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Page 144 - 152 Tameem. H

Face Recognition By Using Nearest Feature Midpoint Algorithm

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Abstract:
Good facial recognition system is a system which can handle variation that arise when making a face image. These variation can include facial expressions, accessories that are used, the level of illumination and direction of image acquisition. Variation will be captured by the virtual lines are made of at least two prototypes in a class. The virtual line will generalize the variation that may occur on the second prototype. Face identification process will be done by finding the shortest distance between the face that will be recognized by all the Variation result of extrapolation and interpolation prototype in each class. Implementation of this method can achieve accuracy rates of more than 90% to the execution time of 0.5 seconds under optimal condition.

Keywords: midpoint, face recognition, nearest feature ,midpoint algorithm, Feature Line, Feature Midpoint

1. Introduction

Face recognition is one of the areas of study in pattern recognition that is always expanding. The reliability of a method can be seen from the calculation process with minimal cost and calculating results with a relatively small error rate. A reliable face recognition systems must be able to work and be able to handle the input face image with variation especially in the angles, expressions, lighting of images as input. Of the three Variation, Variation of the same faces in the lighting and viewpoint at the time of image acquisition is usually much larger than the same facial expression[6].

Nearest Feature Midpoint (NFM) is one of the methods in face recognition which can be described as an improved technique for face recognition by Nearest Feature Line (NFL) [1]. It is expected to be built using this method a face recognition application that is relatively better than the NFL method.

In general, the classification using the NFL and NFM is done by finding the minimum distance between feature points on the face to be recognized (query) with all the features of the existing lines [1]. Feature line is a virtual line connecting the

two prototypes in a class (one person) while the feature midpoint is the midpoint between the two prototype in the same class. Thus, the treasury will face propagated by extrapolation or interpolation feature points in each feature line in the feature space [2,5].

To do this line feature based classification as a former image characterization, we will be used method of formation Eigen face (EF). In common with forming EF space, the dimensions of which is less significant in the face of the image will be reduced leaving only important dimension only. Formation EF space is not separated from the use of "Principal Component Analysis (PCA)" as a means of reducing the dimension[7,8].

2. Principal Component Analysis and Eigen face(EF)

Principal Component Analysis (PCA) is a method for identifying patterns in a set of data for later expressed, these data so that could be seen the differences and similarities between these data. The advantage of the PCA is to shrink the size of data by reducing the dimensionality of the data without eliminating important information from the data set is so often used in image compression [3].

Steps for using PCA as follows:

(a) .Obtaining the data set:

The data will be input PCA could be numerical data any which have been compiled into vectors of data with the dimension of a number of elements in a vector. On the formation of EF, these data form the image of a face with a number of dimension equal to the number of pixels in the image.

(b) . Normalization the data:

Normalization of data is done by finding the average of the data vector, and then subtracting the average vector on the set of initial data Dα (Eq. 1).

$D\alpha = D\alpha - avg(D\alpha)$ …….……(1)

(c) . Calculate the covariance matrix:

C^{min} covariance matrix is needed to measure the value of connectedness between dimension on a set of data. Covariance matrix obtained by searching the covariance value for each dimension of all dimensions in the set of data in equation (2).

$C^{min} = (c_{ij} = cov(Dim_i, Dim_j))$…….……(2)

(d) .Eigen vector(Evec) and Eigen value(Eval):

Briefly, Evec x of a matrix A is a specialized vector that has properties in equation $A_x = \lambda_x$ with λ is the Eval of x. Covariance matrix of size N x N will get an N (Evec and Eva)l. Optimization calculation performed by searching Evec of matrix $T = A^T$ x A Or do M x M [4]. Optimization greatly affect the complexity of the calculation because usually M << N [1].

(e) .Choose the main component of data:

This process is done by sorting the Evec accordance with Eval from the largest to the smallest. Thus obtained Evec set of ordered by the level of strength of connection between dimension. From here, specify that represent the largest Evec P data.

Evec P will be selected and then separated to form the feature vector are vectors that are used to represent data. These vectors were collected in the matrix as columns in the matrix (Equation (3)).

Feature Vector = $(eig_1, eig_2, \ldots eig_P)$ … (3)

In the process of face recognition, Evecs are called as EF. From the experiment ,it was found that the use of 10 EF with largest Eval, the face recognition reaches a value of error is acceptable.

(f) . Establish a set of new data:

The set of new data obtained from the feature vector multiplication. i.e multiplying the feature vectors transpose (the feature vector into a row vector) to transpose the original data is data that has been normalized (Equation (4)).

$Newdata = FeatureVector^T$ x $DataAdjusted^T$ ……..…….(4)

Operation in equation (4) produces transpose of original data projected into the selected feature vector. In the face recognition system, this operation will generate images of origin faces which have been changed due to reduction in dimensions (information) [7].

3. Nearest Feature Line (NFL)

NFL classification algorithm[2] assumed for each class are at least two different prototype. Therefore there are two different members in each class. The next prototype will be referred to as a point. NFL method using a linear model to interpolate and extrapolate from a point of each pair of the same class. From this second point, a line representation capacity to generalize the second point. Line connecting two points in the same class is called the Feature Line [1, 2].

Virtually line will feature provides a points feature unlimited class so that the capacity of the set point in a class prototype will increase. For a Class c with a total membership of $N_c > 1$ will be formed $K_c = N_c (N_c - 1) / 2$ line that can be used as a representation of the class. Suppose for five prototype in a class, then the class representation can be propagated to 10, the number of line feature that can be built. The total number of M line feature class that will be used in the NFL is shown in equation (5)[2].

$$N_{total} = \sum_{c=1}^{M} K_c \quad \text{.....(5)}$$

If implemented on a face image, the changes between the two points can be Variation in the position of the face, lighting and expression when capturing image. The classification process in the NFL is done by calculating the minimum distance between the point feature being tested to the feature line. The result of the classification will also provide the relative position of the point feature that was tested against two of the nearest point in forming a line feature class.

4. Feature line distance

Suppose that there are variation in the face of z_1 to z_2 in image space along with variation that arise therefore in feature space (EF space) from x_1 to x_2. Large of the change can be calculated as $\delta_z = \| z_2 - z_1 \|$ or $\delta_x = \| x_2 - x_1 \|$. When $\delta_z \rightarrow 0$ then $\delta_x \rightarrow 0$. Any change in position x due to change in the variation point can be predicted fairly well using a straight line that runs between x_1 and x_2. So for any change in the variation between the two points can be done interpolating a point on the line. This also applies to the change that were located outside of the line x_1 and x_2.

In this case the linear model will extrapolate the position of the change to the line feature.

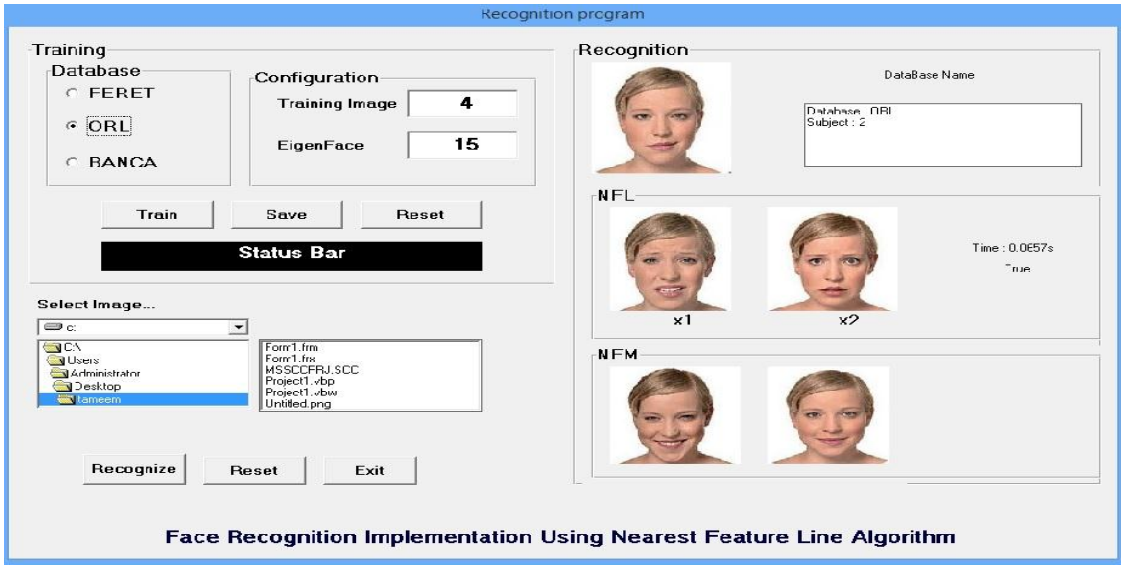

Fig.1. Implementation test.

A straight line passing through x_1 and x_2 in the same class called feature line of the class. Feature point x tested will be projected on the feature line at the point p. The distance between the line feature and x is defined in equation (6) with ||a|| is the value of the length of the vector a. Then the projection point p is calculated by equation (7) with parameters $\mu \in R$ indicates the position of the point p on the line from x_1 feature. μ value can be obtained from the value of x, x_1 or x_2.

Notes: notation feature line on x_1 and x_2 are: $\overline{x1x2}$

$$d\left(x,\overline{x_1x_2}\right)=\|x-p\| \quad \text{.....(6)}$$

$$p=x_1+\mu\left(x_2-x_1\right) \quad \text{.....(7)}$$

Equation (8) is formed as an upright condition:

$$\left(p-x\right)\cdot\left(x_2-x_1\right)=0$$

$$\left(x_1+\mu\left(x_2-x_1\right)-x\right)\cdot\left(x_2-x_1\right)=0$$

$$\mu=\frac{\left(x-x_1\right)\cdot\left(x_2-x_1\right)}{\left(x_2-x_1\right)\cdot\left(x_2-x_1\right)} \quad \text{.....(8)}$$

The notation "." is a symbol for the dot product operation. μ parameter indicates the position relative to x_1 and x_2. Some of the possible value of μ: (1) $\mu = 0$ then $p = x_1$, (2) $\mu = 1$, $p = x_2$, (3) $0 < \mu < 1$ then p is a point interpolation between x_1 and x_2, (4) $\mu > 1$ then p is extrapolated forward on the side of x_2, and (5) $\mu < 0$ then p is extrapolated backwards on the side of x_1.

Change variation between two points in a class can be predicted well by line features for its ability to interpolate the position parameter change.

5. Classification Based NFL

NFL based classification is done by looking for the nearest feature line distance between x and all lines possible feature. Suppose and are two prototype that will be tested. N_{Total} classification process produces a line spacing of the features and attributes are then sorted ascending class, the points that form the line features and μ. Distance NFL is the first order of distance line features that have been sequenced (see equation (9)).

$$d\left(x,\overline{x_i^{c^*}x_j^{c^*}}\right)=\min_{1\le c\le M}\min_{1\le i<j\le N_c} d\left(x,\overline{x_i^c x_j^c}\right) \quad \text{...(9)}$$

The first order of distance line feature gives the classification results NFL consists of classes that are very suitable and two prototype c*i * and j* which is very similar to the prototype test prototype. Position parameter μ* shows the position of a point relative to the projection p:

$$x_{i^*}^{c^*} \quad x_{j^*}^{c^*}$$

6. Nearest Feature Midpoint (NFM)

NFM is a classification method which is an improvement of the NFL. NFM assumes at least there will be two different prototypes in a class. In the NFM a sub feature space is formed for each class of the midpoint of the feature (feature midpoint) between each two prototype in the same class, x_1 and x_2, and denoted as m_{x1x2}. Prototype in the same class will be generalized by the midpoint of the feature to represent Variation from class, and then classifier generalization ability will also increase. Distance NFM is Euclidean smallest distance between the object being tested with all the midpoint of which may be built.

All points on the line feature between x_1 and x_2 can be expressed as $x_1 + \lambda (x_2 - x_1)$ with $-\infty < \lambda < 0$. When $\lambda = 0.5$ then $m_{x1x2} = 0.5 (x_1 + x_2)$ is the midpoint of the feature of the line features. Equation (10) is the midpoint of the distance between the feature point feature being tested x and m_{x1x2} with ||. || means the search operation vector length.

$$d\left(x,m_{x_1x_2}\right)=\left\|x-m_{x_1x_2}\right\| \quad \text{..... (10)}$$

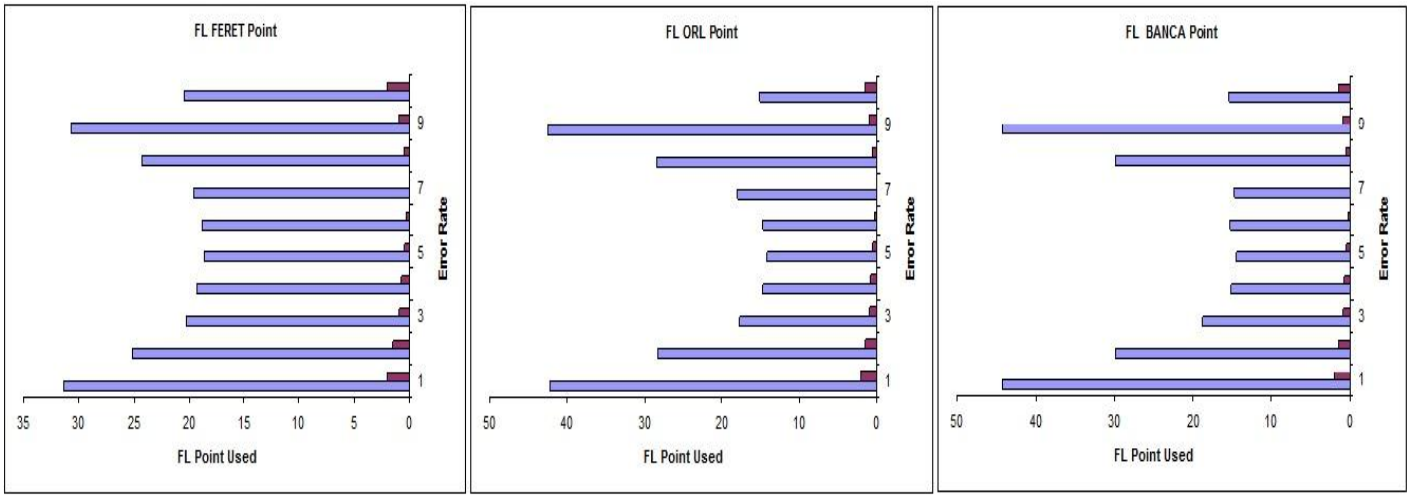

Fig. 2. Graph error rate varied use of projection points.

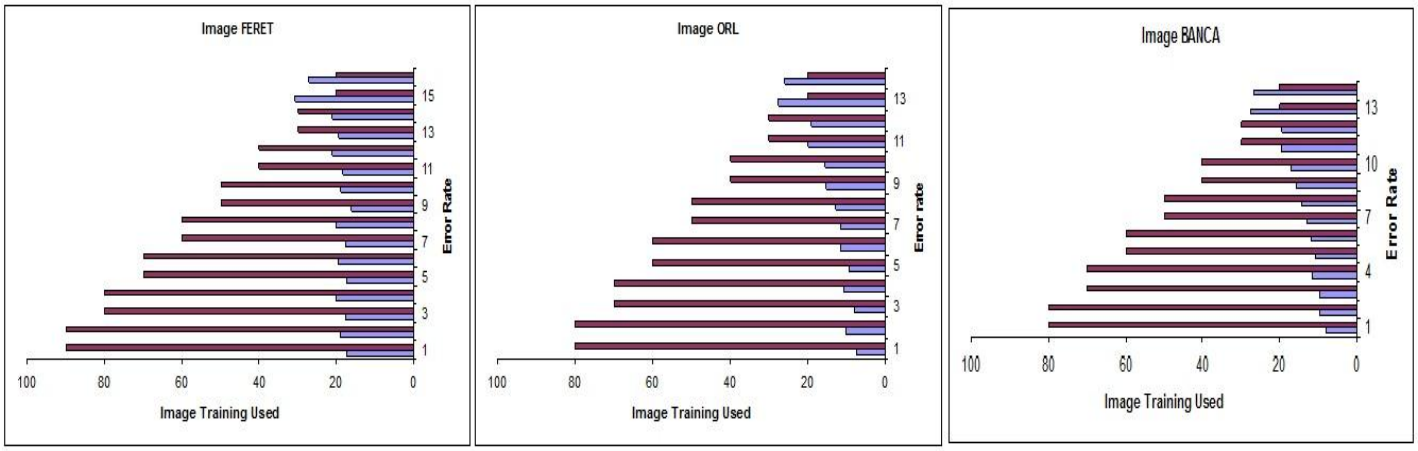

Fig. 3. Graph relations EF use number with an average error rate.

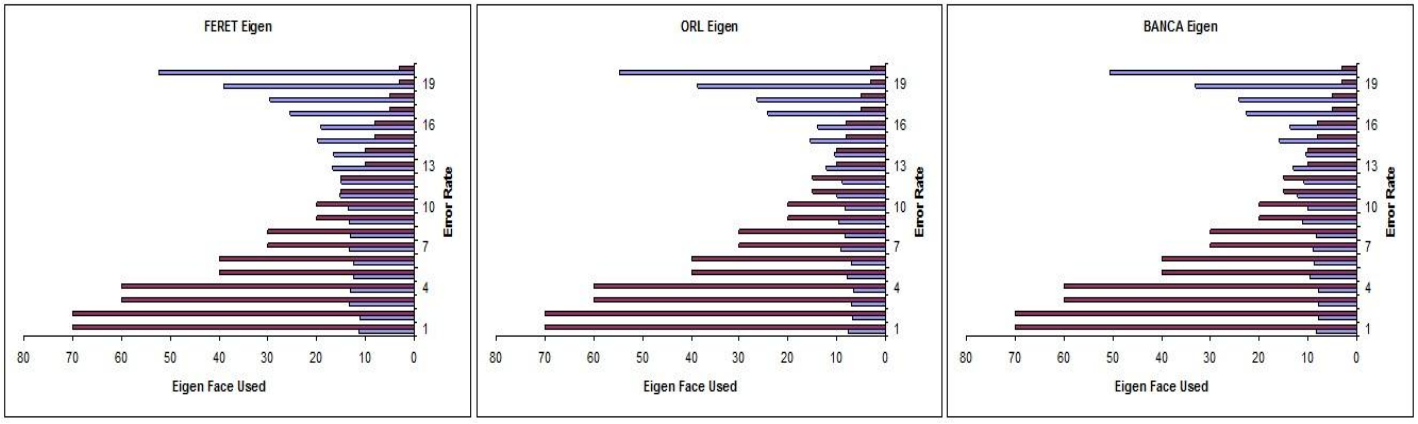

Fig. 4. Graph relations practice the number of images used by the error rate.

\For a Class C with a total membership of $N_c > 1$ will be formed $K_c = N_c (N_c - 1) / 2$ midpoint that can be used as a representation of the class. Same with the NFL, the total amount of the midpoint of the class M formed shown in equation (9) as well as the classification process is done by calculating the minimum distance between the points of the features tested and distance midpoint.

Distance midpoint will be sorted in ascending such a classification with the NFL in equation (11) below:

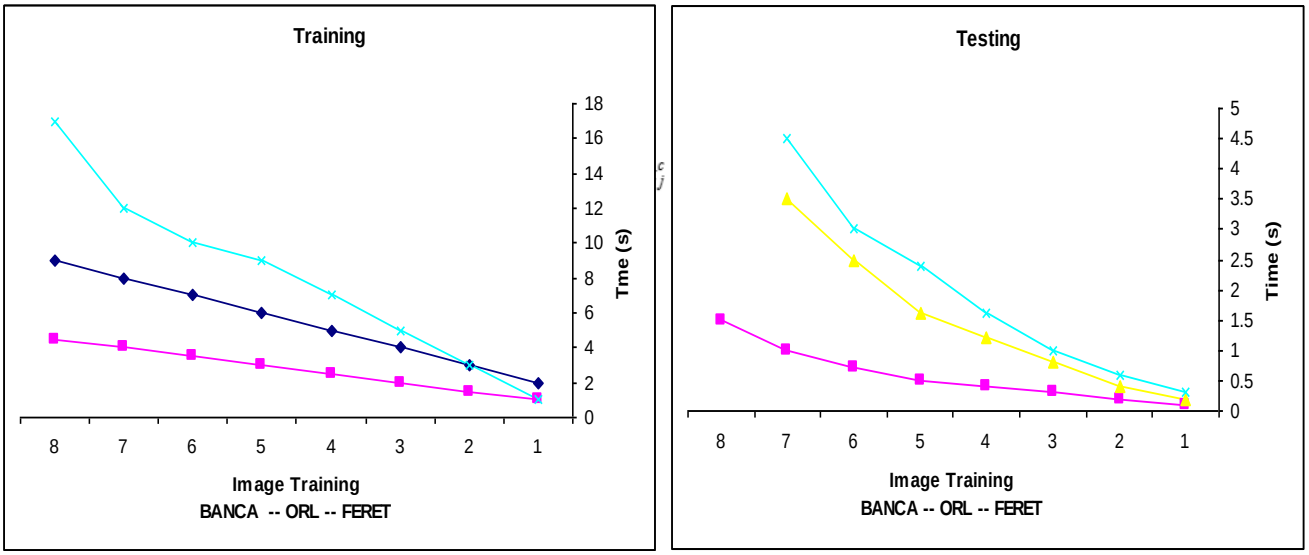

Fig. 5. The relationship between of the imagery training and execution time in the training process.

If the size of the population did not approach the infinite expected value of the population is the mean value. Analogous to determination of the test image projection points on the line feature, the projection points on the process of recognition will approach the midpoint of the line features. Assuming that the dimension of the face very much. Therefore, at the midpoint based classification NFL and NFM will have the same relative degree of accuracy. The midpoint of the NFM is used as a measuring point distance.

7. Implementation and Analysis of Results

The software is implemented in the following environments: Windows 7 and using visual basic ver 6.

The test is done with two steps to get optimal results.

(1) Obtain the optimal configuration of the face recognition system and to compare the performance of the method- NFL and NFM.

The database used in the test are: database FERET[1] (20 subjects, 8 images per subject), ORL (30 subjects, 8 images per subject), and BANCA[2] (20 subjects, 8 images per subject). The database FERET has the characteristics of their relatively small changes in facial expression as well as changes in the position of the head towards the left, right, up and down by 30 degrees. Imagery used beforehand will normalization by reduction in size of the original image (cropping) is the image size 63 x 90. The subjects vary with gender, facial expression, lighting and accessories faces (e.g. goggles) to the data BANCA. Imagery used will first be normalized by performing reduction in size of the original

image to a size of 65 x 89. While the data ORL, subject varies with the orientation of the face

and slight Variation in facial expression. Imagery used will first be normalized by performing reduction in size of the original image to size of 90 x 115.

Step 1.
The process of facial recognition done to try all possible configurations. Doing looping to obtain representative results as much as 10 times. Configuration is intended is:

(1) .The projection of the tested point μ = -1.0, μ = -0.5, μ = 0, μ = 0:25, μ = 0.5 (NFM), μ = 0.75, μ = 1.0, μ = 1.5, μ = 2.0, and uses NFL method (counting parameter μ).
(2) .The number of training images starting from two images (the requirements of establishing FL) until the number of images per class - 2 (as the test images).

Table 1. The accuracy of the testing of step 2

Observation		Database			Mean (%)
		FERET	ORL	BANCA	
Time (s)	NFL	0,300	0.783	0.172	0.4210
	NFM	0.130	0.3482	0.077	0.1855
	Improvement	41.315	42.494	44.002	42.938
Accuracy (%)	NFL	90.429	93.05	87.155	91.545
	NFM	90.386	92.98	86.733	90.033
	Improvement	98.859	98.862	100.67	99.464

(3) Total EF tested = 2, 4, 7, 15, 20, 25, 30, 40, 60 and 70.

For observation of the point of projection in Figure 1 shows the use of FP6 (at point 0.75 * FL), FP5 (NFM), FP4 (at point 11:25 * FL) and NFL (search result parameter image projection test on FL) obtained an error rate of less than 19 %. For the record, FL is a feature point or line features.

It appears from the graph in Figure 2 that for all databases and projections point to the test images FL average error will be smaller with increasing EF used. It also appears that the increase accuracy in the use of at least fifteen EF insignificant. In Figure 3 it appears that the use of imagery training effect on the level of accuracy. Reduced error values in parallel with the increase in training image is used. However, this effect is less significant after the use of at least five training image. While Figure 3 shows that the execution time for training will increase along with increasing training image is used. The phenomenon is also true for the test execution time.

step 2.

Test on two step performed using only the optimal configuration and looping 40 times. From the testing obtained the percentage level of accuracy shown in Table1 To ensure the different level of accuracy and execution time methods of NFL and NFM, the result of accuracy and execution time of these two method will be tested by t-test. Assumed a sample size of less than 28, normally distributed population and consist of two independent samples and paired. Test done at the level of the mean of 0:05 or confidence interval 95% with the application of SPSS v.10.

From the result of the analysis showed that to the hypothesis H0: the average accuracy of the two methods are identical, $t_{count} = 0.028 < t_{(11,0.025)} = 1.80$ with df (degree of freedom) n-1 = 11 and 0025 is half that of α (0.05) = 0.025.

Due t_{count} (0028) < t_{table} (1.80) H0 is accepted that the average accuracy of the

statement method same is true. The decision could also be taken with see significant value Sig. (2-tailed) = 0978> half α = 0.025, H0 is accepted.

H1 test analysis: the average time of the two methods are identical generate value t_{count} = 2,617 > $t_{(11,0.025)}$ = 1.80. Because t_{count} (2617) > t_{table} (1.80) then H1 rejected that statement execution time averaging two methods together is wrong. Due also value Sig. (2-tailed) = 0.016 <half α = 0.025, then H1 is rejected. Based on the analysis proved that H0 and H1 NFM improve execution time of the algorithm NFL.

6. Conclusions

It is possible to distinguish the face by "Nearest Feature Line" technique which depends on the selection of a mid-point which is possible through the characteristics introduced by NFM and NFL. An increment in execution rate by about 42.93% and an accepted accuracy ratio as well in face recognition. The result namely was (91.545%, 90.033% for the NFL and for NFM) i.e. they were close to each other, notably that:

a. The projection point is selected such that to be tested using (FL (NFL)), and the mid-point FL (NFM).
b. The least number for EF is selected as 10.
c. Five faces at least are chosen to examine the required accuracy and speed.

But both methods depend on the input image, where if the differences are large, the result accuracy will be highly affected. This can be treated by a primary treatment on the image such as resizing.

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تمييز الوجه بواسطة استخدام خوارزمية خاصية اقرب نقطة وسطية

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المستخلص :

نظام تمييز الوجه الجيد هو ذلك النظام الذي يتعامل مع التغيير الناشئ من عمل صورة للوجه. تلك التغييرات يمكن ان تشمل التعابير ،الملحقات المستخدمة ، مستوى الاضاءة واتجاه اخذ الصورة .يمكن تحديد التغييرات بخطوط افتراضية لنموذجين حقيقين على الاقل لكل صنف.ستُعمم الخطوط الافتراضية التغيير الذي يمكن ان يحصل على النموذج الحقيقي الثاني وتتم عملية تمييز الوجه بايجاد اقصر مسافة بين الوجه الذي سيمكن تمييزه بواسطة التغييرات الناتجة من التقريب والاستنتاج في كل صنف. كما ان تنفيذ هذه الطريقة يمكن ان يحقق معدلات دقة لاكثر من 90% وبوقت تنفيذ مقداره 0.5 ثانية في افضل حالة .