Human Face Recognition Application Using PCA and Eigenface Approach

Anissa Lintang Ramadhani
Management Information System
Universitas Gunadarma
Depok, Indonesia
alintangr@gmail.com

Purnawarman Musa
Computer System
Universitas Gunadarma
Depok, Indonesia
p_musa@staff.gunadarma.ac.id

Eri Prasetyo Wibowo
Microelectronic and Image Processing Studies
Universitas Gunadarma
Depok, Indonesia
eri@staff.gunadarma.ac.id

***Abstract*— Face is the most memorable part of the body in real life that makes it an important variable. In this research, we use face recognize method that integrated in Ry-UJI robot. The robot is recognized by a detected voice command looking for someone and when a person's face has been found, face recognition is complete. This article will apply the human face recognition system using the eigenface approach. Eigenface is one of the facial recognition methods based on the Principal Component Analysis (PCA) algorithm. PCA involved a mathematical procedure to derive a set of features for face recognition. Face recognition stage begins with face detection process using cascade classifier method, face preprocess, collect and train the face detected and finally the face recognition.**

Keywords*— C++; Eigenface; Face Detection; Face Recognition; OpenCV; PCA.

I. INTRODUCTION

Human and computer interaction in application has been applied in a system. One example of robot RY-UJI that we have developed in university Gunadarma. Application of RY-UJI Robot (see figure 1) that has been integrated with voice commands via MIC. One example of voice commands received by MIC detects and recognizes facial. Face recognition is one of the fastest growing technologies in the field of computer vision. The popularity of the biometric data of the individual is no longer just based on fingerprint data but now it spreads to the face recognition data. Where biometric technology is an individual recognition technology based on special physical features such as fingerprint, hand geometry, iris, and individual faces and behaviors such as voice, hand and handwriting [1].

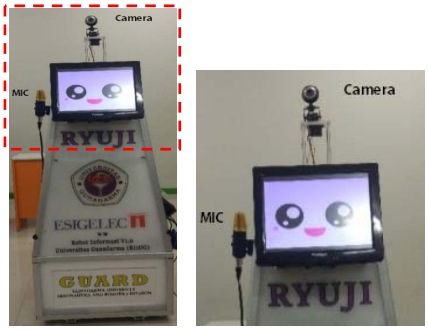

Fig. 1. Overview of Robot RY-UJI

Face is one of the variables that are very easy to remember in real life. Generally humans can remember and recognize a person based on his face. However, face is one of a complex variable when viewed from the perspective of computer vision. Human faces have different features and characteristics of each person so that face recognition is very good to be applied in various areas, including entertainment, smart cards, information security etc [7][3].

The basic concept of the computer vision as useful information from a single image or a sequence of image, usually used the method the automatic extraction, analysis and learning [9]. One of the best methods to perform facial recognition is to use the Principal Component Analysis (PCA) algorithm. PCA is probably the most popular multivariate statistical technique and it is used by almost all scientific disciplines. It is also likely to be the oldest multivariate technique [5]. Multivariate analysis can simply be interpreted as a method associated with large variables in one or more experiments [6]. This method can extract the necessary characteristic data from various data that we have. PCA is a multivariate technique that analyze a data table in which observations are described by several inter-correlated quantitative dependent variables [5].

One of approach by PCA algorithm is Eigenface approach. This article will apply human face recognition system using eigenface approach.

II. RELATED WORKS

Face recognition has been studied by many researcher using various algorithm and approach. Biometric usage is the highest security system compared to traditional systems (using password or ID Card for authentication) on the security system. one of the few applied examples of biometrics is the facial recognition used in the security system [10]. Face recognition it self has two main steps in general [3] which are face detection and face recognition. To perform face detection, Cascade Classifier method or as known as Viola-Jones method is used [11]. To perform face recognition, there are many algorithm that can be applied with face recognition. In [8] face recognition was performed by Feed Forward Neural Networks algoritm (FFNW). In [3], [2], [7] face recogition was performed by Principal Component Analysis (PCA) algorithm.

By observing the literature, especially [3], [2], and [7] PCA algorithm is selected to performed the face recognition. This research also supported by another research like [4].

III. PROPOSED METHOD

This research is using primary data type in the form of image from Red Green Blue (RGB) format that obtained from capturing images by using built-in webcam and secondary data in the form of xml classifier file for face detection and recognition process.

The variable of this research consists of input variables of initial face image and training face image. The output variables of this research are level of similarity and recognition of user's face [12].

A. Detect Object as a Face

The first step to do for face detection is to access the camera that will be used for face detection and recognition. This stage is also check whether the webcam is accessible, if not then the process can not be proceed.

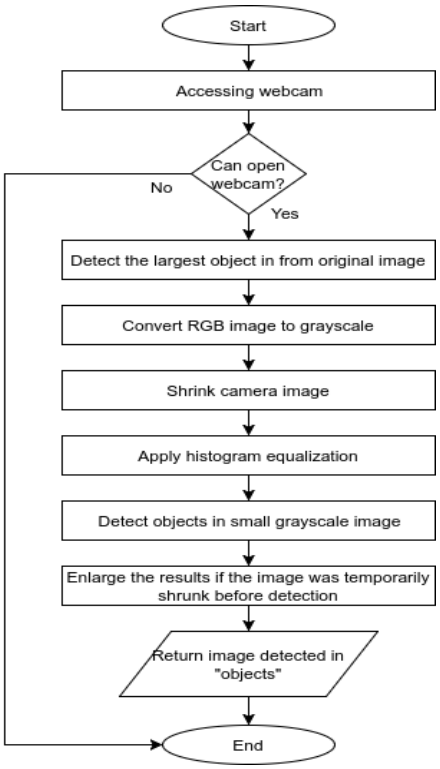

Fig. 2. The process of detecting object as a face.

The detection process starts with detecting objects using CASCADE_FIND_BIGGEST_OBJECT for cascade classifier which will only search one largest object. Furthermore, the initial input image that has RGB format will be changed to grayscale format. The next step is to shrink the camera image to a more reasonable size because the speed of face detection depends on the size of the input image. It will be very slow for large images and will be fast for small images. It is also still fairly reliable to detect face even at low resolutions.

To improve the contrast and brightness, histogram equalization are applied. After that, we finally can detect the face from a small improved grayscale image. The next important thing is to enlarge the results if the image was temporarily shrink because of previous shrinking step. The final step of detect object as a face is to return the face detected and stored it in "objects".

B. Preprocess of Detected Face

Pre-processing steps are performed to minimize failure in recognition process. This stage begins by detecting the location of the eye from the initial input image. Locations of the eyes that have been obtained then saved. The geometric transformation process is then performed by rotating, scaling and translating the images so that the eyes are aligned, followed by the removal of the background from the face image. To have better alignment the detected eye are used to align the face so the positions of the two eyes line up perfectly in desired positions.

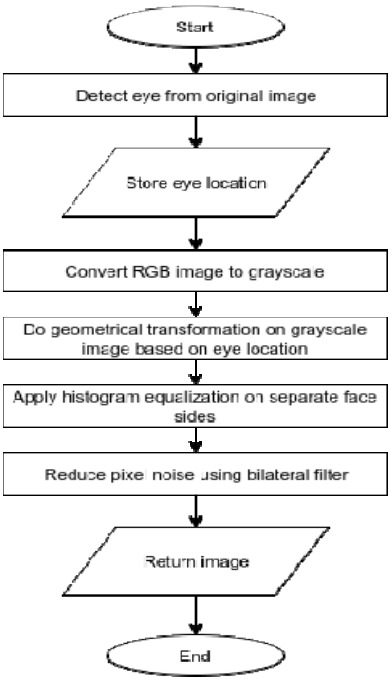

Fig. 3. Face preprocessing.

To rotating phase is to rotate the face so that the two eyes are horizontal. Scaling phase will make the distance between the two eyes is always the same. And then translating phase will translate the face so that the eyes are always centered horizontally and at a desired height.

Many of the cases in which face recognition failed due to the factor of light, both the lack of lighting, the light only coming from one side, as well as excessive lighting. Therefore it is necessary to do histogram equalization separately on the left and right halves of the face, to have standardized brightness and contrast on each side of the face.

The two histogram equalizations will be applied gradually from the left or right hand side towards the center and mix it with a whole-face histogram equalization, so that the center

will use a smooth mix of left or right value and the whole-face equalized value.

The final stage of this process is to apply the bilateral filter which is useful for smoothing most of an image while keeping edges sharp.

C. Collect and train the faces

This step is the key for performed face recognition. Face data collection will be performed which will then become training data for the model. Each time the face capture, the time interval used is one second and must exceed the threshold value of similarity > 0.3. The threshold similarity value is useful for checking whether previously captured and the next face images have variations, because if the data is more varied the better the result of face recognition is done.

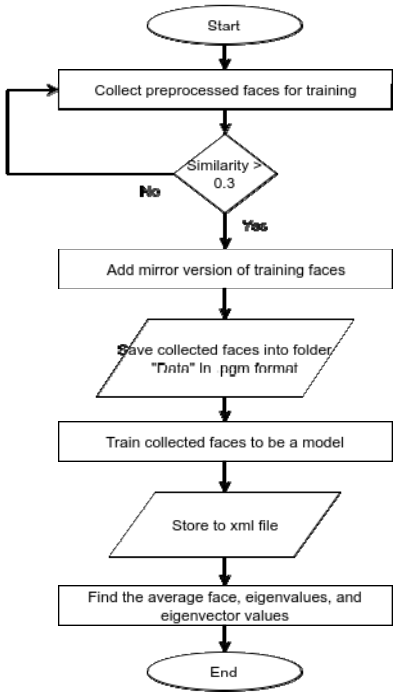

Fig. 4. Collect and train the face detected.

In addition to adding variations of face training data, a mirror version of the training image will also be added to the data. After the data is saved into the "Data" folder with .pgm format, the training will be done which will change the data into a model which is then stored in xml format. The last step is to find the value of average face, eigenvalues, and eigenvector. This can be done using PCA algorithm.

1. Value of average face (mean value) is calculated using this formula:

$$\text{Mean} = \frac{1}{q}\sum_{k=1}^{q}(I_k)$$

2. Substract mean value from test image (D):

$$D = [(I_1 - mean), (I_2\text{-mean}) \ldots (I_k\text{-mean})]$$

3. Find covariance matrix (C):

$$C = DD^T$$

4. Find eigenvalues and eigenvector

   Now in this step system finds eigenvalues and eigenvector. For P dimension vector there will be P eigenvalues and eigenvector.

5. Find eigen image:
   Eigen image (EI) = (D) (Eigenvector)
6. Choose highest eigenvector.

7. Calculate weight matrix (WM):
   WM = (D) (Transpose of largest EI)

The concept of eigenface is a series of eigenvectors used to recognize human faces in a computer vision. Eigenvectors are derived from covariance matrix which has a high probability distribution and vector space dimension to recognize the possibility of a face by reconstruct the face [2].

D. Recognition

To perform a face recognition process, the first step to do is to load the .xml file from the trained facial image of the previous process and the .xml file of the cascade classifier that will be used to detect faces and eyes.

If the .xml file has been successfully loaded, then check whether the webcam is accessible. If the webcam is not accessible, the process will automatically stop and exit, otherwise the system will continue to face detection process and face preprocess.

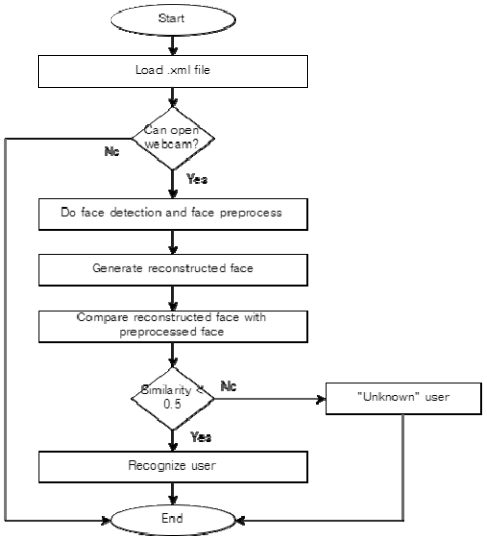

Fig. 5. Recognition process.

The results of face preprocess will be compared with the training model that has been processed into a reconstruct face by back-projecting the eigenvectors and eigenvalues [13]. The threshold value used for comparison is 0.5. If the value of similarity / value of the comparison results less than the threshold value then the user's face can be recognized by the system, otherwise it will be considered as "Unknown" user.

IV. TEST RESULTS

The face recognition's testing will measure the accuracy for face recognition system that has been built. The test will use 6 train user, each user has 40 varieties of imae. Fig. 5 shows the average face images from the database.

Fig. 6. Average face images from the database.

Fig. 6 shows the best 20 eigenface images from images in database.

Fig. 7. Best 20 eigenface images from the database.

By using eigenvalues, we can reconstructed the initial input image to the database model. Figure 7 shows the reconstructed image from one of image database which is "train user 1".

Fig. 8. One of reconstructed images.

At this stage, face recognition testing on the system have been successfully executed.

Fig. 9. Result of face recognition testing (user: "train user 1").

With face data previously trained at the collect and train the face detected, face recognition stage can be done by comparing reconstructed face with preprocess face from initial input image. The testing result is summarized in Table I.

TABLE I. RESULTS OF FACE RECOGNITION TEST

No	*Object*	Recognized Times (%)
1	Train user 1	99
2	Train user 2	97
3	Train user 3	95
4	Train user 4	97
5	Train user 5	92
6	Train user 6	98

It can be seen in Table I, the average results of recognition system is 96.3% or can be said sucessfully done .

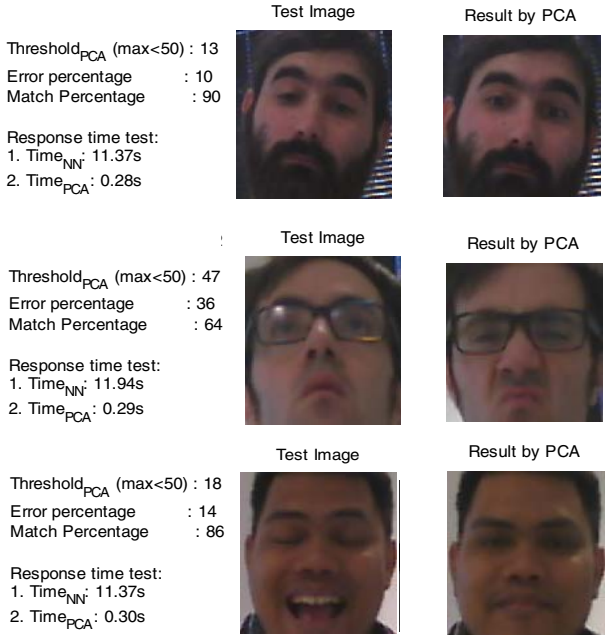

Fig. 10. Result of face recognition testing valid

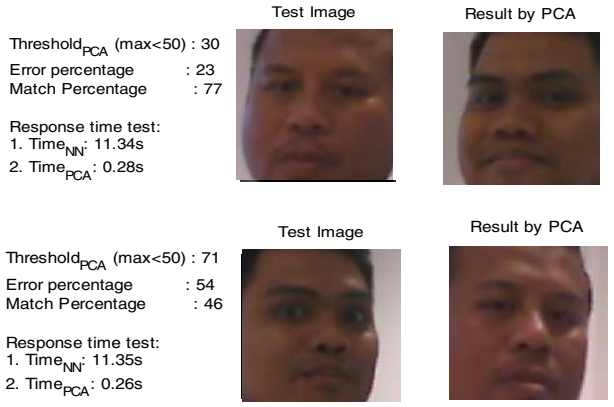

Fig. 11. Result of face recognition testing not valid

Figure 10 shows the test results with a threshold of less than 50 on PCA use with eigenface successfully identifying the face correctly. The face of each personal in the sample of facial data is 20 with a variety of facial expressions. Comparison of test results on Neural network method with PCA method shown in Figure 10, PCA method is more effective in measuring time speed results when identifying face less than 1 second. Figure 11 shows the results of errors in facial recognition, where the first test found similarities to 77%, then in the second test found error of more than 50 values of treshold

V. CONCLUSION

The conclusions obtained from this research, among others:

1. Face detection using cascade classifier method has a very good and fast ability to detect human face.
2. Light and angle factor at the beginning of face detection process is very influential for the recognition process, so the face preprocess stage has to be done which consists of RGB color change to grayscale, geometric image transformation consisting of rotating, scaling and translating the image, and do histogram equalization separately on both sides of faces to make it balance between contrast and brigthness.
3. The more variations of face training data that the system has, the better result of face recognition are and it will also minimize the recognition of unknown faces as one of the known faces in the system.
4. The recognition process will work well when the detection of captured face results are clear and not blurred.
5. Human face recognition using eigenface approach runs very well and quick.
6. The use of eigenvalues and eigenvectors in generate reconstructed face produces excellent images and can be used as a comparison of previously trained images.

REFERENCES

[1] A. H. Triatmoko, S. H. Pramono, and H. S. Dachlan, "Penggunaan metode Viola-Jones dan algoritma Eigeneyes dalam sistem kehadiran pegawai", Jurnal EECCIS, vol. 8, pp. 41-46, June 2014.

[2] A. Singh, and S. Kumar, "Face recognition using PCA and Eigenface approach", Thesis: National Institute of Technology Rourkela, 2012.

[3] D. Kumar, Rajni, "An efficient method of pca based face recognition using simulink", International journal of advanced in computer science and technology, vol. 3, pp. 364-368, May 2014.

[4] D. Pissarenko, "Eigenface-based facial recognition", unpublished.

[5] H. Abdi, and L. J. Williams, "Principal component analysis", John Wiley & Sons Inc, vol. 2, pp. 433-459, August 2010.

[6] I. Urifan, R. Hidayat, and I. Soesanti, "Pengenalan wajah dengan metode Eigenface", Jurnal penelitian teknik elektro,vol. 3, pp. 320-323, December 2010.

[7] M. Slavkovic, and D. Jevtic, "Face recognition using Eigenface approach", Serbian journal of electrical engineering, vol. 9, pp. 121-130, February 2012.

[8] M.S.R.S. Prasad, et al, "Face recognition using pca and feed forward neural networks", International journal of computer science and telecommunications, vol. 2, pp. 79-82, November 2011.

[9] M. B. Subaweh and E. P. Wibowo "Implementation of Pixel Based Adaptive Segmenter Method for Tracking and Counting Vehicles in Visual Surveillance", International conference Informatics and Computer. Lombok – Indonesia 2016

[10] P. Musa, M. Lamsani, and N. Nurvuliani, "Rancang Bangun Pengendali Pintu Automatis Berdasarkan Ciri Wajah Menggunakan Metode Euclidean Distance Dan Fuzzy C-mean", STMIK MDP Palembang, Indonesia 2012

[11] P. Viola, and M. Jones, Robust Real-time Object Detection, IJCV, Vancouver, Canada, 2001.

[12] S. Bayu, A. Hendriawan, and R. Susetyoko, "Penerapan face recognition dengan metode Eigenface dalam intelligent home security", unpublished.

[13] S, Emami, et al, Mastering OpenCV with practical computer vision projects, PACKT publishing: Birmingham, 2012