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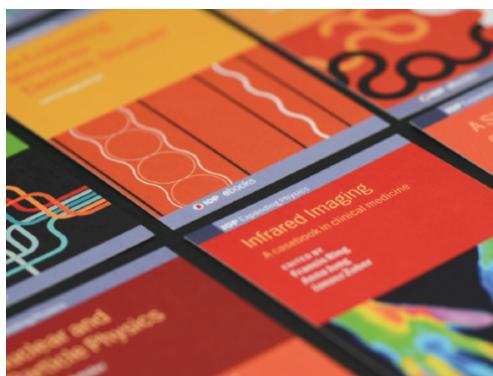
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Face Recognition Using Fisherface Method

Mustamin Anggo^{1*} and La Arapu¹

¹Department of Mathematics, Universitas Cenderawasih, Jayapura, Indonesia.

*supi6976@gmail.com

Abstract. Fisherface is one of the popular algorithms used in face recognition, and is widely believed to be superior to other techniques, such as eigenface because of the effort to maximize the separation between classes in the training process. The purpose of this research is to establish a program of face recognition application using fisherface method by utilizing GUI applications and databases that are used in the form of a Papuan facial image. Image recognition using fisherface method is based on the reduction of face space dimension using Principal Component Analysis (PCA) method, then apply Fisher's Linear Discriminant (FDL) method or also known as Linear Discriminant Analysis (LDA) method to obtain feature of image characteristic. The algorithm used in the process for image recognition is fisherfaces algorithm while for identification or matching face image using minimum euclidean. The method used in this study is literature study that is studying and reviewing various books or literature related to mathematical concepts that underlies the formation of fisherface algorithm to recognize the image of a person's face which is then applied in programming language, especially programming language Matlab7.10. While in the process of preprocessing used Adobe Photoshop CS4 application program, its goal is to make the face image to be uniform in terms of size and format so that the image is ready to be used by the system. The results show that for image recognition where the image of testing is the same as the training image, the percentage of program success is 100%, while for 73 facial test images with various expressions and various positions, 70 faces are recognized correctly and 3 faces are recognized incorrectly, so the percentage of success is 93%..

1. Introduction

The face, as a part of human body, is the easiest and the most often used to distinguish the identity of individuals. From the face, humans can be distinguished and recognized more quickly and easily [1]. Therefore the face is used as a means of identification of a person or face recognition [3]

Generally, the image recognition system is divided into 2 types, namely: feature-based system and image-based system. In the first system, features extracted from the eye image components, nose, mouth, etc. which are then modeled geometrically to determine the relationship between these features. While in the second system using image pixels which are then represented in certain methods such as Principal Component Analysis, wavelet transformation, etc. which is then used for training and image identification classification [2, 5].

Feature extraction is a process for obtaining characteristics that distinguish a face sample from another face sample. Reliable feature extraction techniques are key in solving pattern recognition



problems as the principal component analysis method (PCA) used for face recognition was introduced by Turk and Pentland in 1991 [7].

The PCA method aims to project data in the direction that has the greatest variation (indicated by the eigenvector) corresponding to the largest eigenvalues of the covariance matrix. The weakness of the method is less optimal in the separation between classes [3,7].

In 1991, Cheng et al. introduces Linear Discriminant Analysis (LDA) method for face recognition. This method tries to find a linear subspace that maximizes the separation of two pattern classes according to Fisher Criterion JF. This can be obtained by minimizing the distance of the within classsw distribution matrix and maximizing the split matrix spacing between the Sb classes simultaneously resulting in a maximum Fisher Criterion JF. Fisher Linear Discriminant will find subspaces where classes are linearly separated by maximizing the Fisher Criterion JF. If the data dimension is much higher than the number of training samples will cause Sw to be singular. This is a weakness of the LDA method [3].

In 1997, Belheumeur introduced the fisherface method for face recognition. This method is a combination of PCA and LDA methods. The PCA method is used to solve singular problems by reducing the dimensions before being used to perform the LDA process. But the weakness of this method is that when the PCA dimension reduction process will cause some loss of discriminant information useful in the LDA process [3].

But in its development, face recognition with fisherface method still have some problems, such as computation problems and the condition of the face image into input that will be used as image testing. The problem of computation in face recognition using fisherface method becomes a problem because it has a very complicated and very complex computation process. While the problems that affect the condition of the face image is the diversity of the light of the face image, the attributes of the face image, the expression of the face image, and the variation of the position of the image of the face itself.

The data used in this study is the image of the Papuan's face. Face images of people of Papua used as data in this study because in addition there has been no research data in the form of face images of the Papuans. Another reason is because the images of the face of the Papuans are generally very similar so there is a possibility of influence on the success of the method used in this study [8].

2. Research Methods

2.1. The Design System

Face recognition system using fisherface method is designed to recognize the face image by matching the results of its feature extraction. The system is expected to determine whether the image to be tested is recognized correctly or not.

In this research, as many as 200 facial images, taken from 50 students, are used in *.bmp format. Each student have five face images with different expressions.

2.2. Process Design

2.2.1. Data retrieval process.

This process aims to collect data in the form of face image. Collection of samples is done with photograph directly the face image. The position of the face is facing toward the front and upright position and not blocked by other objects. A total of 50 students photographed with a distance of ± 100 cm, with the aim to equate the quality and the image of each data taken.

2.2.2. Image Processing Process.

The design of this process is divided into two stages: preprocessing stage and processing stage which includes feature extraction and recognition.

- Image Preprocessing

The face image to be used must go through the preprocessing stage first. This stage includes image acquisition, and RGB image conversion to grayscale. Acquisition of face images using camera. The image of this acquisition is a 24-bit RGB image of JPG format with size 92 x 112 pixels. Conversion of face image of acquisition from RGB to 8 bit grayscale, BMP format with size 40 x 40 pixels. Furthermore, the face data is divided into 2 (two) parts ie one part of the image will be used as training image (training dataset) and one part of the image will be used as test image (testing dataset).

- Image Processing

At this image processing stage, Fisherface method will be applied to generate feature vector of facial image data used by system and then to match vector of traits of training image with vector characteristic of test image using euclidean distance formula.

2.2.3. Feature generation process.

Features to be extracted is a feature of the face image of people of Papua. The method used is fisherface method is a method that is a merger between PCA and LDA methods.

3. Result and Discussion

Development In this section will be discussed about the results of facial recognition research using fisherface method. In general, face recognition system in this study can be seen in Figure 1. [6].

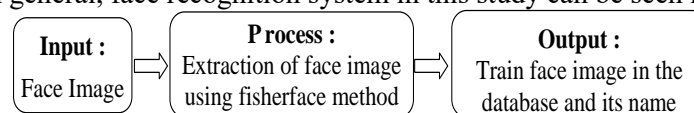


Figure 1. Stages of system process

3.1. Image Data

3.1.1. Image of the photograph result.

Here is a sample of photos photograph with each individual represented by a minimum of 5 samples of face images with different positions and different expressions

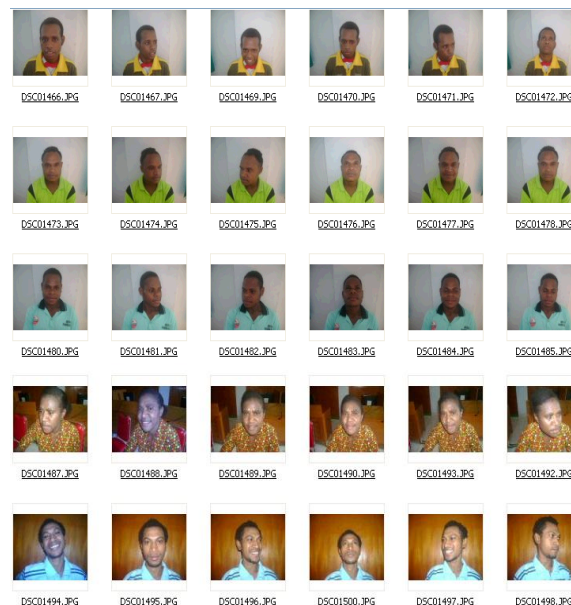


Figure 2. An example of an unprocessed image sample

3.1.2. Image Data Training.

To know the success of the system created, then the system will be trained in the first with several images as follows:



Figure 3. Examples of some training images

3.1.3. Image Data testing.

Below are some examples of test images tested on the system.



Figure 4. Examples of some training images

3.2. Feature generation process withfisherface method

Assumed : Size of rectangular face image with height = N and width = N and consists of h samples image, $\{\vec{a}, \vec{b}, \dots, \vec{h}\}$ and C class $\{x_1, x_2, \dots, x_c\}$.

3.2.1. PCA Algorithm

- Conversion training image $I_1, 2, \dots, m$ with size N x N into vector form with length size N^2 .

$$\begin{array}{cccc}
 \begin{array}{c} \text{Image 1} \\ \text{Image 2} \\ \text{Image 3} \\ \text{Image 4} \end{array} & = \begin{pmatrix} a_1 \\ a_2 \\ \vdots \\ a_{N^2} \end{pmatrix} & \begin{array}{c} \text{Image 5} \\ \text{Image 6} \\ \text{Image 7} \\ \text{Image 8} \end{array} & = \begin{pmatrix} b_1 \\ b_2 \\ \vdots \\ b_{N^2} \end{pmatrix} & \begin{array}{c} \text{Image 9} \\ \text{Image 10} \\ \text{Image 11} \\ \text{Image 12} \end{array} & = \begin{pmatrix} c_1 \\ c_2 \\ \vdots \\ c_{N^2} \end{pmatrix} & \begin{array}{c} \text{Image 13} \\ \text{Image 14} \\ \text{Image 15} \\ \text{Image 16} \end{array} & = \begin{pmatrix} d_1 \\ d_2 \\ \vdots \\ d_{N^2} \end{pmatrix} \\
 \begin{array}{c} \text{Image 17} \\ \text{Image 18} \\ \text{Image 19} \\ \text{Image 20} \end{array} & = \begin{pmatrix} e_1 \\ e_2 \\ \vdots \\ e_{N^2} \end{pmatrix} & \begin{array}{c} \text{Image 21} \\ \text{Image 22} \\ \text{Image 23} \\ \text{Image 24} \end{array} & = \begin{pmatrix} f_1 \\ f_2 \\ \vdots \\ f_{N^2} \end{pmatrix} & \begin{array}{c} \text{Image 25} \\ \text{Image 26} \\ \text{Image 27} \\ \text{Image 28} \end{array} & = \begin{pmatrix} g_1 \\ g_2 \\ \vdots \\ g_{N^2} \end{pmatrix} & \begin{array}{c} \text{Image 29} \\ \text{Image 30} \\ \text{Image 31} \\ \text{Image 32} \end{array} & = \begin{pmatrix} h_1 \\ h_2 \\ \vdots \\ h_{N^2} \end{pmatrix}
 \end{array}$$

- Calculate the average of all face images

$$\vec{m} = \frac{1}{M} \begin{pmatrix} a_1 + b_1 + \dots + h_1 \\ a_2 + b_2 + \dots + h_2 \\ \vdots \\ a_{N^2} + b_{N^2} + \dots + h_{N^2} \end{pmatrix},$$

or written as, $\vec{m} = \frac{\vec{a} + \vec{b} + \dots + \vec{h}}{M}$

- Calculate Matrix A with the formula

$$\begin{aligned} \vec{a}_m &= \begin{pmatrix} a_1 - m_1 \\ a_2 - m_2 \\ \vdots \\ a_{N^2} - m_{N^2} \end{pmatrix}, & \vec{b}_m &= \begin{pmatrix} b_1 - m_1 \\ b_2 - m_2 \\ \vdots \\ b_{N^2} - m_{N^2} \end{pmatrix}, \\ \vec{c}_m &= \begin{pmatrix} c_1 - m_1 \\ c_2 - m_2 \\ \vdots \\ c_{N^2} - m_{N^2} \end{pmatrix}, & \vec{d}_m &= \begin{pmatrix} d_1 - m_1 \\ d_2 - m_2 \\ \vdots \\ d_{N^2} - m_{N^2} \end{pmatrix}, \\ \vec{e}_m &= \begin{pmatrix} e_1 - m_1 \\ e_2 - m_2 \\ \vdots \\ e_{N^2} - m_{N^2} \end{pmatrix}, & \vec{f}_m &= \begin{pmatrix} f_1 - m_1 \\ f_2 - m_2 \\ \vdots \\ f_{N^2} - m_{N^2} \end{pmatrix}, \\ \vec{g}_m &= \begin{pmatrix} g_1 - m_1 \\ g_2 - m_2 \\ \vdots \\ g_{N^2} - m_{N^2} \end{pmatrix}, & \vec{h}_m &= \begin{pmatrix} h_1 - m_1 \\ h_2 - m_2 \\ \vdots \\ h_{N^2} - m_{N^2} \end{pmatrix} \end{aligned}$$

or written as

$$\vec{A} = [\vec{a} - \vec{m}, \vec{b} - \vec{m}, \dots, \vec{h} - \vec{m}] = [\vec{a}_m, \vec{b}_m, \dots, \vec{h}_m]$$

- Compute vector eigen (**eigVecs**) and value eigen (**eigenVals**) by using the method svd of the matrix **A**. Sort eigvecs then reduction with the pca method, pe . pe is **eigenfaces**

3.2.2. LDA Algorithm

- Calculate the average of each person / class

$$\bar{x} = \frac{1}{2} \begin{pmatrix} a_1 + b_1 \\ a_2 + b_2 \\ \vdots \\ a_{N^*} + b_{N^*} \end{pmatrix}, \quad \bar{y} = \frac{1}{2} \begin{pmatrix} c_1 + d_1 \\ c_2 + d_2 \\ \vdots \\ c_{N^*} + d_{N^*} \end{pmatrix},$$

$$\bar{z} = \frac{1}{2} \begin{pmatrix} e_1 + f_1 \\ e_2 + f_2 \\ \vdots \\ e_{N^*} + f_{N^*} \end{pmatrix}, \quad \bar{w} = \frac{1}{2} \begin{pmatrix} g_1 + h_1 \\ g_2 + h_2 \\ \vdots \\ g_{N^*} + h_{N^*} \end{pmatrix}$$

- Construct the scatter matrix S_1, S_2, S_3, S_4

$$S_1 = (\vec{a}_m \vec{a}_m^T + \vec{b}_m \vec{b}_m^T),$$

$$S_2 = (\vec{c}_m \vec{c}_m^T + \vec{d}_m \vec{d}_m^T)$$

$$S_3 = (\vec{e}_m \vec{e}_m^T + \vec{f}_m \vec{f}_m^T),$$

$$S_4 = (\vec{g}_m \vec{g}_m^T + \vec{h}_m \vec{h}_m^T)$$

and matrix within class scatter ($ScatW = S_1 + S_2 + S_3 + S_4$)

- The construct of also matrix between class scatter, ($ScatB$)

$$(ScatB = 2(\bar{x} - \bar{m})(\bar{x} - \bar{m})^T + 2(\bar{y} - \bar{m})(\bar{y} - \bar{m})^T + 2(\bar{z} - \bar{m})(\bar{z} - \bar{m})^T + 2(\bar{w} - \bar{m})(\bar{w} - \bar{m})^T)$$

- Compute the multiplication of matrices tranpose of pe , (Pe^T), with $ScatW$ and $ScatB$ until obtain :

$$Sbb = Pe^T * ScatB * Pe$$

$$Sww = Pe^T * ScatW * Pe$$

- Find eigenvector ($VeSbb$) and generalized eigenvalues ($NeSww$) of (Sbb, Sww) and then sort in ascending order.
- Projection back $VeSbb$ with Pe eigenfaces then formed ($Pe * VeSbb$) \rightarrow Output as **Fisherface**.
- Normalization Fisherface $Pe * VeSbb * N$
- Find the transpose of the normalized **Fisherfaces**, $Pe * VeSbb * N^T$
- Calculate Weights for each training image into a normalized fisherface, $U = Pe * VeSbb * N^T * A$.

The result of the above process is the weight of each training image in the form of eigen vector which will be used to find similarity with face image which will be recognized by using Euclidean distance formula.

3.2.3. Identification or recognition algorithm.

The identity classification steps are as follows :

- Conversion of the face image tested by the size of $N * N$ into the column vector form r_{iN^2}
- Normalization of facial image input to the image of training by finding the value of different matrix Φ_{inp} by subtracting the average value of training image.
- Calculates the weight of the test image by multiplying the eigenval transpose matrix \vec{v}^T with the matrix Φ_{inp} matrix (U_{inp}) ; $U_{inp} = \vec{v}^T \Phi_{inp}$

- Calculate the distance of the difference between the image testing with training face image using euclidean distance.

$$\varepsilon_i = \sqrt{\|U - U_{inp}\|^2}; \quad i = 1 \dots M$$

The result of the identification is the image that has the smallest distance with the test image displayed by the system

3.3. System Testing

To determine whether the system is running well made and properly it is necessary to test. the following process.

3.3.1. Training Process.

The first stage of system testing is the training stage. This stage aims to generate the weight value of each image of existing training.

3.3.2. Image Recognition Process.

After the training process is successfully done, the next stage is to carry out image recognition process. The goal is how big the system successfully recognize the test image or testing properly. The following is the result of the image recognition process performed by the system.

- The training image is the same as the testing image

The purpose of image training is the same as the test image that is the test image used by the system in the recognition process is the same as the training image used at time the training process, both in terms of expression, position and image condition. The number of facial images used in this process is 250 images. The test results show that the system successfully identifies the test image correctly up to 100%.







- The training image is not the same as the testing image.























In this test, the testing image used is not the same as the training image used during the training, whether viewed in terms of expression, position and condition of the image; but the test image and the training image still come from the image of the same person's face. The test results show that the system successfully identified the test image correctly up to 93%.

3.4. Image recognition results

The following is an example of the results of facial recognition process with fisherface method can be seen below.

Table 1. An example of face image recognition results

Training	Testing Image	Result
 23910 ₄ 3 ₅	 23910 ₄ 3 ₆	recognized correctly
 23910 ₄ 3 ₈	 23910 ₄ 3 ₃	recognized correctly
 23910 ₄ 4 ₄	 23910 ₄ 4 ₃	recognized correctly

Training	Testing Image	Result
 23910 ₆ ₄	 23910 ₆ ₁	recognized correctly
 25910 ₅ ₂ ₃	 25910 ₅ ₂ ₂	recognized correctly
 25910 ₅ ₃ ₄	 25910 ₅ ₃ ₂	recognized correctly
 25910 ₅ ₄ ₅	 25910 ₅ ₄ ₄	recognized correctly
 25910 ₅ ₃ ₄	 25910 ₅ ₃ ₁	recognized correctly
 23910 ₃ ₄ ₃	 23910 ₃ ₄ ₂	recognized correctly
 25910 ₆ ₅ ₃	 23910 ₃ ₈ ₁	recognized incorrectly
 25910 ₈ ₇ ₂	 25910 ₈ ₇ ₁	recognized correctly
 25910 ₉ ₁ ₁	 25910 ₉ ₁ ₄	recognized correctly
 25910 ₉ ₅ ₄	 25910 ₉ ₂	recognized incorrectly
 25910 ₉ ₉ ₄	 25910 ₉ ₉ ₁	recognized correctly

4. Conclusion

Face recognition system using fisherface methods able to recognize the image of face testing correctly with 100% percentage for the test image the same as the training image and able to recognize the image of face testing correctly with 93% when the test image different from the training image. Face recognition with fisherface method not only capable of performing an introduction to the test face images with different color components of the training image and a sketch of the original image. This method is also immune to noise-induced images and the blurring effect on the image. As for most of the images that fail in recognition are caused by two factors, namely scaling factors and poses. To overcome the first factor, can be done by using better image scaling, while for the pose problem can be overcome by giving more training images with various poses

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