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Static Face Recognition Using Hierarchical Model

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Abstract— Face is an important biometric feature for personal identification. Human beings easily detect and identify faces in a scene but it is very challenging for an automated system to achieve such objectives. Hence there is need to have reliable identification method for user interactions. A computer application which automatically identifies or verifies a person from a digital image or a video frame from a video source, is presented and it is done by comparing selected facial features from the image and a facial database. One of the retrieving method is Content based image retrieval (CBIR), which retrieves images on the basis of automatically derived features. This paper draws points from it but, focuses on a low-dimensional feature based indexing technique for achieving efficient and effective retrieval performance. A static appearance based retrieving system for face recognition referred to as hierarchical model is presented based on singular value decomposition (SVD) is proposed in this paper and is different from principal component analysis (PCA), which effectively considers only Euclidean structure of face space for analysis and leads to poor classification performance in case of great facial variations such as expression, lighting, occlusion and so on, due to the fact the image gray value matrices on which they manipulate are very sensitive to these facial variations. It is a known fact that every image matrix can always have the well known singular value decomposition (SVD) and can be regarded as a composition of a set of base images generated by SVD and further it is pointed out that base images are sensitive to the composition of the face image. Finally the experimental results show that SVD has the advantage of providing a better representation and achieves lower error rates in face recognition but it has the disadvantage that it drags the performance evaluation. So, in order to overcome that, a controlling parameter 'α ', which ranges from 0 to 1 is introduced a better result is achieved for α=0.4 when compared to the other value of 'α" and it is also seen that it reduces classification redundancy.

Keywords— **Face recognition, Feature based methods, singular value decomposition Euclidean *distance Original gray value matrix.***

I. INTRODUCTION

The automated face recognition system is quite difficult to develop since human face is quite complex, multidimensional and depends on environment changes. The human machine recognition of human faces is a challenging problem due the changes in the face identity and variation between images of the same due to illumination, pose variations and some natural effects. The issues are how the features adopted to represent a face under environmental changes and how we classify a new face image based on the chosen representation. Computers that recognize human faces systems have been applied in many applications such as security system, mug shot matching and model-based video coding.

The problem of face recognition is curse of dimensionality and there are two de-facto baseline approaches namely PCA and LDA however, despite of the achieved successes, these DR methods will inevitably lead to poor classification performance in case of great facial variations such as expression, lighting, occlusion and so on since face image matrix is very sensitive to these facial variations. It is illustrated that the Eigen values of an image are not necessarily be stable hence discrimination of images affected by illumination and other said a factor is very difficult.

The face recognition and classification is a great challenging problem since face images are highly variable, Sources of variability include individual appearance, three-dimensional (3-D) facial expression, facial hair, makeup, and so on and these factors change from time to time. Furthermore, the lighting, background, scale, and parameters of the acquisition are all variables in facial images acquired under real-world scenarios. The variations between the images of the same face due to illumination and viewing direction are almost always larger than image variations due to changes in the face identity.

The approach presented in this paper consists of several phases. The algorithm uses a database of face images for training and recognition. The test images are acquired by the system via camera. The acquired images are then normalized; the dimension of image matrix is then reduced. The reduced image matrix is then decomposed to get singular values and to these singular values a controlling factor is a applied for removing the effects of variations. Finally the evaluated controlling factor is applied to take care of redundant images.

II.PROBLEM STATEMENT

Given an input face image which is complex and a database of face images of known individuals, how can we verify or determine the identity of the person in the input image under large variations and thereby improve the classification rate by taking care of redundancy.

III.OBJECTIVE OF THE STUDY

The larger objectives are:

1) Introduction of a hierarchical Algorithm.
2) To prove that hierarchical algorithm improves the classification rate.
3) To extract the information contained in a face image and use this information for encoding and comparison.
4) To increase computational efficiency by using fewer singular values.
5) To elevate the problem of facial expression, occlusion, illumination.
6) To reduce the redundancy in classification.

Although many face recognition approaches by human beings and machines were developed in past, it is still difficult to design an automatic system for the task because in real world, illumination, complex background, visual angle and facial expression for face images are highly variable.

It has proved and concluded by many researchers that singular value decomposition algorithm is not suitable for such an environment due to poor classification results but this work intended to bridge this gap and to show that singular value decomposition is indeed becomes efficient just by applying minor changes in the algorithm.

IV.ALGORITHMIC OULINE

The hierarchical model of algorithm builds from selection of Eigen features, decomposition of image matrix to get singular values. This second step includes dimensionality reduction by PCA. To this singular matrix a controlling factor is applied and this factor is so selected that it helps to get rid of image classification redundancy (13).

The above processes are outlined briefly as follows:

A) EIGEN FACE

Biggest challenge in face recognition still lies in the normalization and pre-processing of the face images so that they are suitable as input into the recognition module. Eigen face approach is one of the earliest appearance-based face recognition methods, which was developed by M. Turk and A. Pentland in 1991. This method utilizes the idea of the principal component analysis and decomposes face images into a small set of characteristic feature images called Eigen faces.

The Eigen face method simply evaluates the entire image as a whole. These properties make this method practical in real world implementations. The basic concept behind the Eigen face method is information reduction. When one evaluates even a small image, there is an incredible amount of information present. From all the possible things that could be represented in a given image, pictures of things that look like faces clearly represent a small portion of this image space.

The Eigen face images calculated from the eigenvectors of L span a basis set with which to describe face images. As mentioned before, the usefulness of eigenvectors varies according their associated Eigen values. This suggests we pick up only the most meaningful eigenvectors and ignore the rest, in other words, the number of basic functions is further reduced from M to M' (M'<M) and the computation is reduced as a consequence.

The Eigen faces approach for face recognition could be summarized as follows:

- Collect a set of characteristic face images of the known individuals. This set should include a number of images for each person, with some variation in expression and in the lighting (say four images of ten people, so M=40).
- Calculate the (40 x 40) matrix L, find its eigenvectors and Eigen values, and choose the M' eigenvectors with the highest associated Eigen values (let M'=10 in this example).
- Combine the normalized training set of images according to Eq. (6) to produce the (M'=10) Eigen faces $\mu_k, k = 1,......, M'$.

B) SINGULAR VALUE DECOMPOSITION

The singular value decomposition is an outcome of linear algebra. It plays an interesting, fundamental role in many different applications. On such application is in digital image processing. SVD in digital applications provides a robust method of storing large images as smaller, more manageable square ones.

This is accomplished by reproducing the original image with each succeeding nonzero singular value. Furthermore, to reduce storage size even further, images may approximate using fewer singular values.

The singular value decomposition of a matrix A of m x n matrix is given in the form,

$$A = U\Sigma V^T$$

here U is an m x m orthogonal matrix; V an n x n orthogonal matrix, and Σ is an m x n matrix containing the singular values of A.

$$\sigma_1 \geq \sigma_2 \geq \cdots \geq \sigma_n \geq 0$$

along its main diagonal. The principle of SVD is explained mathematically asbelow:

Let A be an m x n matrix. The matrix A^TA is symmetric and can be diagonalized. Working with the symmetric matrix A^TA, two things are true:

1. The Eigen values of A^TA will be real and nonnegative.
2. The eigenvectors will be orthogonal.

To derive two orthogonal matrices U and V that diagonalizes an m x n matrix A,

First, if it is required to factor A as

$$A = U\Sigma V^T$$

then the following must be true.

$$A^TA = (U\Sigma V^T)^T(U\Sigma V^T)$$

$$A^TA = V\Sigma^T U^T U\Sigma V^T$$

$$A^TA = V\Sigma^T\Sigma V^T$$

$$A^TA = V\Sigma^2 V^T$$

this implies that Σ^2 contains the Eigen values of A^TA and V contains the corresponding eigenvectors. To find the V of the singular value decomposition,

$$A = U\Sigma V^T$$

These SVD features are used for facial feature decomposition to represent an image but, these features are found to be effected by facial variations as well as environmental variations. To take care of these variations a controlling factor is introduced and a novel method known as Fractional Order Singular Value Decomposition is proposed by un Liu, Song can Chen, Xiao yang Tan(1) which is outlined briefly below:

C) Fractional Order Singular Value Decomposition.

For each face image matrix A which has the SVD, its FSVD can be defined as,

$$B = U\Sigma^{\alpha} V^T$$

Where U, Σ and V are the SV matrices, and δ is a fractional parameter that satisfies $0 \leq \alpha \leq 1$ .The fractional parameter and it's optimal selection is an important criterion in making the face recognition process more accurate so that redundancy can be checked.

The Fractional singular value approach for face recognition involves the following initialization operations:

1. Acquire a set of training images.
2. Calculate the singular values from the max *r* , *c* training set, keeping only the best *M* images with the highest values. These *M* images define the "face space".
3. Calculate the corresponding distribution in *M*-dimensional weight space for each known individual (training image), by projecting their face images onto the face space. Having initialized the system, the following steps are used to recognize new face images:
4. Given an image to be recognized, calculate the singular features of the *M* faces by projecting it onto each of the faces.
5. These SVs features are raised by a fractional parameter α hence called fractional order based method. On selectivity of this parameter this recognition system can achieve superior performance by deflating the more dominant leading base
6. FSVDR acts an intermediate representation between face images and data representation for face recognition.
7. Determined features are further processed using PCA so as reduce the dimension of the image so as to have more samples since more number of samples will always produce greater classification accuracy,
8. However, principal component analyses (PCA), yields projection directions that maximize the total scatter across all classes, i.e., across all face images. In choosing the projection which maximizes the total scatter, the PCA retains unwanted variations caused by lighting, facial expression, and other factors accordingly, the features produced are not necessarily good for discrimination among classes. In the face features are acquired by using the fisher face or discriminate feature paradigm. This paradigm aims at overcoming the drawback of the PCA paradigm by integrating Fisher's linear discriminate (FLD) criteria, while retaining the idea of the Eigen face paradigm in projecting faces from a high-dimension image space to a significantly lower-dimensional feature space.

V. DESIGN ASPECTS

Due to the complexity of the face recognition problem, a modular design approach is taken whereby the system was separated into smaller individual stages. Each stage in the designed architecture performs an intermediate task before integrating the modules into a complete system. The face recognition system developed performs three major tasks – pre-processing of given face image, extracting the face feature for recognition, and performing classification for the given query sample. The system operates on two phase of operation namely training and testing phase.

The developed face recognition system is shown in figure 1.

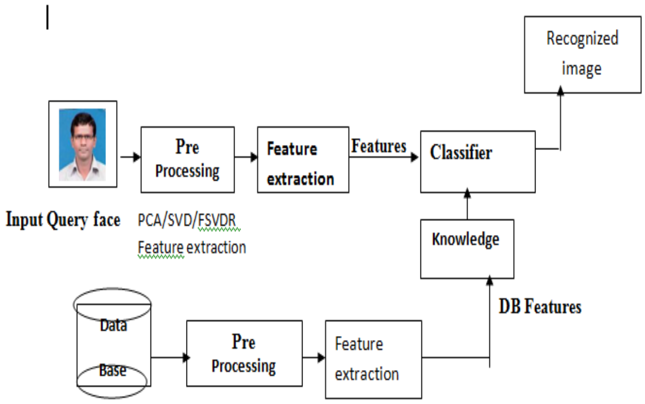

Figure 1: Face Recognition System.

Input Image

This forms the first state for the face recognition module. To this module a face image is passed as an input for the system. The input image samples are considered of non-uniform illumination effects, variable facial expressions, and face image with glasses. Block diagram above shows facial image taken as test sample for face recognition. The input image is randomly picked up from the self built data & Yale data base used for training and evaluated for the recognition accuracy.

Pre-Processing

In this phase of operation the face image passed is transformed to operational compatible format, where the face image is resized to uniform dimension, the data type of the image sample is transformed to double precision and passed for feature extraction.

Feature Extraction

This unit runs the PCA, SVD and FSVD algorithm for the computation of face features for recognition. The unit calculates the U, V, S matrix using SVD operation for given face image. On computation to SVD features for the calculation of FSVD features this unit takes the fractional factor α for the computation of $B=U\ S^{\alpha}V^{T.}$ The obtained facial expressions are the SV used as facial feature for face recognition. These features are passed to the classifier unit for the classification of given face query with the knowledge created for the available database.

Training

For the implementation of the proposed face recognition architecture the database samples are trained for the knowledge creation for classification. During training phase when a new facial image is added to the system the features are calculated and aligned for the dataset formation. This data set consists of the image index and its corresponding features extracted. This feature table is created for the entire database image and passed for recognition.

VI. PROPOSED ALGORITHM

Variations are assumed to be the Independent variables and Singular values are considered to be the dependent variables.

Let the face image in the data Base be represented as F (i) K, where i represent the total number of samples for K^{th} class face image. Then the SVD feature for the given face image is calculated as:

1) Apply SVD on each of the face image for each class in the database, such that $\Psi i = UiSiVi^{\ t}$. where, $U = [u_1, u_2, u_m]$, $V = [v_1, v_2, v_n]$, and $S = [0\ X_i\ 0]$, X_i=diag (s_i), s_i are the computed Singular vector for each face image.

(2) The obtained Singular Vector is applied with the fractional value α and a modified SVD values are obtained as, $Bi=Ui\ Si^{\alpha}Vi^{t}$

(3) Each training face image $F_i^{\ (k)}$ is then projected using these obtained face feature image.

(4) For the obtained representing image apply a DR method PCA, where the Eigen features are computed and for the maximum Eigen values Eigen vectors are located and normalized for this projected image.

(5) A test face image $Tr \sim \epsilon\ R^{m\times n}$ is transformed into a face feature matrix $Yr\ \epsilon\ R^{r\times c}$ by $Yr = UrSrVr^{\ t}$.

(6) For the developed query feature a image representation is developed and passed to the PCA.

(7) For the computed face feature the distance between a test face image T and a training face images $X_i^{\ (j)}$ is calculated and the minimum distance is the recognized image.

(8) The recognised image is such that it is only one for the test face image T which illustrated that redundancy is nullified.

VII. CONCLUSION

In this proposed research, it is shown that the face image matrix *A* can be viewed as a composition of a set of base images generated by their SVD per se, where the leading base images on one hand dominate the composition of *A* and on the other hand are sensitive to the great facial variations within the image matrix *A*. Based on these observations, we propose a novel hierarchical Model which improves classification rate and checks redundancy in classification.

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