COMPARISON OF EIGENFACE AND FISHERFACE METHODS FOR FACE RECOGNITION

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ABSTRACT— ***Biometric information systems have been widely used in the fields of government, shopping centers, education and even security, which offer biological authentication so that the system can recognize its users more quickly. The parts of the human body are identified by a biometric system that has unique and specific characteristics, one of which is the face. Adjustment of facial image deals with objects that are never the same, due to the parts that can change. These changes are caused by facial expressions, light intensity, shooting angle, or changes in facial accessories. With this, the same object with several differences must be recognized as the same object. In this study, the data used were 388 face images and the sata test consisted of 30 face images. Before the face is tested, preprocessing and feature extraction are carried out using the Haar Cascade Classifier and then detected using Eigenface and Fisherface. Based on the research results, the Fisherface method is an algorithm that is accurate and efficient compared to the Eigenface algorithm. The Fisherface algorithm has an accuracy of 88%. while the Eigenface method has an accuracy rate of 76%.***

Keywords – ***Haar Cascade Classifier, Eigenface, Fisherface,.***

Intisari— Sistem informasi biometrik sudah banyak digunakan baik dalam bidang pemerintahan, pusat pembelanjaan, pendidikan bahkan keamanan yang menawarkan autentikasi secara biologis sehingga memungkinkan sistem dapat mengenali penggunanya lebih cepat. Bagian tubuh manusia diidentifikasikan oleh sistem biometrik yang memiliki sifat unik dan spesifik salah satunya adalah wajah. Pengenelan citra wajah berhubungan dengan objek yang tidak pernah sama, dikarenakan adanya bagian-bagian yang dapat berubah. Perubahan tersebut disebabkan oleh ekspresi wajah, intensitas cahaya, sudut pengambilan citra, atau perubahan aksesoris pada wajah. Dengan hal ini, objek yang sama dengan beberapa perbedaan tersebut harus dikenali sebagai satu objek yang sama. Dalam Penelitian ini data yang digunakan sebanyak 388 citra sebagai data training dan 30 citra sebagai data testing. Citra wajah diuji dengan preposesing dan ekstraksi fitur menggunakan *Haar Cascade Classifier* kemudian di deteksi mengunakan *Eigenface* dan F*isherface*. Berdasarkan hasil penelitian Metode *Fisherface* merupakan metode yang akurat dan efisien dibandingkan dengan metode *Eigenface.* Metode *Fisherface* memiliki akurasi sebesar 88%. sedangkan metode *Eigenface* memiliki tingkat akurasi 76%.

Kata Kunci*: Haar Cascade Classifier, Eigenface, Fisherface,*

INTRODUCTION

Advances in technology are currently driving the development of various information systems, one of which is a biometric information system. Biometric information systems have been widely used in the fields of government, shopping centers, education and even security that offer biological authentication so that the system can identify users more quickly. Parts of the human body are identified by a biometric system which has unique and specific characteristics, one of which is the face.

Face recognition is a pattern recognition approach for personal identification purposes in addition to other biometric approaches such as fingerprint recognition, signatures, eye retinas and etc (Kustian, 2017). In general, the way facial recognition works is by converting photos, sketches and video images into a series of numbers called faceprints and then comparing them with other series of numbers that represent familiar faces.

Face image recognition deals with objects that are never the same, because there are parts that can change. These changes are caused by facial expressions, light intensity, image capture angle, or changes in accessories on the face. In this case, the same object with several differences must be

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recognized as the same object. Research conducted by Putranto, et al in 2016 on Face Recognition using Eigenface with naive Bayes shows that the proposed method can predict facial images up to 70%, moreover by adding a normalized Z-Score the prediction increases up to 89.5% (Putranto et al., 2017).

Research conducted by Supriyanto, Hasanah and Santoso on Real-Time Face Imaging Systems with Adabost, Eigenface PCA & MySQL gives a success rate of 80% (Suprianto, 2013).

Research conducted by Phankokkruad and Jaturawat in 2019 concerning Infuence of Facial Expression and Viewpoint Variations on Face recognition Accuracy by Different recognition Algorithm which aims to compare the Eigenfaces, Fisherfaces, and LBPH algorithms. In this study, the highest accuracy was obtained by LBPH which achieved an accuracy of 81.67% (Phankokkruad & Jaturawat, 2017).

Research conducted by Aditya, et al in 2020 concerning Face recognition System Implementation As a media Access to Restricted Room with Histogram Equalization and Fisherface Methods. Has a success rate of 88.33% obtained from 120 trials consisting of 12 poses (Aditya et al., 2019).

Research conducted by Rahman, et al on Face recognition in Low Lighting Conditions Using the Fisherface method and CLAHE Techniques, the system works well for facial recognition with brightness level performance and the system's facial recognition works well at a brightness level of 50% with an accuracy of 76.92% (Rahman, Sthevanie, and Ramadhani, 2020).

In this study, a facial recognition system was used using the Eigenface and Fisherface methods. The main idea of the eigenfaces method consists of extracting facial features and representing faces as linear combinations called “eigenfaces”.

These eigenvectors are derived from the covariance matrix of the probability distribution of the high-dimensional vector space of all facial images in the database (Mantoro, Ayu, and Suhendi, 2018).

Fisherface is one of the popular methods used in face recognition, and is widely believed to be superior to other techniques, such as eigenface because it attempts to maximize the separation between classes in the training process. (Wahyuningsih et al., 2019).

RESEARCH METHOD

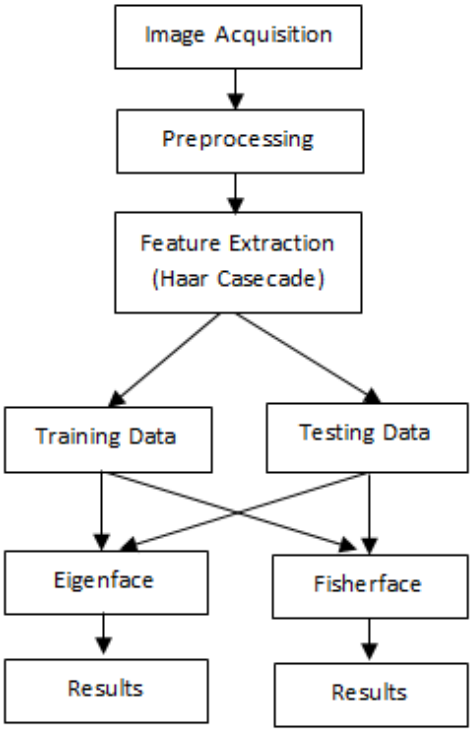


Figure 1. Research Method

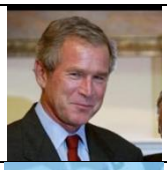
A. Image Acquisition

Image acquisition can be interpreted as the process of capturing an image from an analog image to a digital image (Utama, 2011). The purpose of image acquisition is to determine the data that will later be used in a study (Fadjeri et al., 2020).

The dataset used by the authors comes from Kaggle regarding Face Recognition. Face Recognition data consists of training data and testing data. The training data consists of five classes with a total of 388 facial images and the testing data consists of 30 facial images

Table 1.Sample Face

Name	Dataset 1
Colin_Powell	
Donald_Rumsfeld	

George_W_Bush	
Gerhard_Schroeder	
Tony_Blair	

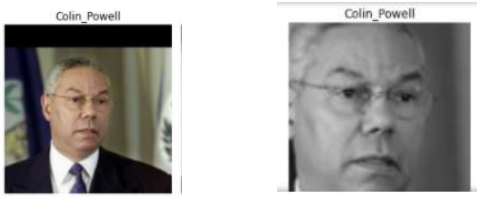
B. **Preprocessing**

Preprocessing is a step taken for data processing to obtain accurate and consistent data (Kumar and Chandrasekhar, 2012). In the preprocessing process, the facial image is converted to a size of 100x100 pixels to make processing easier. Furthermore, the image is converted to grayscale or greyscale in order to simplify the image model.

C. Ekstraksi Fitur Haar Cascade Classifier

In this study, implementing the Haar Cascade Classifier to detect human faces using an Open Source Computer Vision Library called OpenCV. Originally, this method was provided by Paula Voila and Michael Jones (Viola and Jones, 2001). For human face detection, haar features are the main part of haar cascade classifier. The haar feature is used to detect the presence of features in a given image (Singh et al., 2013)

Feature extraction uses the Haar Cascade Classifier where the overall form of the detection process using the haar cascade is a form of degeneration of a decision tree called a cascade. A positive result from the first classifier triggers an evaluation of the second classifier which has also been adjusted to achieve a very high detection rate. A positive result from the second classifier triggers the third classifier and so on. A negative result at any point leads to an immediate rejection of the sub-window (Viola & Jones, 2001).



(a) (b)

Figure 1. Sample Face Picture

(a) Original Image
(b) Converted to gray scale and then cropped for the detected facial area using the Haar-cascade Classifier

D. Save the dataset to the database

In this study there are 5 classes that allow for facial recognition. The image samples from each of these classes are extracted from the features into the Haar Cascade Classifier and then saved in the form of an xml file.

E. Eigenface

The basic idea of eigenfaces is that all face images are similar in all configurations and can be described in terms of the base face image. Based on this idea, the eigenfaces procedure is as follows (Kshirsagar et al., 2011).

a) assumes the set of training images is Γ1, Γ2, .., Γm with each image is I (x, y). Convert each image to a new set of vectors and full size matrices (m × p), where m is the number of training images and p is x × y.

b) Find the average face with :

$$\Psi = \frac{1}{m}\sum_{i=1}^{m} \Gamma i \quad \text{..... (1)}$$

c) Calculate the face minus the average:

$$\Phi i = \Gamma i - \Psi,\ I = 1, 2, \ldots, m \quad \text{.....(2)}$$

A = [Φ1, Φ2,..., Φm] is the matrix vector minus the mean and size A_{mp}.

d) By applying matrix transformation, the vector matrix is reduced by:

$$C_{mp} = A_{mp\,x}\, A_{pm}^{T} \quad \text{..... (3)}$$

where C is the covariance matrix and T is the transpose matrix

e) Determine the eigenvectors, Vmm and eigenvalues, λm from the matrix C use the Jacobi method and construct the eigenvectors with the highest eigenvalues. The Jacobi method was chosen because of its accuracy and reliability compared to other methods.

f) Apply the eigenvector matrix, Vmm and the adjusted matrix, Φm. This vector defines a linear combination of the training set images to form eigenfaces :

$$U_k = \sum_{n=1}^{m} \Phi_n\, V_{kn}\ , k = 1, 2, \ldots, m \quad \text{..... (4)}$$

g) Based on eigenfaces, each image has a face vector by:

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$$W_k = U_k^T(\Gamma - \Psi), k = 1,2 \ldots m \quad (5)$$

and the vector mean minus size (p × 1) and eigenfaces is U_{pm}. the weights form the feature vector:

$$\Omega^T = w_1 w_2, \ldots . w_m \quad (6)$$

h) A face can be reconstructed using its features, vectors ΩT and the previous eigenfaces, U_m ' as:

$$\Gamma = \Psi + \Phi_f \quad (7)$$

Where,

$$\Phi_f = \sum_{i=1}^{m} w_i U_i \quad (8)$$

F. Fisherface

Fisherface was developed to overcome the weakness of Eigenface (Mutiara & Prasetyo, 2019). Fisherfaces (Phankokkruad & Jaturawat, 2017) is a strong method with arguments in favor of using the linear method for dimension reduction in facial recognition problems at least when one is looking for insensitivity to lighting conditions. Since learning sets are labeled, it makes sense to use this information to build more reliable methods to reduce the dimensionality of the feature space.

Using class-specific linear methods for dimensionality reduction and simple classifiers in reduced feature space, one might get better recognition rates. However, the results of many studies reveal that both methods have effective processing time and storage usage. *Fisher's Linear Discriminant* (FLD) is an example of a class-specific method, in the sense that it tries to "shape" a spread to make it more reliable for classification. This method selects w so that the spread ratio between classes and the spread of the inner class is maximized. Let the scatter matrix between classes be defined as:

$$S_b = \sum_{j=1}^{C} \sum_{i=1}^{nj} (x_{ij} - \mu_i)(x_{ij} - \mu_i)^T \quad (9)$$

where xij is the ith sample of class j, μj is the mean of class j, and nj is the number of samples of class j. Likewise, 232 between class differences were calculated using the scatter matrix between classes,

$$S_b = \sum_{j=1}^{C} (\mu_j - \mu)(\mu_j - \mu)^T \quad (10)$$

where μi is the average image of the class Xi, and μ is the average image of all classes. Ni is the number of image samples of class Xi, and C is number of classes. Sw is the maximized value of the inter-class scatter matrix whereas w is the minimized in-class scatter matrix for use in the classification process.

To illustrate the benefits of class-specific linear projections, construct a low-dimensional analogue for a classification problem in which the samples from each class lie in a close linear subspace.

G. Face recognition

Face recognition in this study calls the xml file from the training data and the xml file from the cascade classifier which is used to detect faces and eyes. The facial recognition process for the two methods analyzed is the same if the confidence value is higher than the threshold value, if the ID is equal to -1 then the face cannot be recognized.

H. Accuracy

Accuracy is a measure of the total system in classifying correctly, which means that objects are detected correctly and the background is not detected. Sensitivity is the percentage of the number of objects that are correctly detected (objects of interest) in the entire set of images that contain objects of interest. Meanwhile, specificity is the percentage of the number of objects other than faces (objects of interest) in the entire set of images where there are no objects of interest.

Equation (11) to Equation (13) shows the formula for calculating accuracy, sensitivity, and specificity parameters. True Positive (PB) can be analogous to the object being seen as a detected face. True Negative (TN), that is, objects other than faces (background) are not correctly detected as faces. False Positive (FP) is an object other than a face (background) detected as a face. False Negative (FN) is a face object that is not detected as a face (Hardiyanto & Anggun Sartika, 2018).

$$Precision = \frac{TP}{TP+FP} \quad (11)$$

$$Recall = \frac{TP}{TP+FN} \quad (12)$$

$$Akurasi = \frac{TP+TN}{TP+TN+FP+FN} \quad (13)$$

RESULTS AND DISCUSSION

A. Eigenface Method Processing

The following are the results of facial recognition testing using the Eigenface method.

Table 2. Confusion Matrix Eigenface Method

Colin_Powell	5	0	0	0	0
Donald_Rumsfeld	0	5	0	0	0
George_W_Bush	0	1	2	0	2
Gerhard_Schroeder	0	0	0	5	0
Tony_Blair	1	0	2	0	2
	Colin_Powell	Donald_Rumsfel	George_W_Bush	Gerhard_Schroed	Tony_Blair

Based on the table above, we can see that Colin Powel can all be detected, George W Bush is detected in 4 images while 1 image is detected as Tony Blair as well as Donal Rumfeld, then 2 are detected as Donal Rumfeld 2 are detected as Tony Blair and Donal, Gerhard Schoeder is successfully detected all, then 2 detected as Tony Blair and 2 detected as George.

B. Fisherface Method Processing

The following are the results of facial recognition testing using the fisherface method

Table 3. Confussion Matrix Fisherface Method

Colin_Powell	5	0	0	0	0
Donald_Rumsfeld	0	5	0	0	0
George_W_Bush	0	0	4	0	1
Gerhard_Schroeder	0	0	0	4	0
Tony_Blair	0	0	1	1	3
	Colin_Powell	Donald_Rumsfel	George_W_Bush	Gerhard_Schroed	Tony_Blair

In the table above we can see that Colin Powel can be detected all, as well as Donal Rumfeld, then 4 detected as Donal Rumfeld 1 detected as Tony Blair, George W Bush detected 4 images while 1 image detected as Tony blair. Gerhard Schoroed detected 4 images and 1 was detected as Tony Blair, then 3 were detected as Tony Blair 1 was detected as George and 1 was detected as George.

C. Comparison of Accuracy, Precision, and Recall of Eigenface and Fisherface

The following is the result of a comparison of the Eigenface and Fasherface Methods

Table 4. Comparison of Accuracy, Precision, and Recall of Eigenface and Fisherface

Method	Precision	Recall	Accuracy
1. Eigenface	73%	76%	76%
2. Fisherface	88%	88%	88%

Based on the table above, we can see that the Fisherface method is superior to the Eigenface method. The Eigenface method is still difficult to recognize faces compared to the Fisherface method which can still recognize faces when there is a change in facial expressions

CONCLUSION

Based on research using face datasets grouped into five classes, processed using feature extraction of the Haar Cascade Classifier and processed using the Eigenface and Fisherface facial recognition methods, it can be concluded that the Fisherface method is an accurate and efficient method compared to the Eigenface method. The Fisherface method has an accuracy of 88%. while the Eigenface method has an accuracy rate of 76%.

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