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A Novel Approach to Face Recognition using Split PCA

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Abstract

Human face recognition has attracted significant consideration as one of the most effective applications of image analysis and understanding. Face recognition provides us a convenient way to identify and recognize a person in a large database. Lighting condition changes, facial expressions, and pose variations complicate the face recognition. This paper will present a novel approach for solving face recognition problem. Our method modifies Principal Component Analysis (PCA) method as Split PCA and uses Support Vector Machine (SVM) classifier with constant hyperplane. The experiments of the proposed method have been conducted on ORL data sets. The experiment result is presented and discussed, which shows the effectiveness of the strategy described.

Keywords: PCA, SVM, hyperplane, eigenfaces

1. INTRODUCTION

Face recognition have become a popular research topic in the computer vision, image processing, and pattern recognition areas. As the terrorist threats are increasing, identification of person is necessary. Person can be identified in many ways with biometric and non-biometric methods. Biometric methods may include ID-card, credit cards, passwords etc. But these methods are less effective, as credit cards can be stolen; passwords may get cracked, etc. Non-biometric methods involve iris, palm geometry, fingerprint, facial expressions etc. In some methods, co-operation from the person is required while face recognition can be done without requiring the attention of a person. Just a camera is to be installed at a particular place and then detection and recognition process can be carried out [3]. Face recognition provides the wide applications in almost every field such as commercial, law enforcement, and military, airport security and access control, building surveillance and monitoring, human-computer intelligent interaction and perceptual interfaces, smart environments at home, office, and cars. [1]

The human face is not a unique, rigid object. Several factors can cause the appearance of the face to vary. These include illumination, pose, ageing, external factors like beard, spectacles, hair style etc. Even facial expression influences the face recognition. All these factors affect the accuracy of face recognition.[2]

Many researches have been done in face detection and recognition in recent years[3],[4]. However, most of the researches are based on certain preconditions, and only few works have been practiced in real environment due to the performance issues[4].

In this research, novel approach of hybrid face recognition technique is introduced. The face recognition system is developed with split PCA and constant hyperplane for SVM classifier.

2. PRINCIPAL COMPONENT ANALYSIS

It is a mathematical procedure that performs a dimensionality reduction by extracting the principal components of the multi-dimensional data. The first principal component is the linear combination of the original dimensions that has the highest variability. The n^{th} principal component is the linear combination with the maximum variability, being orthogonal to the n-1 first principal components [5].

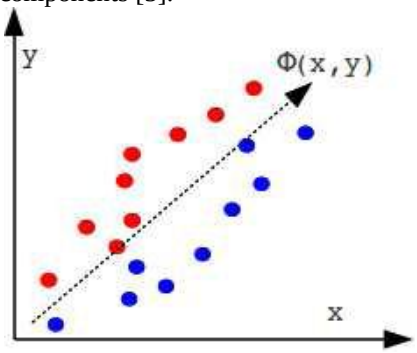

Figure 1 PCA. x and y are the original basis. □ is the first principal component[5].

The scheme is based on an information theory approach that decomposes face images into a small set of characteristic feature images called 'Eigenfaces', which are actually the principal components of the initial training set of face images. An important feature of PCA is that one can reconstruct any original image from the training set by combining the Eigenfaces. The technique used in creating Eigenfaces and using them for recognition is also used outside of facial recognition. This technique is also used for handwriting analysis, lip reading, voice recognition, sign language/hand gestures interpretation and medical imaging analysis [6].

During the training phase, each face image is represented as a column vector, with each entry corresponding to an image pixel. These image vectors are then normalized with respect to the average face. Next, the algorithm finds

the eigenvectors of the covariance matrix of normalized faces by using a speedup technique that reduces the number of multiplications to be performed. This eigenvector matrix is then multiplied by each of face vectors to obtain their corresponding face space projections. Finally, the recognition threshold is computed by using the maximum distance between any two face projections [7],[8].

In the recognition phase, a subject face is normalized with respect to the average face and then projected onto face space using the eigenvector matrix. Next, the Euclidean distance is computed between this projection and all known projections. The minimum value of these comparisons is selected and compared with the threshold value calculated during the training phase. Based on this, if the value is greater than the threshold, the face is new. Otherwise, it is a known face [7],[8].

2.1Method of finding principal components[9]

- First of all we need to find the linear combination of the original variables with large variance.
- The covariance matrix C or the correlation matrix R is then calculated.
- The eigen values and eigenvectors of C or R is found
- The eigen values e_1, e_2, e_3....., e_p are computed in descending order (from largest to smallest).
- Finally the corresponding eigenvectors a_1, a_2, a_3....., a_p are found, thus

$y_1 = a_1'x = a_{11}x_1 + a_{12}x_2 +.....+ a_{1p}x_p$ is the first principal component

$y_2 = a_2'x = a_{21}x_1 + a_{22}x_2 +.....+ a_{2p}x_p$ is the second principal component

……

$Y_p = a_p'x = a_{p1}x_1 + a_{p2}x_2 +.....+ a_{pp}x_p$ is the p'th principal component.

2.2Choosing principal components[9]

$$\frac{\sum_{i=1}^{K} \lambda i}{\sum_{i=1}^{M} \lambda i} \rightarrow Threshold \qquad (e.g.\ 0.9\ or\ 0.5)$$

By using this criterion the requirement of the number of principal components can be determined.

3. Support Vector Machine (SVM)

SVM is a classification method that aims to separate two data sets with maximum distance between them. It is proposed by Vapnik (1998)[10]. SVM finds the hyperplane that separates the largest possible fraction of points of the same class on the same side, while maximizing the distance from either class to the hyperplane.[11]

This method separates two data sets by searching for an optimal separating hyperplane (OSH) between them.[10]

SVM has been employed for face recognition by several other researchers and has been shown to yield good results [2],[12]-[17].

In this paper, we have used constant hyperplane.

4. Results and Analysis

To test the performance, some experiments are performed on a set of face images taken at the Olivetti Research Laboratory (ORL) in Cambridge University, U.K, which can be used freely for academic research. ORL face database contains images of 40 distinct persons, each person having ten different face images. There are 400 face images in total, with 256 gray degrees and the resolution of 92 x 112. All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position, with tolerance for some tilting and rotation of up to 20°. The variation in scale is up to about 10%.

Experiments were carried on pca and modified pca for different number of persons. In modified pca, training set is internally divided into two parts and average face of each part is calculated individually and then both the average image arrays are merged. This gives fine refinement in average face which helps in increase in accuracy performance. Here, for svm, constant hyperplane is used.

Table 1 shows the comparison of performance of pca and modified pca with two classes.

Table 1 Performance comparision of pca and modified pca

Training Faces 1 face/person	Testing Faces Total Faces	Pca Performance %	Modified Pca Performance %
40	400	30%	74%
30	300	40%	80.33%
20	200	30%	78.5%
10	100	50%	90%

Figure 2 shows that with pca, accuracy obtained is 30-50% while with modified pca, accuracy obtained is 74-90%.

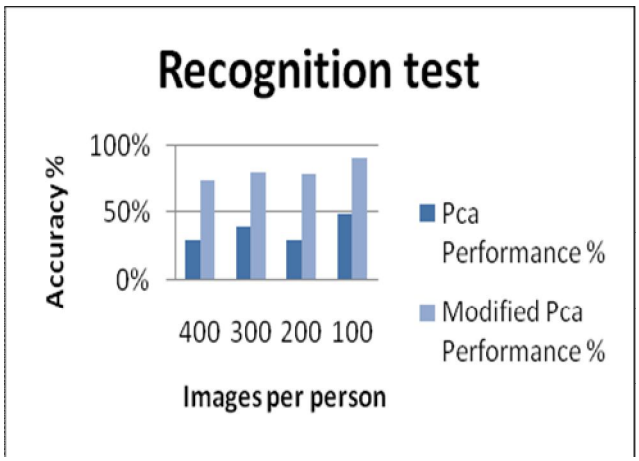

Figure 2 Comparison chart for pca and modified pca

5. CONCLUSION

Face recognition method using eigenfaces is proposed. We used ORL database of face images which contains 400 images of 40 different persons (10 images per person). From the results, it can be concluded that, pca gives 30-50%. By using modified pca, average image gets more refined and accuracy increased upto 74-90%.
The proposed improved face recognition application may be quite useful in security systems, Process plant interface with working personal, Visa offices, virtual entertainment, banks or even in mobile and web security.

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