Face Recognition System based on Wavelet, PCA-LDA and SVM

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Abstract

Face recognition has become one of the important research areas that is used in wide range of applications such as security systems, Information security and personal identification etc. In this paper, we deal with a face recognition system using wavelet transformation to preprocessing of face image and combination of Linear Discriminate Analysis and Principle Components Analysis, algorithm to extract features. Finally, support vector machine algorithm is used for classification. An experiment on Olivetti-Oracle Research Laboratory face is implemented to test performance of the proposed method. The results of this experiment showed the reliability and effectiveness of the proposed method.

Keywords: Face recognition, Principal Component Analyses, Linear Discriminate Analysis, Support Vector Machine.

1. Introduction

Human faces provide a variety of different communicative functions such as identification, the perception of emotional expression, and lip-reading [1].Hence face recognition is one of the most recent biometric identification techniques, which can recognize an individual person based on their facial features as essential elements of distinction [2]. A number face recognition system based of dimensionality reduction techniques have been developed in recent years. The most representative recognition techniques are frequently used in conjunction with face recognition are Principal Component Analysis (PCA) and Fisher's Linear Discriminate Analysis (LDA).PCA is one of the most popular appearance-based methods used mainly for dimensionality reduction in compression and recognition problem. PCA is known as Eigen-space Projection which is based on linearly Projecting the image space to a low dimension feature space that is known as Eigen-space. It tries to find Eigen vectors of Covariance matrix that corresponds to the direction of Principal Components of original data [4]. Meanwhile, another powerful dimensionality reduction technique is LDA. It is a well-known method which projects the data onto a lower-dimensional vector space such that the ratio of the between-class distance to the within-class distance is maximized, thus achieving maximum discrimination. The optimal projection can be readily computed by applying the eigen-objective functions, such as face recognition, all scatter matrices in question can be singular since the data is from a very high-dimensional space, and in general, the dimension exceeds the number of data points. This is known as the under sampled or singularity problem [5].After subspace features are computed, most methods use simple Euclidian distance of the subspace features to classify the face images. Recently, more sophisticated classification method, such as support vector machine, has been shown to make further improvement the classification performance of the PCA and LDA subspace feature [6]. Recently, Support Vector Machines (SVM) have received a growing attention in the area of classification due to certain significant characteristics such as an adequate generalization to new objects, the absence of local minima and representation that depends on few parameters [7]. SVMs provide efficient and powerful classification algorithms that are capable of dealing with high-dimensional input features and with theoretical bounds on the generalization error and sparseness of the solution provided by statistical learning theory [8].

This paper is organized as follows: Section 2 reviews description of the system. Transformation method is given in section 3. Section 4 and 5 explain the feature extraction and classification methods. Finally,

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experimental result, and Conclusions are stated in Section 6.

2. Description of System

The structure of proposed system consists of three major stages: The first stage is involved applying wavelet transformer. The second stage is extracting Facial feature using PCA-LDA. Finally, the obtained feature vectors are fed up into SVM for classification. The block diagram of overall system is shown in figure (1). These steps are elaborated as follow:

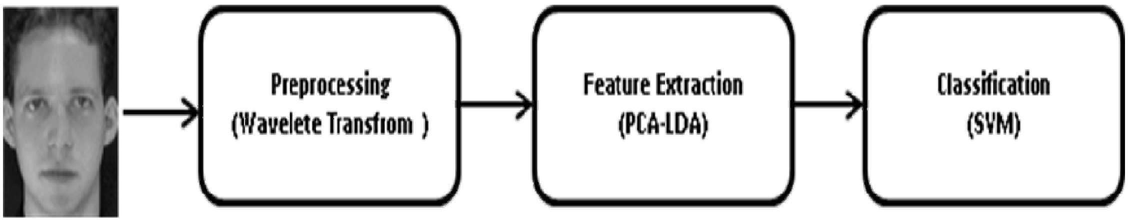

Figure.1 The block diagram of overall system

3. Wavelet Transform

Applying wavelet transform is the first stage of the face recognition system. The wavelet transform is used for two benefits. The first one is decomposing the resolution of the face image and thus reducing the number of input to the SVM. The second benefit of applying wavelet transform is to remove the density in all but the lower sub- band. An image is decomposed one time into four sub bands (LL, LH, HL, HH) as shown in Figure (2). The band LL is a coarser approximation to the original image. The bands LH and HL is recorded respectively the changes of the image along horizontal and vertical directions while the HH band shows a higher frequency component of the image. If the 112x92 decomposed one time the size of 1,2,3,4 sub-bands become 56x64.Hence the size of the input image is decomposed to the half.

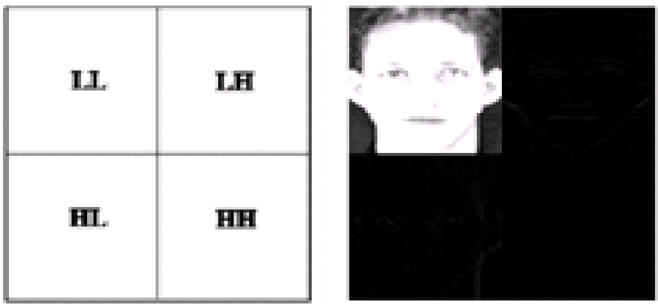

Figure.2 Face images with one-level wavelet transform.

4. Feature Extraction

In resent year, many techniques have been developed to extract the facial features from images or video sequences of faces that to be used for classification. Without using this stage, classification stage becomes immensely complicated and cumbersome. In this proposed system, combination of two main techniques (PCA-LDA) are used for data reduction and feature extraction .These two techniques are used to evaluate the low-dimensional features from a high dimensional space that are used to group images that returned from the same class and separate images that returned to different classes. Later the extracted features that are obtained from this stage can be used in recognition stage.

4.1Pca-Lda Algorithm

Let the face image (Input Image: I(x,y)) that is represented as a two-dimensional NxN array of intensity values is converted to a vector of length N^2. Thus a typical image of size 92 x 112 is converted to a vector of dimension 16484 but this image vectors cannot be used in recognition because all human face images are quite similar to each other as well as the 10304-dimension space is large. Therefore PCA-LDA is used to find a better representation of faces. After creating the training set, there are M numbers of face images, and for each image, there are N pixels and each image is considered a vector. The mean of face images is calculated according to Equation 1:

$$\mu = \frac{1}{M}\sum_{i=1}^{M} U_j \tag{1}$$

Uj is the face image in the training set. The normalized is performed in training set to obtain the zero mean that show a degree of difference between the mean face $\boldsymbol{\mu}$ image and the original face image by equation 2:

$$Yi = U_i - \boldsymbol{\mu} \qquad i = 1, 2\ldots m. \tag{2}$$

The scatter matrix S of the training set is calculated by equation 3:

$$S = \sum_{i=1}^{M} Y_j Y_j^T \tag{3}$$

Then eigenvectors $\{v_1, v_2 \ldots v_k\}$ corresponding to the largest k eigenvalues of S is calculated .Hence the new projected of LDA is determined as show in the equation 4:

$$Zj = A^T Y_j \qquad j = 1, 2\ldots m. \tag{4}$$

The mean image $\boldsymbol{\mu}$zj of each class and the mean image $\boldsymbol{\mu}$z of all the classes in the database can be computed as shown in equations 5and 6:

$$\mu_{zj} = \frac{1}{n}\sum_{j=1}^{n} Z_j \tag{5}$$

$$\mu_z = \frac{1}{n}\sum_{j=1}^{n} \mu_{zj} \tag{6}$$

Then the within-class scatter matrix S_w and the between-class scatter matrix S_b are evaluated as shown in equations 7 and 8:

$$S_b = \sum_{j=1}^{c} n_j \left(\mu_{zj} - \mu\right)\left(\mu_{zj} - \mu\right)^T \tag{7}$$

$$S_w = \sum_{i=1}^{c} \sum_{j=1}^{N_j} (z_j - \mu_{zi})(z_j - \mu_{zi})^T \qquad (8)$$

Then the eigenvector wk that satisfies the Equation below to be computed as the following:

$$S_b w_k = \lambda S_w w_k \qquad k = 1,2,....,m. \qquad (9)$$

Where λ is the eigenvalue, and m is the number of eigenvectors.

5. Classification of Face

After feature extraction stage, the important and final stage of system is implemented .Classification can be considered as the high level of image processing field. It is aimed to identify the similarity between faces from the same individual and different individuals after all the face images in database are represented with relevant features.

5.1 SVM

A brief introduction of the basic idea of SVM is presented in this section. For two class problem, let $\{\{(x_1,y_1),....,(x_i,y_i)\}$ is the set of label training samples. Where xi is the feature sample that relates to one of the two class and y_i = 1 or -1 is the label that xi belong to. SVM aims at finding the linear discriminate function f(x):

$$f(x) = w^T \cdot x + b \qquad (10)$$

Where w is the weight of the vector and b is the bias. The goal of the SVM is to maximize the margins between two classes to find the optimal separated hyper-plane. The decision of classification function is given by the formulation below:

$$f(x) = \sum_{j}^{r} \alpha_j \, y_j \, k(x.x_{j)} \qquad (11)$$

Where n is the number of the support vectors and αi is the Lagrange multiplier. For linear separated space, the decision of classification function of the optimal separated hyper-plane is given as:

$$f(x) = \mathbf{sign}\left(\sum_{i}^{n} \alpha_i y_i (x,x_i) + b \right) \qquad (12)$$

To extend the SVM to nonlinear separated space, there are many types of kernel functions commonly used to provide good separated solution, such as (polynomials, Multi- Layer Perception and Radial Basis Function) which are defined as following:

Linear Kernel:

$$k(x, x_j) = x \cdot x_j \tag{13}$$

Polynomial Kernel:

$$k(x, x_j) = (x^T x_j + 1)^{q} \tag{14}$$

Radial Basis Kernel:

$$k(x, xj) = e^{-\gamma \|x - xj\|^2} \tag{15}$$

Where q is the order of the polynomial kernel and the γ is the controller parameter in the case of the Radial Basis Kernel. In this research, polynomial kernel function is used to solve the separation problem.

6. Experimental Results

In this section, an experiment on the one of the most famous and commonly used databases in most researches is implemented to evaluate the performance of proposed methods.

6.1 The Experiments on the ORL database

The Olivetti-Oracle Research Lab database (ORL) [9] face database was used to test the reliability of face recognition algorithms under the condition of minor variation of scaling and rotation. ORL face database contains 40 classes, total 400 face images, and 10 images per class with variation in pose, illumination, facial expression (open/closed eyes, smiling/not smiling) and facial details (glasses/no glasses). Every image's size is 112 × 92,256 grey level. 32 classes are used for training & testing, and the other 8 different classes are used for testing only. The training set contains 160 samples (5 samples per class) and the remaining 240 samples are used as testing set. For this database, 40% of data is used for train and 60% of data is used for test. The sensitivity, accuracy and specificity of database are calculated (Table (1) shows the recognition results for experiment) and from the recognition results can be seen that, using SVM classifier gives good recognition rate of the system.

7. Conclusion

For many years, the face recognition is considered as challenging problem and still takes attention of the researches in pattern recognition, biometrics and computer vision field. For preprocessing and feature extraction stages, combination of wavelet transform and PCA-LDA is performed. While though the classification stage, the SVM is explored for robust decision. The experiment on the ORL database proved that the combination of Wavelet, PCA-LDA and SVM give high performance, the lowest overall training time, the lowest redundant data, and the highest recognition rates. From the practical results obtained can deduce the following, the proposed method can be used in real time applications.

Table 1. The recognition results for ORL experiment

Number of class	40
Number of training samples	160
Number of testing samples	240
Sensitivity	95.12195
Specificity	98.734177
Accuracy	97.5

References

Kwang H.,and Myung J.,(2010) " Learning Discriminative MspLBP Features Based on Ada-LDA for Multi-Class Pattern Classification", 2010 IEEE International Conference on Robotics and Automation, May, pp.4804-4808.

Annapurna M., Monorama S. and Bodhisattva D.,(2012) " An Approach to Face Recognition of 2-D Images Using Eigen Faces and PCA", Signal & Image Processing: An International Journal (SIPIJ), Vol.3, No.2, April, pp.143-156.

Kyu-Dae B., Keun-C., Su-Young C., and Yun-Koo C.,(2006) " Appearance-based Face Recognition from robot camera images with Illumination and Distance Variations", SICE-ICASE International Joint Conference 2006,Oct,pp.321-325.

Neeta N., Prashant G., Nitish A., Rakesh P. and Subhash C., (2008)"Proceedings of the World Congress on Engineering 2008", Vol. I, July.

Hythem A., Jedra M. and Zahid N.,(2012) " Face Recognition Systems Using Relevance Weighted Two Dimensional Linear Discriminant Analysis Algorithm", Journal of Signal and Information Processing, Feb, pp.130-135.

Zhifeng L. and Xiaoou ., (2004) " Bayesian Face Recognition Using Support Vector Machine and Face Clustering", IEEE Computer Society Conference on Computer Vision and Pattern Recognition.

Manuel D., Arthur G., Arnaud D., and Peter J., (2002) "Optimized Support Vector Machines for Nonstationary Signal Classification", IEEE Signal Processing Letters, Vol. 9, No. 12, Dec.

Jaime M., Ricardo M. and Richard W. (2005) ," Linear Penalization Support Vector Machines for Feature Selection", Pattern Recognition and Machine Intelligence, Vol. 3776, pp.188-192.

The Olivetti-Oracle Research Lab Database Available: http://www.cl.cam.ac.uk/research/dtg/attarchive/facedatabase.html(URL).

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