ISSN No. 2278-3083

Volume 1, No.4, September – October 2012
International Journal of Science and Applied Information Technology
Available Online at http://warse.org/pdfs/ijsait01142012.pdf

Rapid Face Recognition Technology using Eigenfaces and Gabor Filter

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ABSTRACT

Face recognition is one of biometric methods, to identify given face image using main features of face. Face recognition system is a computer application for automatically identifying or verifying a person from a digital image. Gabor filters have proven themselves to be a powerful tool for feature extraction. Proposed methodology is connection of two stages – Face detection using Haar based cascade classifier ,Feature extraction using Gabor Filter and recognition using Eigen faces. The Eigenface approach used for the recognition of the images. It gives us efficient way to find the lower dimensional space.

Keywords: Eigen faces, Eigen value, Eigen vector, Gabor Filter, Haar based cascade classifier, Mahalanobis Distance.

1. INTRODUCTION

Developing a computational model of face recognition is quite difficult, because faces are complex, multidimensional an d meaningful visual stimuli.. In that case the dynamic images received from the camera can first be converted in to the static ones and then the some procedure can be applied on them [3]. Some of the possible problems recognition system is given below:

- Scale invariance: The face can be presented to the system at different scales. This may happen due to the focal distance between the face and the camera. As this distance gets closer, the face image gets bigger.
- Shift invariance. The same face can be presented to the system at different perspectives and orientations .For instance, face image of the same person could be taken from frontal and profile views. Besides
- head orientation may change due to translations and rotations
- Noise invariance: Robust face recognition system is insensitive to noise generated by frame grabbers or cameras.
- Facial expression change: A smiling face, a crying face, a face with closed eyes, even a small nuance in the facial expression can affect the face recognition system significantly.

The proposed system utilizes the Eigen face method is information reduction for the images. There is an incredible amount of information present even in a small face image. Each face that we wish to classify can be projected into face-space and then analyzed as a vector. Mahalanobis Distance measure can be used for classification.

2. FACE DETECTION AND RECOGNITION SYSTEM

This section gives an overview on the major Face detection and recognition system module , There are six functional block whose responsibility are given below.

2.1Image Acquition module

This is the entry point of face recognition system. In this module camera capture the image and convert the static image into Dynamic image in this module total 16 images are captured by the camera and stored into train database and One image is captured for authentication purpose.

2.2 Face detection using HAAR Cascade Classifiers

1. Read the input image
2. Computation of Haar Feature Selection
3. Find the Integral, Summation of pixel values of the original image. Value at location (x,y) = sum of values of pixels above and to the left of (x,y).Whole image converted to integral image and a window buffer used to scan the entire image classifier. This classifier responds with a 1 for a pass or a 0 for a fail.
4. Weights and sizes associated with features obtained through AdaBoost.
5. Classifier sum = $\sum$ (area * weights)
6. Multiple stages, each stage has different number of classifiers.
7. Threshold obtained from AdaBoost algorithm
8. Cascade of stages. Candidate must pass all stages in the cascade to be concluded as a face.

The more window looks like a face, more classifiers to be computed and the longer it takes to Classify that window. Thus, if the window is not a face the classifiers will quickly reject it after considering small fraction of feature in it[6].

2.3 The pre-processing module

The aim of the pre-processing phase was to obtain images which have normalized intensity, uniform size and shape. In this module the images are normalized and enhanced to improve the recognition of the system. The preprocessing steps implemented are as follows:

- **Image size normalization**. It is usually done to change the acquired image size to a default image size such as 128 x 128, on which the face recognition system operates. This is mostly encountered in systems where face images are treated as a whole like the one proposed in this project.
- **Conversion of Grayscale image.** In image processing grayscale digital image is an image in which the value of each pixel is a single sample, that is, it can carry only intensity information. Images of this sort also known as black-and-white are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest.
- **Histogram equalization.** It is usually done on too dark or too bright images in order to enhance image quality and to improve face recognition performance. It modifies the dynamic range (contrast range) of the image and as a result, some important facial features become more apparent.
- **3-point normalizations.** Now we will describe our implementation of 3-point normalization method. Pointing the centers of two eyes and tip of the chin on each face image, Initially image are denoised (using Gaussian filter with σ=0.5 and window size 5x5 all images are properly rotated, translated, scaled and cropped into 100×100 pixels. In this module the images are normalized and enhanced to improve the recognition of the system[1].

2.4 Face feature extraction using Gabor Filter

A Gabor filter-based face feature extraction is proposed in this section [5]. We try to obtain some feature vectors which provide optimal characterizations of the visual content of facial images. For this reason we choose the two-dimensional Gabor filtering, a widely used image processing tool, for feature extraction. Besides face recognition, Gabor filters are successfully used in many other image processing and analysis domains, such as: image smoothing, image coding, texture analysis, shape analysis, edge detection, fingerprint and iris recognition Gabor filters can exploit salient visual properties such as spatial localization, orientation selectivity, and spatial frequency characteristics. Gabor filter works as a band pass filter for the local spatial frequency distribution, achieving an optimal resolution in both spatial and frequency domains. The 2D Gabor filter $\psi_{f,\theta}$ (x, y) can be represented as the complex Sinusoidal signal can be modulated by a Gaussian kernel function as follows:

$\Psi_{f,\theta}(x,y)$
can be represented as a complex sinusoidal signal modulated by a G
function as in equation 1.

$$\Psi_{f,\theta}(x,y) = \exp\left[\frac{1}{2}\left\{\frac{x_{\theta_n}^2}{\sigma_x^2} + \frac{y_{\theta_n}^2}{\sigma_x^2}\right\}\right] \exp(2\pi f x_{\theta_n}) \quad (1)$$

Where, $\begin{bmatrix} x_{\theta_n} \\ y_{\theta_n} \end{bmatrix} = \begin{bmatrix} \sin\theta_n & \cos\theta_n \\ -\cos\theta_n & \sin\theta_n \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$

3. FACE RECOGNITION USING EIGENFACES

Eigen faces approach seemed to be an adequate method to be used in face recognition due to its simplicity ,speed and learning capability. Eigenfaces are a set of eigenvectors used in the computer vision problem of human face recognition. They refer to an appearance-based approach to face recognition that seeks to capture the variation in a collection of face images and use this information to encode and compare images of individual faces in a holistic manner. Specifically, the eigenfaces are the principal components of a distribution of faces, or equivalently, the eigenvectors of the covariance matrix of the set of face images, where an image with N x N pixels is considered a point (or vector) in N 2-dimensional space [6].Eigenfaces are mostly used to:

• Extract the relevant facial information, which may or may not be directly related to human intuition of face features such as the eyes, nose, and lips. One way to do so is to capture the statistical variation between face images.

• Represent face images efficiently. To reduce the computation and space complexity, each face image can be represented using a small number of dimensions.

3.1. Eigen Values and Eigen Vectors

In linear algebra, the eigenvectors of a linear operator are non-zero vectors which, when operated on by the operator, result in a scalar multiple of them. The scalar is then called the eigenvalue associated with the eigenvector(X). Eigen vector is a vector that is scaled by a linear transformation. It is a property of a matrix. When a matrix acts on it, only the vector magnitude is changed not the direction.

$AX = \lambda X$ (1) Where A is vector function

3.2. Calculations of Eigen values and Eigen vectors

By using (1), we have the equation,
(A-$\lambda I)X = 0$ (2)
Where **I** is the n x n Identity matrix. This is a homogeneous system of equations, and from fundamental linear algebra, we know that a nontrivial solution exists if and only if
Where **I** is the n x n Identity matrix. This is a homogeneous system of equations, and from fundamental linear algebra, we know that a nontrivial solution exists if and only if

$$\det(A - \lambda I) = 0 \quad (3)$$

Where det ( ) denotes determinant. When evaluated, becomes a polynomial of degree n. This is known as the characteristic equation of A, and the corresponding polynomial is the characteristic polynomial. The characteristic polynomial is of degree n. If A is n x n, then there are n solutions or n roots of the characteristic polynomial. Thus there are n eigenvalues of A satisfying the equation,

$AX_i = \lambda X_i$ (4)

Where i=1,2,3,…….,n

If the eigenvalues are all distinct, there are n associated linearly independent eigenvectors, whose directions are unique, which span an n dimensional Euclidean space.

The overall problem is to be able to accurately recognize a person's identity and take some action based on the outcome of the recognition process. Recognize a person's identity is important mainly for security reason, but it could also be used to obtain quick access to medical, criminal, or any type of records[3].

Steps

1. The first step is to obtain a set S with M face images. In our example M = 16 .Each image is transformed into a vector of size N and placed into the set.$S = \{\Gamma_1, \Gamma_2, \Gamma_3, \ldots\ldots\ldots, \Gamma_M\}$. new full-size matrix (m×p).where m is number of training image and p is $x \times y$
2. Find the mean image ψ $\psi = \frac{1}{M}\sum_{i=1}^{M} \Gamma i$
3. The mean image is subtracted from each image of training set as well as from the test image .After subtraction we will get new image called difference image.$\Phi_i = \Gamma_i - \psi$ (I =1, 2,3, …….M) where, $A=[\Phi_1, \Phi_2, \Phi_3, \ldots\ldots\ldots, \Phi_m]$ is the mean-subtracted matrix vector with its size Amp .
4. The covariance matrix is given by:$C_{mn} = A_{mp} \times A_{pm}^T$

   $$C = \frac{1}{M}\sum_{n=1}^{M} \Phi_i \; \Phi_i^T$$

5. It is from this matrix that we are interested in finding the set of vectors u_k and scalars λ_k that satisfy the relations $\lambda_k = \frac{1}{M}\sum_{n=1}^{M}(u_k^T \; \Phi_n)^2$ is a maximum, subject to $u_k = \delta_{lk} = 1$ if l = k

   $= 0$ otherwise

6. Calculation of the Eigenvectors and Eigen values from the covariance matrix using Jacobi's method
7. For an eigenvector v_i associated to an eigenvalue λ_i we have:

   $C v_i = \lambda i \, v_i$. The matrix C has the form AA^T. Let us consider the matrix

   $L = AA^T$ having the Eigenvectors u_i associated to Eigenvalues e_i $L_i = e_i u_i$

   Let $AA^T \; u_i = e_i u_i$

   By multiplying by A the left of the two sides of the equality,

   we obtain: $AA^T \; A \, u_i = A \, e_i u_i$

   And since $C = AA^T$ we can simplify (8):

   $C \, Au_i = A \, e_i u_i$

   According to the definition of the eigenvectors and Eigen values of the matrix C we have:

   $v_i = Au_i$

   $\lambda_i = e_i$ $C(Au_i) = e_i(Au_i)$

8. Each eigenvector belongs to one of the eigenface. These vectors (v_1) determine linear combinations of the M training set face images to form the eigenfaces u_1

   $u_l = \sum_{k=1}^{M} v_{lk} \; \Phi_k$ $l = 1,2, \ldots\ldots\ldots, M$

9. Based on the eigenface each image has its face vector .then the weight of the test image is subtracted from each weight vector of the difference image. $\omega_k = u_k^t(\Gamma - \psi)$ .Therefore, for each face image in the training set, we would have a set of M' weights, $\Omega^T[\omega_1, \omega_2, \omega_3, \ldots\ldots\ldots\ldots, \omega_M]$,which describes the contribution of each Eigen face to the face image and its size is $M' \times 1$
10. The training and test image vectors can be reconstructed by a back transformation from the eigenface space to the image vector space.
11. Reconstructed image vector.$\Gamma_f = \psi + \Phi_f$ Where $\Phi_f = \sum_{k=1}^{m'} \omega_i \, u_i$

4. RECOGNITION PROCEDURE USING MAHALANOBIS DISTANCE

First, the image Γ_i is transformed into its components Eigen faces according above formula $\Omega_{new}^T = [\omega_1, \omega_2, \omega_3, \ldots\ldots\ldots\ldots, \omega_{M'}]$ Then, the class of face providing the best description of Γ_{new} is determined by calculating the minimal distance between the vector Ω_{new}^T and those stored in the data base. he most used metric is the Mahalanobis Distance. Let X, Y be eigenfeature vectors of length n. Then we can calculate the following distances between these feature vectors Mahalanobis space is defined as a space where the sample variance along each dimension is one. Therefore, the transformation of a vector from image space to feature space is performed by dividing each coefficient in the vector by its corresponding standard deviation. This transformation then yields a dimensionless feature space with unit variance in each dimension. If there are two vectors x and y in the unscaled PCA space and corresponding vectors m and n in Mahalanobis space. First,we define $\lambda_i=\sigma_i^2$ where λ_i are the eigenvalue,σ_i^2 is the variance along those direction and σ_i is the standard deviation. The relationship between deviation is defined as :

$$m_i = \frac{x_i}{\sigma_i} \qquad n = \frac{y_i}{\sigma_i}$$

$$d(x,y) = \sqrt{\sum_{i=1}^{k}(m_i - n_i)}$$

Where λ_i is the i^{th} Eigenvalue corresponding to the i^{th} Eigenvector.

A face Γ_{new} belongs to a class K when the minimum distance between Ω_{new} and Ω_{k}(1<K<M) is below a certain threshold θ, otherwise the face is regarded as unknown and can be possibly used to create a new class.The above procedure takes place in a Face Recognition System such as shown in the Figure 1:

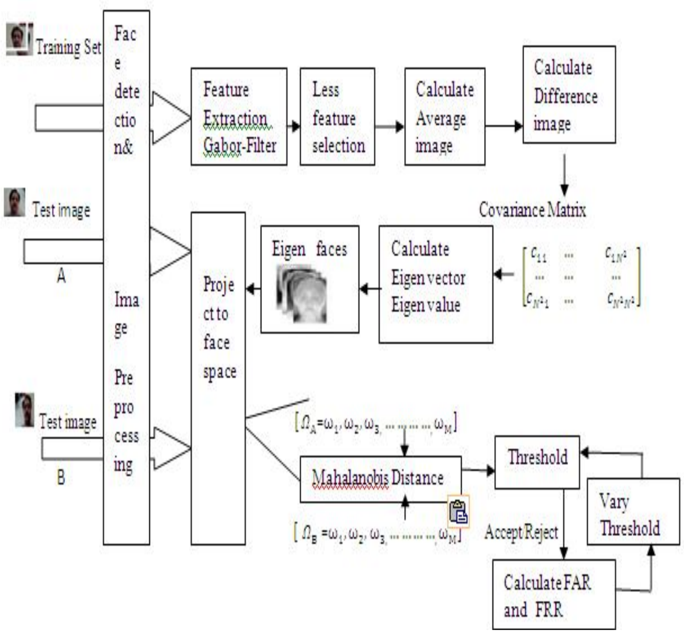

Figure 1:Face Detection and Recognition system

5. CONCLUSION

The proposed face detection is performed by using Haar based cascade classifier. It was capable of classifying known faces as well as discarding unknown face images. Combination of Eigen face approach and Feature extraction using Gabor Filter, Eigen face approach and Mahalanobis Distance we will achieve very high recognition accuracy using real time database.

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