Face Recognition Using Partial Feature Extraction

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ABSTRACT: *This paper presents an algorithm that has been developed to solve the occlusion problem that usually occurs in facial recognition. Although the normal PCA method can recognize faces, its accuracy is highly reduced under occlusion and facial expression alterations. Hence an extension of this method can increase the efficiency by eliminating some features that are responsible for reducing the accuracy of face recognition.*

KEYWORDS: PCA, Image processing, Face recognition, Partial Occlusion.

1. INTRODUCTION

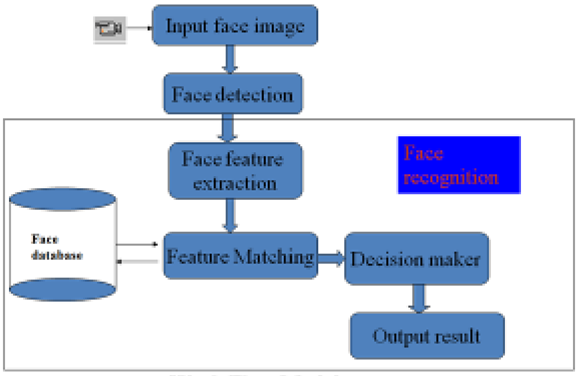
Face recognition has become a significant research topic in computer vision, with a large number of studies emphasizing on the rising security threats such as organized crime and terrorism. Conventional applications of face recognition system, especially those of access control, authentication, and surveillance, normally need maximum information of face to attain superior recognition performance. However, occasionally it is difficult to get a full face under certain restricted situations. For example, a non-cooperative face can lead to face occlusion. Moreover, people have to hide their face due to occupation (i.e. soldier), transmittable disease, naturally or accidentally distorted face and religious practices. Thus, to solve the problem of face recognition in restricted circumstances mentioned above, the partial face recognition can give one of the possible solutions.

There are many challenges to overcome in face recognition; illumination variation, facial expression, poses, occlusion. Lot of work have been done on face recognition, however, it remains still an unsolved problem which presents only successful results under controlled scenarios where the acquisition conditions like illumination, pose, facial expressions and face occlusions don't vary significantly. This paper proposes an approach to deal with some of these difficulties; more specifically to deal with problems due to face occlusions and facial expression variations which are present in most of the real face recognition systems.

2. RELATED WORK

Automated face recognition is a relatively new concept. Developed in the1960s,the first semi-automated system for face recognition required the administrator to locate features (such as eyes, ears, nose, and mouth) on the photo-graphs before it calculated distances and ratios to a common reference point, which were then compared to reference data. In the 1970s, Goldstein, Harmon, and Lesk used 21 specific subjective markers such as hair color and lip thickness to automate the recognition. The problem with both of these early solutions was that the measurements and locations were manually computed. In 1988, Kirby and Sirovich applied principle component analysis, a standard linear algebra technique, to the face recognition problem. In 1991, Turk and Pentland discovered that while using the eigenfaces techniques, the residual error could be used to detect faces in images. Although the approach was somewhat constrained by the environmental factors, nonetheless created significant interest in furthering automated face recognition technologies. The technology first captured the public attention from the media reaction to a trial implementation at the January 2001 Super Bowl, which captured surveillance images and compared them to a database of digital mug shots. This demonstration initiated much needed analysis on how to use the technology to support national needs while being considerate of the public's social and privacy concerns.

General work flow model for face recognition



Work Flow Model

3. A BRIEF NOTE ON EIGENFACES

Eigenfaces are a set of eigenvectors used in the computer vision problem of human face recognition. Eigenfaces assume ghastly appearance. 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 NxN pixels is considered a point (or vector) in N2 dimensional space.Eigenfaces is still considered as the baseline comparison method to demonstrate the minimum expected performance of such a system

A. Approach followed for facial recognition using eigenfaces

The whole recognition process involves two steps,

a. Initialization process
b. Recognition process

The Initialization process involves the following operations:

1. Acquire the initial set of face images called as *training set.*

2. Calculate the eigenfaces from the training set, keeping only the highest eigenvalues. These *M* images define the face space. As new faces are experienced, the eigenfaces can be updated or recalculated.

3. Calculate the corresponding distribution in *M*-dimensional weight space for each known individual, by projecting their face images on to the *"face space"*.

These operations can be performed from time to time whenever there is a free excess operational capacity. This data can be cached which can be used in the further steps eliminating the overhead of re-initializing, decreasing execution time thereby increasing the performance of the entire system.

Having initialized the system, the next process involves the steps,

[1] Calculate a set of weights based on the input image and the *M* eigenfaces by projecting the input image onto each of the eigenfaces
[2] Determine if the image is a face at all (known or unknown) by checking to see if the image is sufficiently close to a *"free space"*.
[3] If it is a face, then classify the weight pattern as either a known person or as unknown.
[4] Update the eigenfaces or weights as either a known or unknown

If the same unknown person face is seen several times then calculate the characteristic weight pattern and incorporate into known faces.

The last step is not usually a requirement of every system and hence the steps are left optional and can be implemented as and when the there is a requirement.

4. APPLICATION OF PCA IN FACIAL RECOGNITION

The main idea of the principal component analysis is to find the vectors which best account for the distribution of face images within the entire image space. Each vector is of length N^2, describes an *N* by *N* image, and is a linear combination of the original face images. Because these vectors are the eigenvectors of the covariance matrix corresponding to the original face images, and because they are face like in appearance, we refer to them as eigenfaces.

Let the training set of face images be $\Gamma 1, \Gamma_2 ... \Gamma_M$. The average face of the set is defined by $\Psi = 1/M \sum \Gamma_k$. Each face differs from the average by the vector $\Phi i = \Gamma_i - \Psi$. This set of very large vectors is then subject to principal component analysis, which seek a set of M orthogonal vector, u_k, which best describes the distribution of data. The kth vector u_k chosen such that,

$$\lambda_k = (1/M)\,(u_k^T\,\Phi_n)^2 \qquad (1)$$

The vector u_k and λ_k scalar are eigenvector and eigenvalues respectively of the covariance matrix

$$C = (1/M)\Sigma^M_{n=1}\,\Phi.\Phi^T \qquad (2)$$

$$= A.\,A^T$$

where the matrix A=[□□□□□□□□□□□□□□□□□□□□□$_M$]

The matrix C, however, is N^2 x N^2 by N,and determining the N eigenvectors and eigenvalues is an intractable task for typical image sizes. A Computationally feasible method is to be funded to calculate these eigenvectors. If the number of data points in the image space is $M(M<N^2)$, there will be only $M-1$ meaningful eigenvectors, rather than N^2. The eigenvectors can be determined by solving much smaller matrix of the order M^2xM^2 which reduces the computations from the order of N^2 to M pixels. Therefore we can construct the matrix L

$$L=A.A^T$$

$$A^T.A \quad (3)$$

where $,L_{MN=}=\square_m$

and find the M eigenvector u_l of L .These vectors determine linear combination of the M training set face images to form the eigenfaces v_l

$$v_l=\square\square u_{lk}$$

where $l = 1......M$

Once the eigenfaces are created, identification becomes a pattern recognition task. The eigenfaces span an N^2-dimensional subspace of the original A image space. The M' significant eigenvectors of the L matrix are chosen as those with the largest associated eigenvalues. A new face image (I) is transformed into its eigenface components (projected into "face space") by a simple operation,

$$\Omega_k = v_k^T \square \Gamma_k - \Psi$$

where $k = 1.......M'$

This describes a set of point-by-point image multiplications and summations.

$$\Omega^T = \square \Omega_1 \Omega_2 .... \Omega_{M'}$$

that describes the contribution of each eigenface in representing the input face image, treating the eigenfaces as a set for face images. The vector is used to find which of a number of predefined face classes, if any, best describes the face. The simplest method for determining which face class provides the best description of an input face image is to find the face class k that minimizes the *Euclidean distance*

$$\square\square \; \Omega - \Omega_k$$

where Ω_k is a vector describing the k_{th} face class

A face is classified as belonging to class k when the minimum εk is below some chosen threshold $\theta\varepsilon$ .Otherwise the face is classified as "unknown". The distance threshold, $\theta\varepsilon$, is half the largest distance between any two faces images, mathematically can be expressed as

$$\theta\varepsilon = \tfrac{1}{2} \max_{jk} \{ || \Omega - \Omega_k || \} \quad (8)$$

where $j,k = 1 ...M$

Recognition process can formulated as:

If

$\varepsilon \geq \theta\varepsilon$:- then input image is not a face

$\varepsilon < \theta\varepsilon , \square \geq \theta\varepsilon$:- then input image contains an unknown face

$\varepsilon < \theta \square_{k'} = min\{\square\} < \theta$:-

then image contains face of individual k'

- In the first case, an individual is recognized and identified.
- In the second case, an unknown individual is present.
- In the first case, the image is not a face image. Case one typically shows up as a false positive in most recognition systems

5. IMPLEMENTATION ON WITHOUT OCCLUSION & RESULTS

The above discussed methodologies have been implemented in MATLAB. The Algorithm has been tested for the standard image databases such as Yale's database [6], and for the testing purpose a small color image Database having 10 test subjects each with 3 facial postures and small illumination change, with a total of 30 images.

And the results from the above implementation are –

DATABASE TYPE	NUNBER OF IMAGES	RECOGNATION RATE
YALES DATABASE	400	77%
COLOR IMAGES	30	65%

6. THE PROPOSED TECHNIQUE

The technique proposed in this paper is a natural extension of the PCA approach where several subsets of images are created through masking. In each subset, the images used in the training and recognition stages are masked in those regions where significant modifications are expected to occur as a

consequence of occlusion or expression change. Fig 2 shows the six subsets of images which correspond to the whole face (original image), and the masking of the left eye, the right eye, eyes, nose and mouth respectively.

Fig 2. Training images for PCA

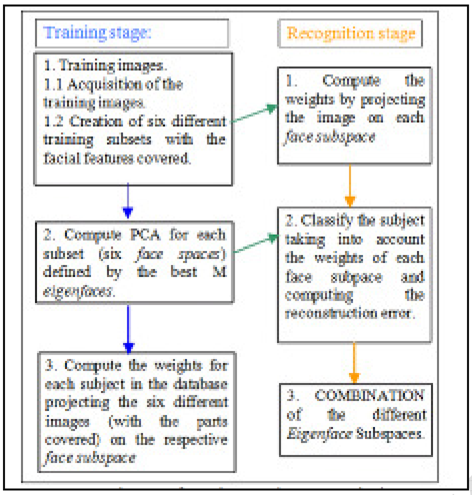


Fig. 3 Summarization of main steps of the technique

The diagram shown in Fig. 3 summarizes the main steps of this technique. Therefore instead of having only one set of training images which will be used to create only one face space, six different training subsets are used to create six different face projection spaces.

The objective of introducing the masks (black rectangles) is that the part of the face covered with them, will have no influence in the respective projection subspace. Thus, if the face image, used in the recognition task, presents one occluded part or parts that have changed drastically (e.g. moustaches and beards) the best match will take place when projecting to the face subspace with this part covered.

7. ACKNOWLEGMENT

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8. REFERENCES

[1] Mr.Dinesh Chandra Jain and Dr. V. P. Pawar, “A Novel Approach For Recognition of Human Face Automatically Using Neural Network Method”, International Journal of Advanced Research in Computer Science and Software Engineering, 2010.

[2] Yasmina Andreu, Ram´on A. Mollineda, and Pedro Garc´ıa-Sevilla , “Gender Recognition from a Partial View of the Face Using Local Feature Vectors”.

[3] Dr. V.Cyril Raj, Head of the Computer Science & Engg. Department, Dr.MGR Educational and Research Institute Chennai, Tamilnadu, INDIA, “An efficient method for face recognition using principal component analysis”, International Journal of Advanced Technology & Engineering Research (IJATER) ISSN NO: volume 2, issue 2, March 2012.

[4] Jeong-Seon Park, You You Hwa Oh, Sang Chul Ahn,and Seong-Whan Lee, Sr. Member, IEEE, “Glasses Removal from Facial Image Using Recursive Error Compensation”, April 2007.

[5] R.Chellapa, L.Wilson and S.Sirohey “Human and machine recognition of Faces: A Survey ”, Proc IEEE, vol.83, pp. 705-740, 1995.

[6] Yales Face Database http://cvc.yale.edu/projects/yalefaces/yalefaces.html

[7] M.Turk and A. Pentland, "Eigenfaces for Recognition", Journal of Cognitive Neuroscience, March 1991.