Improvement of Face Recognition System Based on Linear Discrimination Analysis and Support Vector Machine

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ABSTRACT

Face recognition is one of the most important research fields in many of applications and it is used in various domains including human computer interaction, security systems and personal identification. Many of face recognition systems have been developed for decades. In general, the accuracy of the face recognition system is determined by the accuracy of the method that is used to extract features and the accurate of the classification method. This paper introduces an improvement of face recognition system by using Linear Discrimination Analysis and Support Vector Machine. Two types of experiments off-line and on-line are done. In off-line experiment, the Olivetti Research Laboratory face database is used and in on-line experiment, DVD Maker 2 adapter is used to capture live image from digital camera, and digitalize it to be compared with training database. The Comparison with Linear Discriminate Analysis and Artificial Neural Network is implemented .The results show that the proposed method gives better results in off-line experiment than previous methods in terms of recognition rate.

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

تحسين نظام تمييزالوجه بالاعتمادعلى التحليل المميزالخطي وآلة المتجه الداعم

الخلاصة

تمييزالوجه هوواحدأهم المجالات البحثية في العديدمن ا لتطبيقات ويتم استخدامه في مختلف المجالات بمافي ذلك التفاعل بين أ جهزةالكمبيوتروالإنسان،أنظمة الأمن والهوية الشخصية. لعقودعدة تم تطويرالعديد من أنظمة تمييزالوجه. بشكل عام،يتم تحديد دقة نظام تمييزالوجه من خلال دقة النظرية المستخدمة في استخراج الميزات ودقة طريقة التصنيف. يهدف البحث التقديم نظام تميزللوجه باستخدام تحليل المميزالخطي (Linear Discrimination Analysis)وآلة المتجه الداعم.(Support Vector Machine) تم إجراء نوع ينمن التجارب (off-line) و .(on-line) (في النوع الأولتم استخدام قاعدة البيانات (Olivetti Research Laboratory)وفي

النوع الثاني تم استخدام المحول (DVD Maker 2)لالتقاط صورةحية ومباشرة باستخدام كامرة رقمية وتحولها الى بيانات رقمية ليتم مقارنتها مع قاعدة البيانات . من خلل مقارنة النتائج التيتم الحصول عليها في الطريقة المقترحة مع طريقة تحليل المميز الخطي والشبكة العصبية الاصطناعية تبين أنا لطريقة المقترحة تعطي نتائج أفضل من حيث معدل ا لاعتراف.

INTRODUCTION

The face is our primary focus of attention in social intercourse, playing a major role in conveying identity and emotion [1]. Thus face recognition is a huge research area in computer vision, pattern recognition and plays a vital role in the applications of image analysis and understanding. [2].

Face Recognition is a unimodal biometric system for image identification and verification. It is carried out using many techniques like Linear Discrimination Analysis (LDA) , Principal Component Analysis (PCA), Kernel Principal Component Analysis (KPCA), Independent Component Analysis (ICA), Modular Principal Component Analysis (MPCA) and 2-Dimensional Principal Component Analysis (2DPCA) [3].

One of the most popular dimensionality reduction approaches for supervised dimensionality reduction is the LDA. It has been successfully applied to face recognition and other pattern recognition problems. [4].LDA aims to find a linear transformation that maximizes the between-class scatter (S_b) (S_b displays how classes are separated each other) and minimizes the within-class scatter (S_w) (S_w shows how face images are distributed closely within classes), which preserves the discriminating information and is suitable for face recognition [5].

In recent years, Support Vector Machines (SVM) because of its excellent learning and classification performance, has become a hot topic in the field of machine learning and has been applied in many areas, such as face detection and recognition, handwriting automatic identification and automatic text categorization [6].

Vijayshree et al. [7] introduced modified fisher face, fuzzy fisher face and included gradual level of assignment to class being regarded as a membership grade which helps to improve recognition results.

Faruqe et al. [8] used PCA to play a key role in feature extractor and the SVMs to tackle the face recognition problem.

Ming et al. [9] proposed a new random sampling LDA by incorporating feature selection for face recognition, that is, some redundant features are removed using the given feature selection methods at first, and then PCA is employed, finally random sampling is used to generate multiple feature subsets .

Zhen et al. [10] proposed an effective local frequency descriptor (LFD) for low resolution face recognition, by building upon the ideas behind local phase quantization (LPQ) and exploring both blur-invariant magnitude and phase information in the low frequency domain .

Keche et al. [11] introduced compare between the different face recognition techniques like visual face recognition, thermal face recognition, eigenface approach and feature extraction techniques like geometry-based feature extraction (Gabor wavelet transform), appearance based techniques, color segmentation based techniques and template based feature extraction .

This paper aims to improve the rate of face recognition system .For this reason, LDA is used to extract the important features of face image and support vector machine is used as classifier. Finally, comparison between the results of (LDA+SVM) and (LDA+ANN) is done to verify the effectiveness of the proposed method.

FACE RECOGNITION SYSTEM DESCRIPTION

The proposed recognition system consists of four classical stages: face detection, normalization, feature extraction from the face image and finally, classification of the feature vectors that model the faces. Figure 1 show the general block diagram of the Face recognition system.

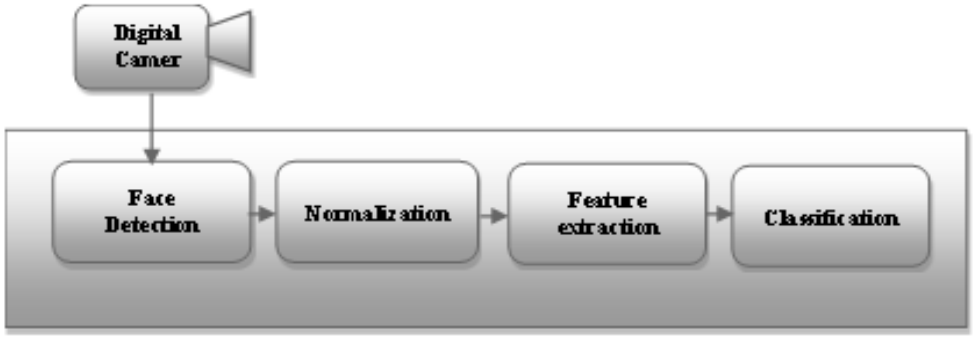

Figure (1) General block diagram of the Face recognition system.

FACE DETECTION

A Face detection technique is aimed to detect a human face in the image and neglect all other objects in image. There are many techniques that used to detect the face in the image such as model-based, by color and face detection as a pattern-classification task. In this system, the face detection stage is implemented using Matlab 2012a software. The system uses the Viola-Jones detection algorithm [12] for detection. Viola-Jones face detector algorithm consists of three main critical steps. These critical steps are: the integral image, AdaBoost learning algorithm, and finally, the cascade structure.

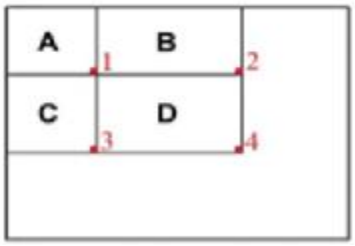

Figure (2) the calculation of pixel sum Within a rectangle D.

At the beginning, the integral image is computed from the input image. The integral image at location x, y contains the sum of the pixels above and to the left of x, y in the input image as follows in equation1:

$$ii(x, y) = \sum_{x' \le x,\ y' \le y} i(x', y') \qquad \dots (1)$$

Where *ii* is the integral image and *i* is the input image. It is noticed that, the definition of the integral image guarantees that computing the integral sum for any rectangular region requires only four array references. Referring to Figure (2), as an illustrative example, the integral sum of the rectangular region D can be computes according to equation 2:

$$\boldsymbol{ii(point\ 4) + ii(point\ 1) - ii(point\ 2) - ii(point\ 3)} \quad \dots (2)$$

Then, using the integral image, three kinds of simple Haar-like features: two-rectangle feature Figure (3 A&B), three rectangle feature Figure (3-C) and four-rectangle feature Figure (3-D), are computed. It is noticed that, the grey or white regions have the same size and shape in a given feature. The value of a Haar-like feature is defined as the difference between the sum of pixels in the grey rectangles and the sum of the pixels in the white rectangles. It is worth mentioning that employing the integral image dramatically reduces the computational cost for computing the Haar-like features.

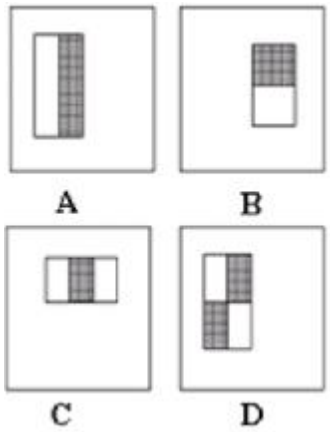

Figure (3) four basic features in Viola Jones algorithm.

In order to classify a given sub-window as a face or a non-face region, a variant of the Gadabouts learning algorithm [13] is employed. This stage involves the selection a small set of critical features from the given sub-window. Then, a classifier is trained over a large database of face images. It is noticed that, during the learning phase, each feature is considered to be a potential weak classifier, described by equation 3:

$$h_j(x) = \begin{cases} 1 & if\ p_j f_j(x) < p_j \theta_j \\ 0 & otherwise \end{cases} \quad \ldots (3)$$

Where, x is (24×24) pixel sub-window, fj is a feature, θj is a threshold, and pj is a parity indicating the direction of the inequality sign. A final strong classifier can be constructed as a weighted sum of those weak classifiers using the modified AdaBoost algorithm.

To focus more on promising face-like regions and to quickly discard non-face regions, Viola-Jones face detector was designed to have a cascade structure with increasingly more complex classifiers in multiple stages figure 4 describe the cascade structure operation. Each stage uses a strong classifier trained by using the AdaBoost learning algorithm on increasingly stronger features from a large number of training face images, until the target detection and false positives rates are met [14].

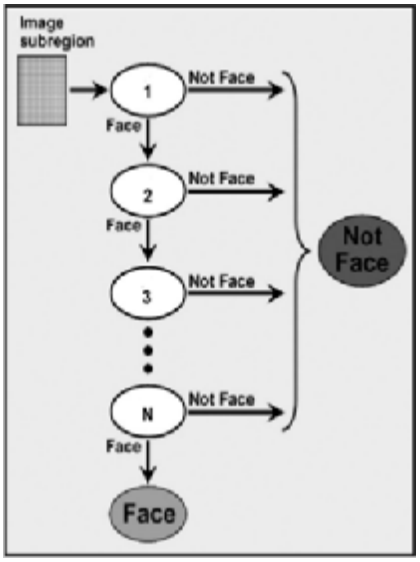

Figure (4) Schematic depiction of a detection cascade.

NORMALIZATION

There are some of normalization steps that must be implemented on face image to obtain the perfect results. In this stage of the system, image size and Histogram equalization normalization are performed.

- Image size normalization: To normalization the size of the face image bi-cubic interpolation algorithm is used. Bi-cubic interpolation is an extension of cubic interpolation for interpolating data points on a two dimensional regular grid. In this algorithm the closest 4 x 4 block of input cells is used to compute each output cell value. The weighting factors for the average of the input cells are computed using a cubic (third-order) function of distance. The weighting coefficients of bi-cubic interpolation are given by equation 4:

$$h_{Bicubic}(s) = \begin{cases} 1-2|s|^2+|s|^3, & 0 \le |s| < 1 \\ 4-8|s|+5|s|^2-|s|^3, & 1 \le |s| < 2 \\ 0, & 2 \le |s| \end{cases} \quad \dots (4)$$

  Equation (4) indicates that bi-cubic convolution interpolation has less computational complexity and the interpolated surfaces that give by Bi-cubic algorithm is smoother than corresponding surfaces obtained by bilinear interpolation or nearest-neighbor interpolation [15].

- **Histogram equalization:** Some of images may be too dark or too bright therefore histogram equalization is used for adjusting the image by make each intensity level contains an equal number of pixels to balance light and dark area such that the appearance of the image is improved. For I(x,y) face image

with N pixels and a total number of k grey levels . The histogram equalization can be defined as follows: given the probability P(i) = ni / N , (i.e. the actual histogram of I(x,y)) of an occurrence of a pixel with a grey level of i, where i ∈ 2 0, 1, ..., k − 1 and ni denotes the number of pixels in I(x,y) with the grey level value of i, the mapping from a given intensity value i to a new transformed one inew is defined by equation 5:

$$i_{new} = \sum_{i=0}^{K-1} \frac{n_i}{N} = \sum_{i=0}^{K-1} P(i) \qquad ...(5)$$

Equation (1) defines a mapping of the pixels' intensity values from their original range (0-255) to the domain of [0, 1]. Thus, to obtain pixel values in the original domain, e.g., the 8-bit interval, the values i_{new} have to be rescaled [16].

FEATURE EXTRACTOR

In this system, LDA method is used to extract face feature. It can be used to calculate the low-dimensional features from a high dimensional space that used to group images that returned of the same class and separate images that returned to different classes. The LDA method aims to select features that maximize the ratio of the between-class scatter S_b to the within-class scatter S_w. The bad and good separated between two classes are decrypted in Figure (5).

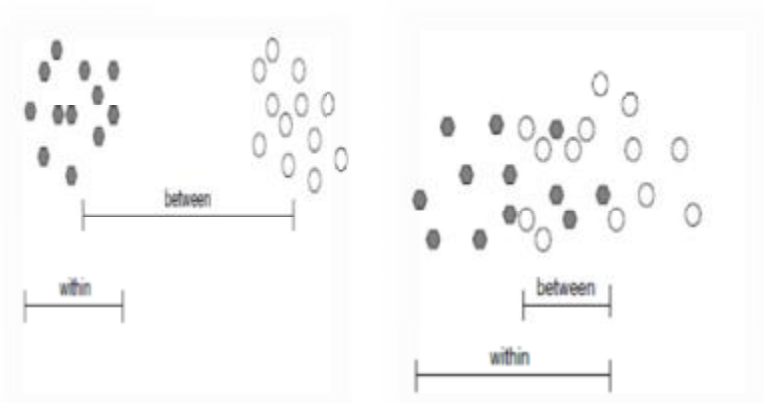

Figure (5) Good class separation (left side) and bad class Separation (right side).

LDA aims to solve an optimal discrimination projection matrix A which is defined in the equation below [17]:

$$A = avg_A max | A^T S_b A | / | A^T S_w A | \qquad ...(6)$$

Where S_w is the within-class scatter matrix and S_b is the between-class scatter matrix. The S_w and S_b are defined in the equation below [18]:

$$S_b = \sum_{j=1}^{c} (\mu_{j-}\mu)(\mu_{j-}\mu)^T \quad ...(7)$$

$$S_w = \sum_{j=1}^{c} \sum_{i=1}^{N_j} (y_i^j - \mu_{qi})(y_i^j - \mu_{qi})^T \quad ...(8)$$

Where μ is the mean of all classes, y_j^i is the *i*th sample of class j, μ_j is the mean of class j, c is the number of classes, and N_j the number of samples in class j.

CLASSIFICATION

SVM, known as a powerful classification and regression tool, has performed successfully in many applications such as handwritten digit recognition, face detection and object recognition [19].

SVM aims to classify data by finding the best hyper-plane between two classes. The SVMs maximize the margin between the separating hyper plane and the data to find an optimal separating hyper plane. The vectors that closest to the boundary are called support vectors. The decision function f(x) is given by equation below [20]:

$$f(x) = \sum_{i=1}^{L} y_i \alpha_i k(x, x_i) + b \quad ...(9)$$

Where x_i is the training sample, k is the kernel function, and $y_i \in \{-1, +1\}$ their respective class labels, α_i and b are the parameters of the model obtained after training. At test time, f(x) is compared to a threshold θ .There are different kernel functions that use to perform the computation of scalar products in the feature space such as (linear, polynomial and radial basis functions) define as following:

Linear Kernel:

$$K(x_i, x_j) = x_i , x_j \quad \dots (10)$$

Polynomial Kernel:

$$K(x_i, x_j) = (x_i, x_j + 1)^d \quad \dots (11)$$

Radial Basis Kernel:

$$K(x_i, x_j) = e^{-\gamma \left\| x_i - x_j \right\|^2} \quad \dots (12)$$

Where x_i and x_j are two samples. The degree d is the controller parameter in the case of the polynomial and the γ is the controller parameter in the case of the RBF kernel.

Experimental Results

To evaluate the performance of the proposed method, two experiments (Off-line and On-line) are performed on two types of databases.

Off-line experiment

The first experiment is performed using the Olivetti Research Laboratory (ORL) database [21] for testing two approaches. This database contains 400 individual images of 40 persons, for each person 10 different images are taken under different light, expression and perspective. Figure 6 shows 10 different images for the same person. The image is gray-scale and its resolutions 112 × 92 pixel. The 160 samples (5 samples for each person) selected as the training set. The remaining 240 samples are used as the test set.

Figure (6) 10 Deterrent images for the same person.

The first approach is a combination between LDA and ANN. Where LDA is used to reduce dimensionality and extract features, while ANN is used as classifier. Two layer feed foreword neural network with log sigmoid activation function in hidden layer and purelin in output layer are used. While in the second approach, the LDA and SVM are used. SVM is used as classifier with Polynomial kernel function. Table (1) shows the comparisons of methods on recognition accuracy between LDA+ANN and LDA+SVM.

Table (1) the recognition accuracy.

No. of class	No. of training samples	No. of testing samples	Method	Accuracy (%)
40	160	240	LDA+ANN	90.00%
40	160	240	LDA+SVM	96.25 %

ON-LINE EXPERIMENT

In the last experiment, the database created by the authors is applied on two approaches. The face recognition system detects the faces from live capture image, and

then these faces are checked with training images dataset based on descriptive features. Three main hardware parts are used to convert live captured images to digital data, which are computer, DVD Maker2 adapter and digital camera. Computer is the important part of system to process and analyze image. Image acquisition from camera is performed by using DVD Maker2 adapter. Finally, acquisition toolbox that is provided by Matlab software enables image acquisition from DVD Maker2 adapter. This toolbox supports acquiring resolution of adapter, triggering specification, color space, number of acquired image at triggering and any frame rate, etc.

The database contains 300 individual images of 16 persons. Figure (7) shows 8 images for four persons. The image is gray-scale and its resolution is (128 × 128) pixel. 120 samples selected as the training set and the remaining 180 samples are used as the test set. As the previous experiment, a combination of LDA and ANN is used in the first approach and LDA and SVM are used in the second approach. Table (2) shows the recognition accuracy between LDA+ANN and LDA+SVM.

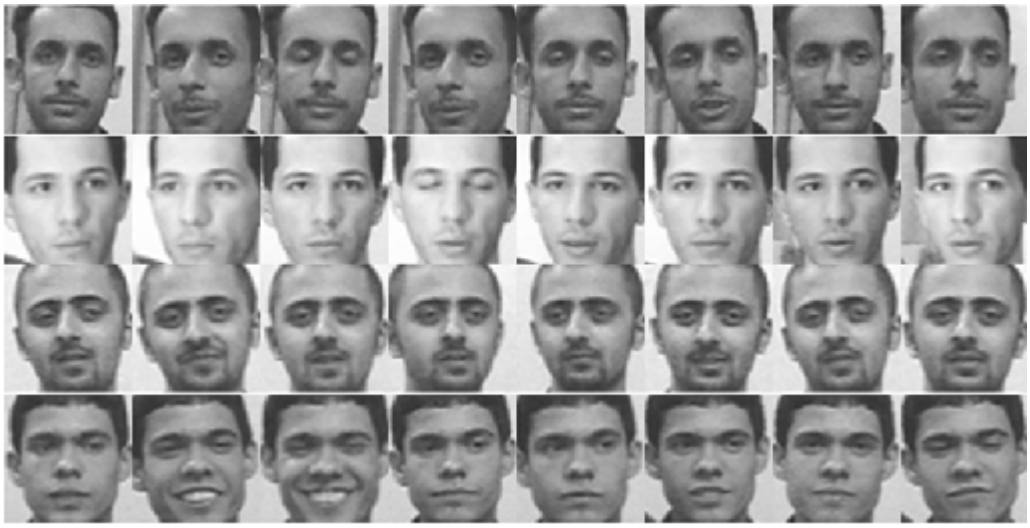

Figure (7) eight deferent images for four persons.

Table (2) The recognition accuracy.

No. of class	No. of training samples	No. of testing samples	Method	Accuracy (%)
16	120	180	LDA+ANN	87.77%
16	120	180	LDA+SVM	95.56 %

A comparison between (LDA+SVM) and (LDA+ANN) results in off-line and On-line experiments is shown in Figure (8). it is noticed that SVM classification method gives the best results compared with ANN classification method.

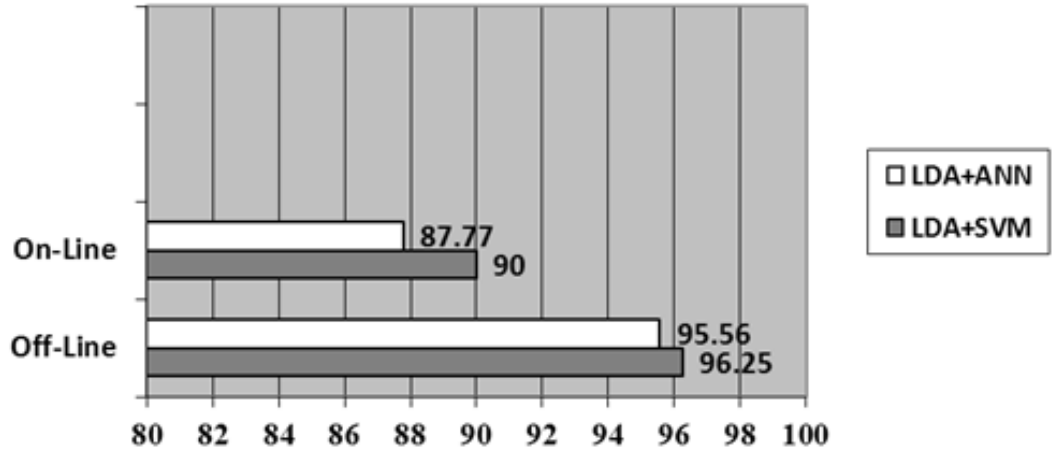

Figure (8) Comparison of two approaches on Off-line and On-line experiments.

CONCLUSIONS

This paper presents a face recognition system using LDA and SVM. LDA is used as feature extraction technique and SVM for the classification. Then comparison with (LDA+ANN) is done to verify the effectiveness of the system. Finally, the face recognition experiment show that the proposed method led to enhance recognition accuracy by 1% in off-line experiment and 2.23% in on-line experiment compared with LDA method and ANN.

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