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Research of Face Recognition with Fisher Linear Discriminant

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Abstract. Face identification systems are developing rapidly, and these developments drive the advancement of biometric-based identification systems that have high accuracy. However, to develop a good face recognition system and to have high accuracy is something that's hard to find. Human faces have diverse expressions and attribute changes such as eyeglasses, mustache, beard and others. Fisher Linear Discriminant (FLD) is a class-specific method that distinguishes facial image images into classes and also creates distance between classes and intra classes so as to produce better classification.

1. Introduction

Technological developments are growing rapidly today especially in the field of information technology [1], various applications have been designed to seek information about one's self-data, one of which is the application of self-knowledge [2]. Facial recognition is one of the pattern recognition approaches for personal identification purposes in addition to other biometric approaches such as fingerprint recognition, signature, and retina of the eye and so on [2]. The recognition of the face image is related to an object that is never the same, because of the parts that can change [2] [3] [4]. These changes can be caused by facial expressions, shooting angles, or changes in accessories on the face. In this experiment, the same object with some of the differences must be identified as a single object [5].

Generally, facial recognition has several stages to identify the face of face detection, face alignment, feature extraction and also face matching [6]. Many methods are used in facial recognition applications, one of which is the Fisher Linear Discriminant method which is the basis of the Fisher face and the development of Principal Component Analysis (PCA) [2] [5] [7]. The Fisher Linear Discriminant (FLD) method is used to find the average face value of each class and to calculate the distribution matrix in the class and the spreading matrix between the classes and to find the optimal projection value of the image to obtain the face weights [5] [8]. The Fisher Linear Discriminant Method (FLD) is the most widely used method for pattern recognition. Fisher Linear Discriminant (FLD) is an example of a class-specific method, as it seeks to form the scatter between classes and intra classes so as to produce a better classification [9].

This paper conducted experiments to test the resemblance of the face with Fisher Linear Discriminant algorithm, the testing process is done gradually by showing the workings of Fisher Linear Discriminant in examining the similarity of the face and compare the image in the test so that the percentage of similarity of the face is known.

2. Fisher Linear Discriminant

Fisher Linear Discriminant (FLD), also known as Linear Discriminant Analysis (LDA) was discovered by Robert Fisher in 1936 for taxonomic classification and became one of the most widely used techniques in pattern recognition [3] [4] [6] [9]. FLD is an example of a class-specific method, and it is a well-known method for classifying class into class-and-class matrices of classes that could be taken for classification, as it seeks to form inter-class and intra-class scatterings so as to produce a ranking better [6] [9] [10]. Following steps do the calculation of Fisher Linear Discriminant (FLD) method:

a. Specify the number of classes and members of each class.

b. Establish the average value of the *training set (m)* and the average face value of each class (average class face, m_i), The formula as below

$$m = \frac{1}{N}\sum_{i=1}^{N} X_i \quad (1)$$

The formula calculation looks for the average value of each class:

$$m_i = \frac{1}{N_i}\sum_{j=1,x'j\in X_i}^{N} x_j' \quad (2)$$

c. Perform an inter-class matrix of inter-class (between-class scatter matrix, S_b) and in-class scatter-matrix, S_W matrices. By calculating the formula:

$$s_{W} = \sum_{i=1}^{C}\sum_{j=1,x_j'\in x_i}^{N_i} (x_j' - m_i)(x_j' - m_i)^T \quad (3)$$

$$S_B = \sum_{i=1}^{C} N_i\,(m_i - m)\,(m_i - m)^T \quad (4)$$

d. Find eigenvalue or W_{FLD} projection matrix with formula calculation:

$$W_{FLD} = \lambda \ and\ W_{FLD} = \frac{S_B}{S_W} = S_B.S_w^{-1} \quad (5)$$

e. Calculate the value of *eigenvector (w)* by the formula:

$$w = S_w^{-1}\,(m_1 - m_2) \quad (6)$$

f. Calculate the total scatter matrix to obtain the PCA projection matrix

$$S_T = \sum_{i=1}^{N}(m_i - m)(m_i - m)^{\boldsymbol{T}} \quad (7)$$

g. Calculate the optimal projection matrix W_{opt}^T

$$W_{opt}^T = W_{FLD}^T\, W_{PCA}^T \quad (8)$$

h. Calculate the weight value of each of the face images with the optimal projection matrix W_{opt}^T with the calculation of the formula.

$$F_i = X_i\, W_{opt}^T \quad (9)$$

Before performing face recognition with Euclidean Distance similarity calculation [11] [12], the facial image to be tested with the average value of training set with the formula calculation:

$$\Phi_{input} = X_{input} - m \quad (10)$$

After the normalization value of the test face image is obtained, then the further project is examined into the optimal projection matrix.

$$F_{test} = W_{opt}^{T}\, \Phi_{input} \tag{11}$$

3. Result and Discussion

The experiments were conducted by examining 3 (three) face images that have similarities, of the three face images compared and know which image has the highest similarity, the testing process is done by using Fisher Linear Discriminant algorithm with the stages that have been determined, for more details can be considered in the following process:

a. Grayscale Process and Threshold Image Training

The face image is changed from the RGB shape into the grayscale form and then turn into a black and white image by doing the threshold, and the result is as follows:

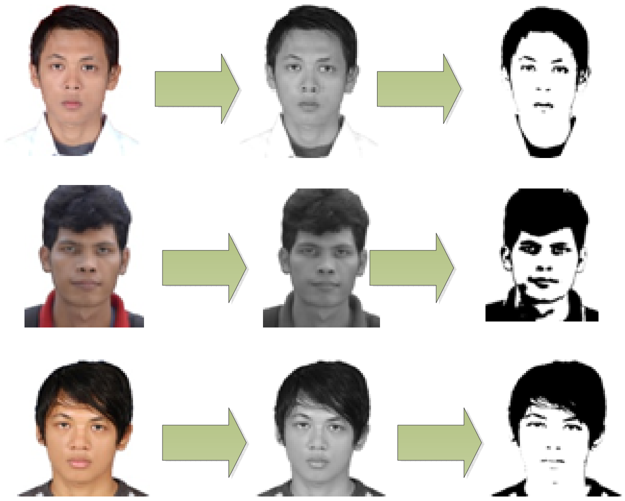
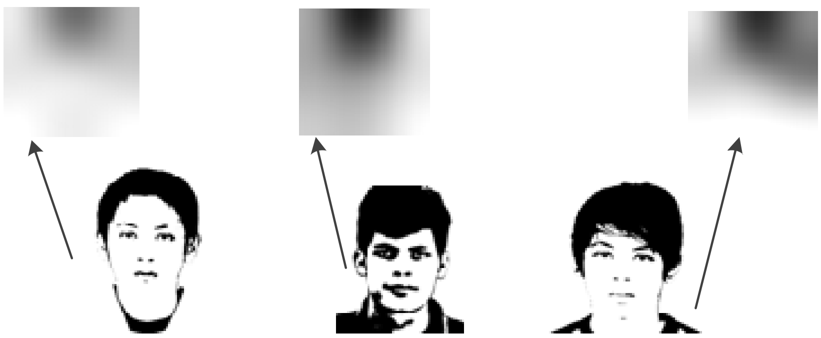


Figure 1. RGB Image Change to Grayscale and Threshold

Once the training image is formed in the threshold, three images can be obtained with a size of 3 x 3 pixels as can be seen in Figure below



$$\begin{bmatrix} 214 & 106 & 190 \\ 236 & 234 & 223 \\ 253 & 212 & 250 \end{bmatrix} \quad \begin{bmatrix} 139 & 0 & 127 \\ 196 & 174 & 209 \\ 117 & 153 & 178 \end{bmatrix} \quad \begin{bmatrix} 180 & 23 & 151 \\ 204 & 173 & 173 \\ 229 & 249 & 225 \end{bmatrix}$$

Figure 2. Image Training Results Threshold

b. Fisher Linear Discriminant Calculation

The use of the formula from steps 1-8 will be tested by the formula already described previously with the pixel value contained in FIG. 2, the result of the testing process using the Fisher Linear Discriminant method and the Euclidean distance to recognize the face can be seen in the following tables:

Table 1. Weight Training Image Value

Face of	j	$F_{j,1}$	$F_{j,2}$	$F_{j,3}$	$F_{j,4}$	$F_{j,5}$
1	1	-185.072	-189.196	-172.310	-238.204	-259.480
	2	-104.195	-96.621	-83.608	-201.076	-214.892
2	3	-135.977	-130.039	-114.449	-191.628	-206.433
		$F_{j,6}$	$F_{j,7}$	$F_{j,8}$	$F_{j,1}$	$F_{j,6}$
1		-242.412	-249.451	-266.149	-247.350	-243.412
		-199.871	-151.034	-164.574	-154.433	-199.871
2		-192.679	-239.666	-263.224	-247.824	-192.679

Table 2. Different Squares of Each Image Training of Imagery Test

j	$(F_{j,1} - F_{uji,1})^2$	$(F_{j,2} - F_{uji,2})^2$	$(F_{j,3} - F_{uji,3})^2$	$(F_{j,4} - F_{uji,4})^2$	$(F_{j,5} - F_{uji,5})^2$
1	$((-185.072)-(20.32))^2$	$((-189.196)-(35.52))^2$	$((-172.310)-(13.98))^2$	$((-238.204)-(13.79))^2$	$((-259.480)-(34.76))^2$
2	$((-104.195)-(20.32))^2$	$((-96.621)-(35.52))^2$	$((-83.608)-(13.98))^2$	$((-201.076)-(13.79))^2$	$((-214.892)-(34.76))^2$
3	$((-135.997)-(20.32))^2$	$((-130.039)-(35.52))^2$	$((-114.449)-(13.98))^2$	$((-191.628)-(13.79))^2$	$((-206.433)-(34.76))^2$
j	$(F_{j,6} - F_{uji,6})^2$	$(F_{j,7} - F_{uji,7})^2$	$(F_{j,8} - F_{uji,8})^2$	$(F_{j,9} - F_{uji,9})^2$	$(F_{j,6} - F_{uji,6})^2$
1	$((-243.412)-(21.86))^2$	$((-249.451)-(16.39))^2$	$((-266.149)-(27.43))^2$	$((-248.350)-(9.86))^2$	$((-243.412)-(21.86))^2$
2	$((-199.871)-(21.86))^2$	$((-151.034)-(16.39))^2$	$((-164.574)-(27.43))^2$	$((-154.433)-(9.86))^2$	$((-199.871)-(21.86))^2$
3	$((-192.679)-(21.86))^2$	$((-239.666)-(16.39))^2$	$((-263.224)-(27.43))^2$	$((-247.824)-(9.86))^2$	$((-192.679)-(21.86))^2$

Table 3. Sum of Squares of Each Image of Training on Test Image

j	$(F_{j,1} - F_{uji,1})^2$	$(F_{j,2} - F_{uji,2})^2$	$(F_{j,3} - F_{uji,3})^2$	$(F_{j,4} - F_{uji,4})^2$	$(F_{j,5} - F_{uji,5})^2$
1	42187.51	49161.26	34705.86	63503.49	86852.47
2	15505.57	17463.19	9524.41	46169.54	62330.6
3	24430.75	27412.23	16495.31	42198.60	58178.40
j	$(F_{j,6} - F_{uji,6})^2$	$(F_{j,7} - F_{uji,7})^2$	$(F_{j,8} - F_{uji,8})^2$	$(F_{j,9} - F_{uji,9})^2$	Sum Result $(F_{j,i} - F_{uji,i})^2$
1	65677.84	70674.14	86191.62	66158.21	565112.4
2	49166.80	28032.50	36867.49	26992.97	292053.08
	49166,80	28032,50	36867,49	26992,97	292053,08
3	46029.08	65567.28	84482.71	66402.28	431196.64

Table 4. Final Result Calculation of Euclidean Distance Similarity

Face -	j	Sum Results $(F_{j,i} - F_{test,i})^2$	$d_v = \sum_{j=1}^{m} \lVert F_{train\ of\ j,w} - F_{test,w} \rVert$	Result
1	1	565112.4	751.7396	
	2	292053.08	540.4193	**Minimal**
2	3	431196.64	656.6556	

Table 4 generates a minimum value of 540.41935. The value lies on the 2nd face so that the face recognition tests have similarities on the 2nd object. The output of this facial recognition process is a recognizable facial image.

4. Conclusion

Based on the discussions and evaluations that have been done on facial recognition application using Fisher Linear Discriminant (FLD) method, it is concluded that the application of Fisher Linear Discriminant (FLD) method in face recognition has high accuracy because this method divides class specifically and face recognition application with Fisher Linear Discriminant (FLD) method is able to recognize faces with various expressions are also able to recognize the face with attribute changes such as glasses, whiskers, and others.

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