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ORIGINAL ARTICLE

Face Recognition Using Eigenfaces: Effect of the Different SVM Core Functions

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ABSTRACT
This study has been established based on the combination of the Principal Component Analysis, eigenface and the support vector machines. Due to the categorization of pictures into two training and test pictures sectionsby using algorithm analysis of Principal Component, the feature extraction is achieved in this study. The extracted training and test pictures feature vectors is entered into the feature vector for categorization. In order to evaluate the test pictures, the ORL database has been applied in this study. The obtained results of these test pictures showed that if we want to consider only the increase of the system recovery, the MLP core function will be only suitable response in this regard but if the both rate and number parameters are considered, the face recovery system with the radial function will be applied due to its better functions and performance than other core functions.
Key words: *Face Recognition, eigenfeatures, eigenfaces, Multi-Layer Perceptron (MLP), Support Vector Machines(SVM), Principal Component Analysis(PCA), Radial Basis Function(RBF)*

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INTRODUCTION

One of the most important issues being considerably studied in the recent years, is subjected to the recognition of the face. The face recognition is an action that the human beings frequently achieve it in their daily life affairs continually with the highest rate. The main tendency towards the related applied study is subjected to the increasingly requirement of the commercial markets and the increase of the personal computers (PCs) and cheap domestic appliances.

The fingerprint, sound and face are the main features that they have been applied to recognize the human being identity [1].

Heimeyer has introduced six main biometric features that have been adapted in the MRTD systems along with the face features. The face recognition conceptualization categorization can be achieved by two possible ways as following:

- The verification of face as a one to one comparison comparing the related face along with a picturesque framework that has been recognized and registered before in this case.
- The face recognition that has been achieved by one or several adaptation process seeking the face picturesque in the pictures base.

It is necessary to find only one similar face in some conditions. The process of seeking can be achieved in the picture base allocating a special score to every frame in this case. All these scores will be categorized and the highest score is established in the first ranking as the most similar picture. But when we require higher case than similar pictures, a threshold level will be defined for the system and the whole pictures of the face will be reported according to their scores in the same threshold level [2].

The extraction ways of the face features can be categorized into three general groups as following:

- The appearance features of a face such as eyebrows, nose, eyes and other parts of the face have been organized in a face. There are many various limitations in the extraction of these features
- The obligatory features that every picture is shown as a matrix that many various algebraic operations and mathematic equations can also be done on them One of the most important

operations that can be fulfilled on the related matrix is subjected to the principal component analysis of PCA as the most essential method for Algebraic extraction regarding to the appearance picture.

- The dot statistical specification is used to explain the picture. Due to the two- dimensionality of the used pictures,the picture dots are used as the statistical data. In this method, the high power features are used to explain the picture sufficiently and it will be considered as the most complete and comprehensive method for explaining a picture potentially. The extracted features will be also saved as vector and when these vectors have more dimensions, the data reduction case will be done to make and facilitate the classification and categorization process [3].

By displaying the man's appearance the picture matrix will be obtained along with the same lines of the matrix and the picture will be also considered in a higher spatial dimension. Due to the similar features of the appearances and faces, it can be concluded that the feature vectors have been established in the lower spatial dimensions. By considering the face towards the sub-space of these pictures, a new establishment can be obtained that every face is defined by the help of these regular basis vectors. Indeed, every picture is a linear combination of these pictures. The coefficient of this linear combination is applied as the feature vector [4].

In this method, a two-dimensional face picture with $n \times m$ dimension is transformed into $p=nm$one-dimensional long line of columnar vector element. In other words, the same picture can be imagined as a dot in nm space.

The main purpose of PCA is to find the vectors that can achieve the best way of recognition in the sub-space location. These vectors define the face space[4].

PCA algorithm is used in order to reduce the dimensions of the related data. In continue, section 2 reviews the algorithm PCA; section 3 introduces support vector machine (SVM). In section 4, we will introduce ORL picture data and in Section 5 and Section 6 concludes simulation is proposed.

MATERIALS AND METHODS

Principal Component Analysis

In a collection of the information, it is considered as the main recognition patterns and methods being applied in the dimension reduction stating the similarities and differences based on their own main communicative elements. The main element analysis is a powerful tool for analyzing the data. By the reduction of the number of dimensions without losing the main volume, it will find the pattern saving the related data. The main purpose of the related algorithm is to summarize the data taking them in the process of saving and compacting issues [5].

Principal Component Analysis in the face recognition:

The main idea of the principal component analysis has been suggested by Trek and Pant land in 1991 [6] the main regular basis of the Pantland suggestion is to use the PCA for defining and describing the face features by Kirby and Sirovich [7]. This method has been also applied to reduce the dimension and extraction feature to be able to interact with the sub-spatial vectors. This makes a better display for the data distribution. This sub-space is called the face space when it appears on the face data. After specifying the vectors, the whole pictures will be transferred into the sub-space representing the same sub-space. By comparing the recent weighs similarities with the new picture weigh, it can specify the entered picture[8].

Eigenface methodology:

This method has been suggested by Pantland for continuing the studies in relation to recognize the face [9] making the data independent to the extent possible and this can be obtained by interacting the whole vertical vectors and PCA will be applied here. Indeed, the Eigenface uses the PCA Algorithm filtration for compacting its information; in other words, it finds firstly the covariance matrix feature vectors using these vectors for transferring the information and finally it achieves the reduced dimentional space for fulfilling the recognition process through its neighbor.

The eigen extraction of the PCA:

The first phase of the eigen extraction is subjected to the person's face features in every face recognition system. The suggestive algorithm is subjected to PCA in this thesis. The extracted features of the pictures in one space with the higher dimensions are the most essential cases increasing the calculation complexities in every categorization phase. On the other hand, this can reduce the rate and performance of the categorizing system. The main reason is subjected to the distribution of the feature vectors in a space with higher dimension. To prevent the related problem, it is necessary to write a sub-space with lower dimension before categorizing along with a suitable method of feature with a sub–space higer

dimensional vector or eigen vector. For achieving this, PCA linear separator will be utilized potentially [10].

Calculation of eigen face:

Every picture is considered as two-dimensional matrix$T$. In this method,in fact every $T_i$is a picture with $n\times m$ dimension which is transferred into $P = nm$; in other words, we consider a picture as a column vector with $P\times1$ element *such as*$T^i = (T_1^i ..... T_P^i)^T$.The obtained vectors make the columns of matrix Arespectively. The dimensions of this matrix is$M\times$P that M is related to the number of the pictures. In the next phase, the total average of faces will be obtained as following:

$$=\frac{1}{M}\sum_{n=1}^{M} T_{n(1)}\Psi$$

We will subtract the total average of and save these vectors into a matrix. Indeed, the data will be transferred into the zero centers. By doing this, the mean of the faces will also be zero getting ready for calculating the basic elements[4].

$\Phi_i = T_i - \Psi$ *For* $i=1,2,..... M$ (2)

The covariance matrix will be measured for the new matrix that it will be also obtained by the multiply of the transpose matrix A into itself.

$C = A^T A$ (3)

Note that $(\Phi_i)s$ make the columns of thematrix A

$A=\{\Phi_1, \Phi_2, \Phi_3,....., \Phi_i\}$ *For* $i=1,2,..... M$ (4)

The covariance matrix, eigenvectors and eigenvalues are obtained using the following equation:

$CV' = \lambda' V'$ (5)

V' refers to eigen vectors and$\lambda'$to eigen values.

The eigenvector matrix is the same vertical vectors that compose the sub-space feature transferring the data into these sub-spaces in order to be independent [11].

The eigen features can be applied to describe the human's face features [4] that can also be obtained by the following equation:

V = A.V'(6)

In the next phase,the eigenvalues and eigenvectors should be arranged from the big towards small. We ignore vectors with small changes, because most of the changes are done to the special value, and gradually move on to the smaller eign values to reach the less cattering vectors. Byinnear product V^T into matrix A, the data matrix will be transferred into a new sub-space.

$A_{project} = V^T.A$(7)

Picturesin thenew spaces are defined by a matrix $A_{project}$. The new matrix is the basis for comparison.

Support Vector Machine(SVM):

The support vector machine is a training algorithm for learning the categorization and regulation of the regression from the related data. This algorithm has been suggested by Vapnik Vladimir in 1965s [12] as the most famous trainees' categorization ,a Russian researcher, [13] and has been also recovered by Vapnik and Corinna Cortes in 1995 for the nonlinear mood [14] coming from the Statistical Learning Theory being organized and arranged on the operational risk minimization process. This method is one of the most fairly newest approaches that has been innovated in the recent years in comparison to the traditional methods such as Perceptron Neural Nets [15]. The support vector machines take in to consideration the operational risk as the aim variable and calculate the optimized value. The main purpose of the support vector machine is to obtain the function F(x) as a determinant of the hyper-sheet. There have been many various hyper-sheets that are able to separate the data. But the main question is what hyper-sheet to choose? The training concept of the pictures being categorized into the higher dimensions in a one space is not unique. The main distinction of the related algorithm is subjected to the selection this hyper-sheet.

Figure 1 shows the best way of choosing the separative.

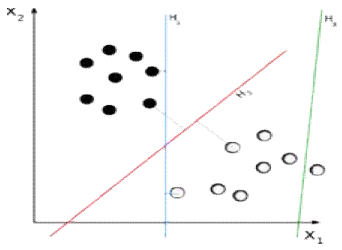

Figure 1: Way of the best separator [14]

As it is shown in figure 1, there have been established some separator to categorize the related data in this case. But due to the figure, the separators *H3* has not separated the two categories correctly. The separators *H1* and *H2* have achieved the best separation but if one case of data is measured again being established out of the separator *H1*, it will be specified that the separation has not been achieved efficiently, but the separator *H2* has categorized the task correctly. Indeed, the difference between *H1* and *H2* is correct in the operational risk or the lack of categorization risk. In the support vector machine the main purpose is subjected to maximize the margins of the two classes. Thus, a hyper-sheet should be selected whose distance from the nearest data in both sides of linear separators is maximum. If we reach such a hyper-sheet, it will be introduced as the maximum margin separator [16]. Figure 2 shows the related explanation and description.

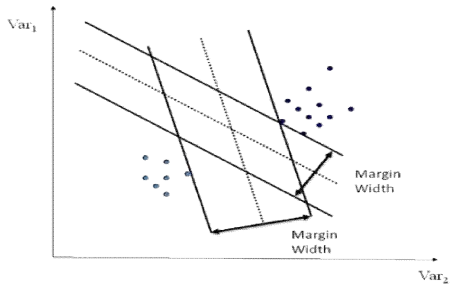

Figure 2:Shows the selection of the maximum hyper-sheet [14]

In order to separate the data, two territorial sheets which are in parallel with separation sheet, must be drawn and then made away from each other to the extent that theycontact the related data; this makes the appearance of the maximum margin. The best separator is a sheet that has the highest distance from the territorial sheets. The nearest training samples to the separator hyper-sheet are called the support vectors so that they compose the classes' territories.

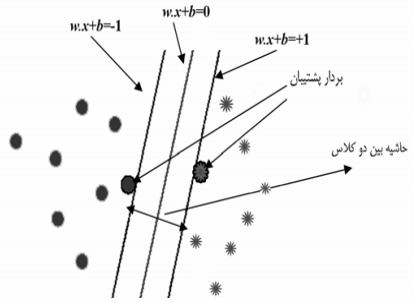

Figure 3: Optimized hyper-sheet for showing two complete separate cases [17]

The decision-making function for categorizing the data is determined with the support vectors and the use of these support vectors instead of the whole data can lead this algorithm to compact the related data. The linear support vector machine is also used as a rapid and accurate categorizing machin for seeking the face in a two-dimensional space [18].

ORL Face database:

This database has been gathered from 1992 to 1994 in AT & T laboratory [19] and it can be stated that it is one of the most applied face databases for the face recognition algorithms. This database includes 400 different pictures of 40 persons from each 10 pictures have been taken. Photographing process has been carried out in different lightening conditions in different time periods. There have been established different moods for the pictures such as open and close eyes with other details like having beard or being beardless, laugh or without laugh.

The forehead and hair of people can be observable in the related pictures. The face situation towards the camera angle is variable from top to bottom and left to right side. All the pictures are black and white with *92×112* pixels. The most common approach for evaluating the face recognition system is the application of ORL database in which everybody's face pictures have been categorized into two sections according to the system requirement; the first section of the pictures has been applied for training and the second section is subjected to the test pictures issues. For example, five pictures out of ten sections can be considered for training and others left for the test pictures issues.

In the training section of the investigated algorithm, the pictures in the training section are used in order to produce the models of 40 persons in the same 40 classes. In the next phase, the pictures in the test pictures section can be applied to determine the rate of the accuracy of the system. In order to obtain the value of the recognition accurately, the above mentioned evaluation is usually repeated for several times along with training and test pictures collections and general recognition will be represented by measuring the mean of the results.

Figure 4: Related pictures of four persons from ORL database in four lines

5-Simulation:
MATLAB Software is applied for the simulation and 5 pictures out of the ten pictures in the ORL database have been used for training and other 5 have also been applied to testthe system. The total test pictures will be included 200 pictures.

Figure 5: Obtained faces for training collection

The extracted eigenvectors have been written into the sub-space with a low dimension. The obtained sub-space dimension should be selected by the user which is considered as a degree of freedom (DF). In these test pictures, different values for the DF are selected and then the performance of the face recognition system will be tested against the selected values.
But, how to specify this system performance?
The system performance for every case is compared with standard criterion of recognition accuracy. The system recognition accuracy is obtained by the number of the specified faces in a correct test pictures divided by the whole number of the test pictures. The system recognition accuracy can be obtained by the different dimensions of the eigenvectors in the sub-space PCA.
The obtained results can be charted into a diagram. This diagram is established based on the sub-space dimension. Hence, we will enter the obtained results into the support vector machine. One against all is one of the most common ways being applied in this present study. In the categorization SVM, the radial base function and MLP core function have been applied with different values and then we will compare the obtained results. SVM can be found by valuing for several times.
The adjustment coefficient (SVM) is an equilibrium variable between the maximum margin and minimum categorization risk. The value of the related variable should be led to increase the ability of categorization recovery. If the optimized value is taken up for the SVM, the highest recognition rate can be obtained for SVM.
About 200 training eigenvectors have been applied for the system training; 5 vectors with positive 1 and 195 remaining ones with negative 1 have been categorized and 200 test eigenvectors have been efficiently tested and the results are noted here. In the second phase, the first 5 positive vectors out of 200 training vectors are eliminated.. Now, the number of training system eigenvectors is 195 and again 5 vectors with positive 1 and 190 remaining ones with negative 1 should be categorized trying to testify the training collection in this regard. 40 phases should be carried out for obtaining the final results. 40 categorized SVM functions have been written in the program and it can testify the total test system

collection with different dimensions; from 10 to 90 eigenvectors have been tested in the study. In order to obtain the recognition value, the whole obtained results of every phase, 5 pictures have been added together and divided by 200. In fact, the number of the recognized test faces will be divided by the total number of the test system recognition faces in every dimension. RBF, Polynomial and MLP eigenvectors categorization into the support vector machine will be applied in this case.
In every case, the optimized value for every function parameter and the optimized value for adjustment coefficient SVM and C will be taken up along with valuing of parameters that the highest ability will lead to the recognition value for SVM.C parameter helps to increase the margin function , and to decrease the test error. Its amount is changing between 1 to 10, and the assumed number is 10. Its increase causes the modeling accuracy [20].
Table 1 shows the results of 200 tested pictures with the eigenfaces and RBF.
"**σ**" is a Gaussian Kernel function.First, we will apply 10 eigenfaces for obtaining the recognition rate. In the second phase, the number of eigenfaces will be considered 20 trying to measure the rate and then we will continue the task up to 90 eigenfaces in this regard.

Table 1: The average recognition value of 200 test pictures using RBF kernel function and by using one against all method

C=0.01 =4 σ	The corefunction**(RBF)**
The recognition rate(%)	The number of specific figures used
93.5	10
96	20
94.5	30
94	40
95	50
94.5	60
93.5	70
91.5	80
90	90

According to the carried out method for RBF, we will obtain the results for the Polynomial core by the same number of training and test pictures and number of eigenfaces. By the trying and error method, the value C=0.01 and d=4 will be taken up."d" is parameter kernel function polynomial . Polynomial kernel with a default order of 3.Table 2 shows the average recognition value of 200 test samples using the Polynomial core function and one against all method.

Table 2: the recognition value of 200 test samples using the Polynomialcore function and one against all method.

C=0.01 =2 d	The core function**(polynomial)**
The recognition rate(%)	The number of specific figures used
93	10
90	20
89	30
89.5	40
88	50
88.5	60
88	70
88	80
88	90

Results for MLP core are obtained similar to RBF and polynomial cores.
Table 3 shows the recognition value of 200 test samples using the MLPcore function and one against all method.

Table 3: the recognition value of 200 test samples using the MLP function and one against all method

C=0.01 [0.1 -0.1]	The corefunction(MLP)
The recognition rate(%)	The number of specific figures used
94	10
96	20
95.5	30
96	40
97.5	50
97	60
97	70
97	80
97	90

We will also design the histogram diagram for every obtained result. Figure (6), (7), (8) shows the rate diagram based on the number of eigens.

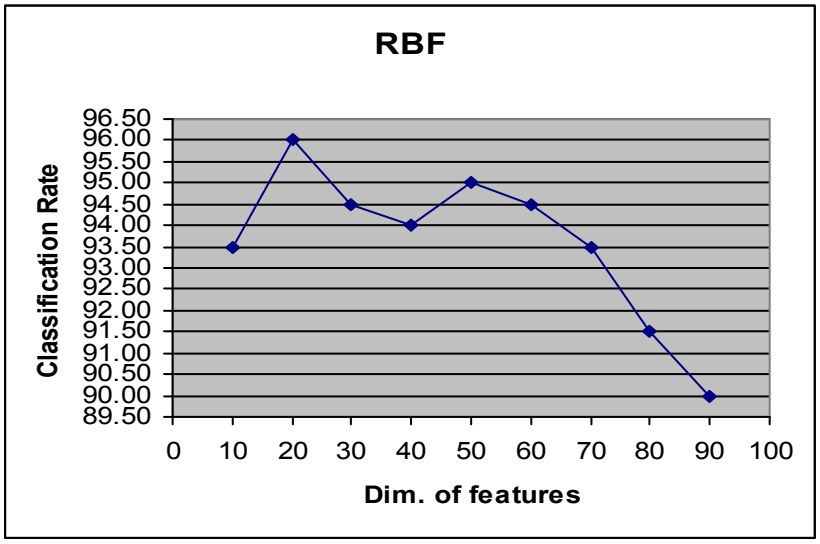

Figure (6) diagram of rate based on the number of eigens

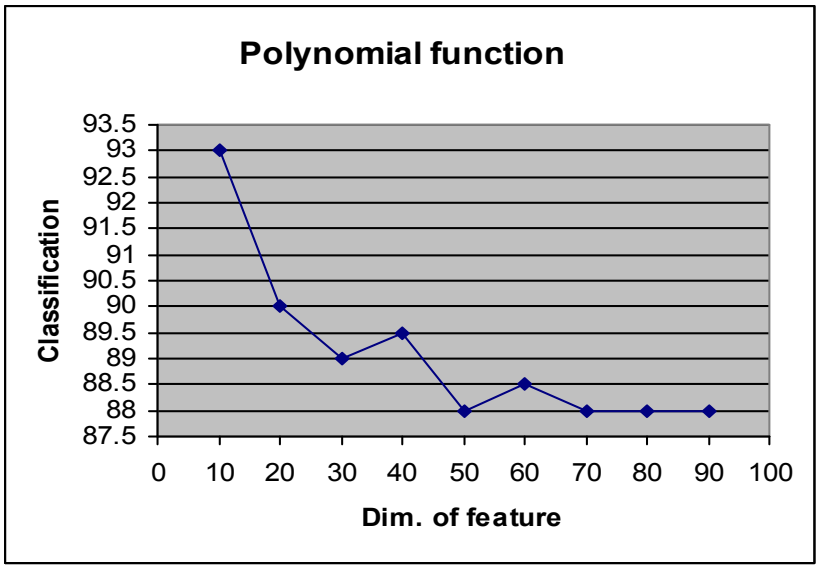

Figure (7) diagram of rate based on the number of eigens

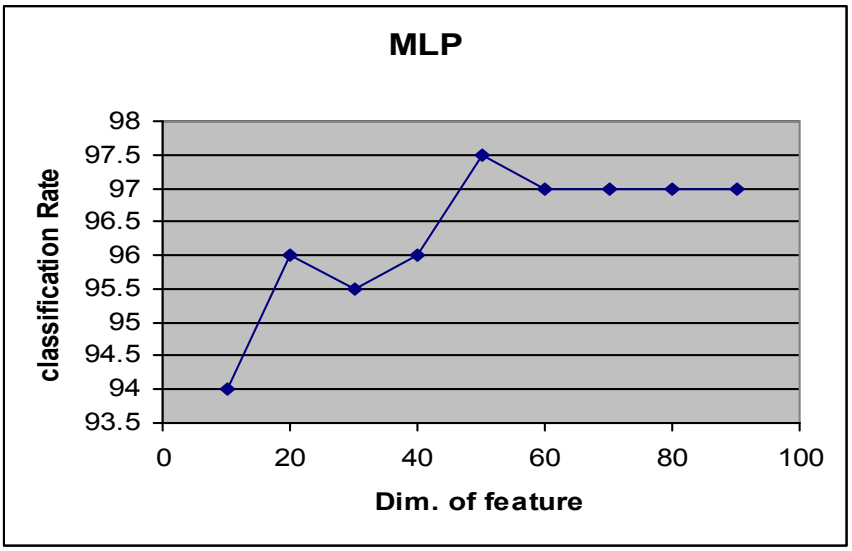

Figure (8) diagram of rate based on the number of eigens

CONCLUSION

In this study, the recognition of face by using Analysis of Principal Component Algorithm, face specification and support vector machine, was analyzed in the ORL database. The final aim of face recognition system is to recognize the picture of a person automatically by a computer. This is done by extracting the features from the person's face. Data base pictures are categorized into training and test pictures. Then, by using Analysis of Principal Component Algorithm, reduction of dimension, and the extraction of features are applied in order to find sub-space in which the data distribution is shown efficiently.

After extracting the feature vectors, the data are applied to the SVM's one-against-all categorizing system. In the SVM classifier, the radial basis function and MLP core function have been applied with different values. In every case, the optimized value for every core function parameter (d for Polynomial core, σ for RBF core and, [-0.1 0.1] isvariable rangefor MLP core) ,and the optimized value for SVM adjustment coefficient (C) are obtained by try and error.

The whole training system including 200 samples is studied throughdifferent experiments on the different number of eigenfaces (10 to 90) with three different core functions. The recognition rates are 96% for RBF core with 20 eigenfaces, 93% for Polynomial core with 10 eigenfaces and 97.5% for MLP core with 50 eigenfaces.

The results show that if we consider only the rate of recognizing system, the function parameter of core MLP will response adequately, but if both rate and the number of the special vectors parameters are being considered, then the face recognition system with the radial basis function will merit because of its exactness and velocity, efficiency, and its better functioning in comparison to other core variables.

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