoor lock prototype

Figure 6 shows the condition of an open door after successful face detection.

IV. CONCLUSION

Based on the test results data, it can be concluded that the system can develop facial recognition using LPH on a smartlock system with Rasberry Pi obtained the optimal processing speed of 2.43 seconds with a resolution of 320 x 240. This system can also work optimally with lux values from 10 to 750 lux. For testing the optimal distance in this method is 20 to 200 cm. This system can recognize faces well if the face as an object is still in the range of face capture. In the future, the author will develop a system for face detection that is robust against lighting.

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