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Eigenface Approach For The Recognition Of Face And Detection Of The Face

Er. Anup lal Yadav, Er. Sahil Verma, Er. Kavita
M-Tech Student
Asst. Prof. in C.S.E. Deptt.
EMGOI , Badhauli.
sahilkv4010@yahoo.co.in
Asst. Prof. in C.S.E. Deptt.
EMGOI , Badhauli

Abstract
As one of the most successful applications of image analysis and understanding, face recognition has recently received significant attention, especially during past few years. Recently face recognition is attracting much attention in the society of network multimedia information access. Areas such as network security, content indexing and retrieval, and video compression benefits from face recognition technology because "people" are the center of attention in a lot of video. Network access control via face recognition not only makes hackers virtually impossible to steal one's "password", but also increases the user-friendliness in human-computer interaction. Indexing and/or retrieving video data based on the appearances of particular persons will be useful for users such as news reporters, political scientists, and moviegoers. For the applications of videophone and teleconferencing, the assistance of face recognition also provides a more efficient coding scheme. In this paper, we give an introductory course of this new information processing technology.

Introduction

Face recognition is one of biometric methods identifying individuals by the features of face. Research in this area has been conducted for more than 30 years; as a result, the current status of face recognition technology is well advanced. Many commercial applications of face recognition are also available such as criminal identification, security system, image and film processing.

From the sequence of images captured by camera, the goal is to find best match with given image. Using a pre-stored image database, the face recognition system should be able to identify or verify one or more persons in the scene. Before face recognition is performed, the system should determine whether or not there is a face in a given image or given video, a sequence of images. This process is called face detection. Once a face is detected, face region should be isolated from the scene for the face recognition. The face detection and face extraction are often performed simultaneously. The overall framework of face recognition system is shown in fig 1:

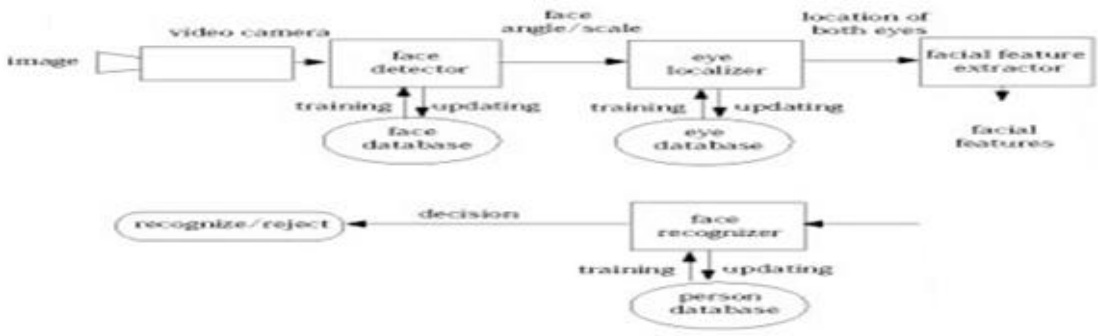


FIG 1: FARMEWORK OF FACE RECOGNITION Face recognition can be done in both a still image and video which has its origin in still-image face recognition. Different approaches of face recognition for still images can be categorized into tree main groups such as holistic approach, feature-based approach, and hybrid approach

Holistic Approach

In holistic approach, the whole face region is taken into account as input data into face detection system. Examples of holistic methods are eigenfaces (most widely used method for face recognition), probabilistic eigenfaces, fisherfaces, support vector machines, nearest feature lines (NFL) and independent-component analysis approaches. They are all based on principal component-analysis (PCA) techniques that can be used to simplify a dataset into lower dimension while retaining the characteristics of dataset.

Feature-based Approach

In feature-based approaches, local features on face such as nose, and then eyes are segmented and then used as input data for structural classifier. Pure geometry, dynamic link architecture, and hidden Markov model methods belong to this category.

Hybrid Approach

The idea of this method comes from how human vision system perceives both local feature and whole face. There are modular eigenfaces, hybrid local feature, shape-normalized, component-based methods in hybrid approach.

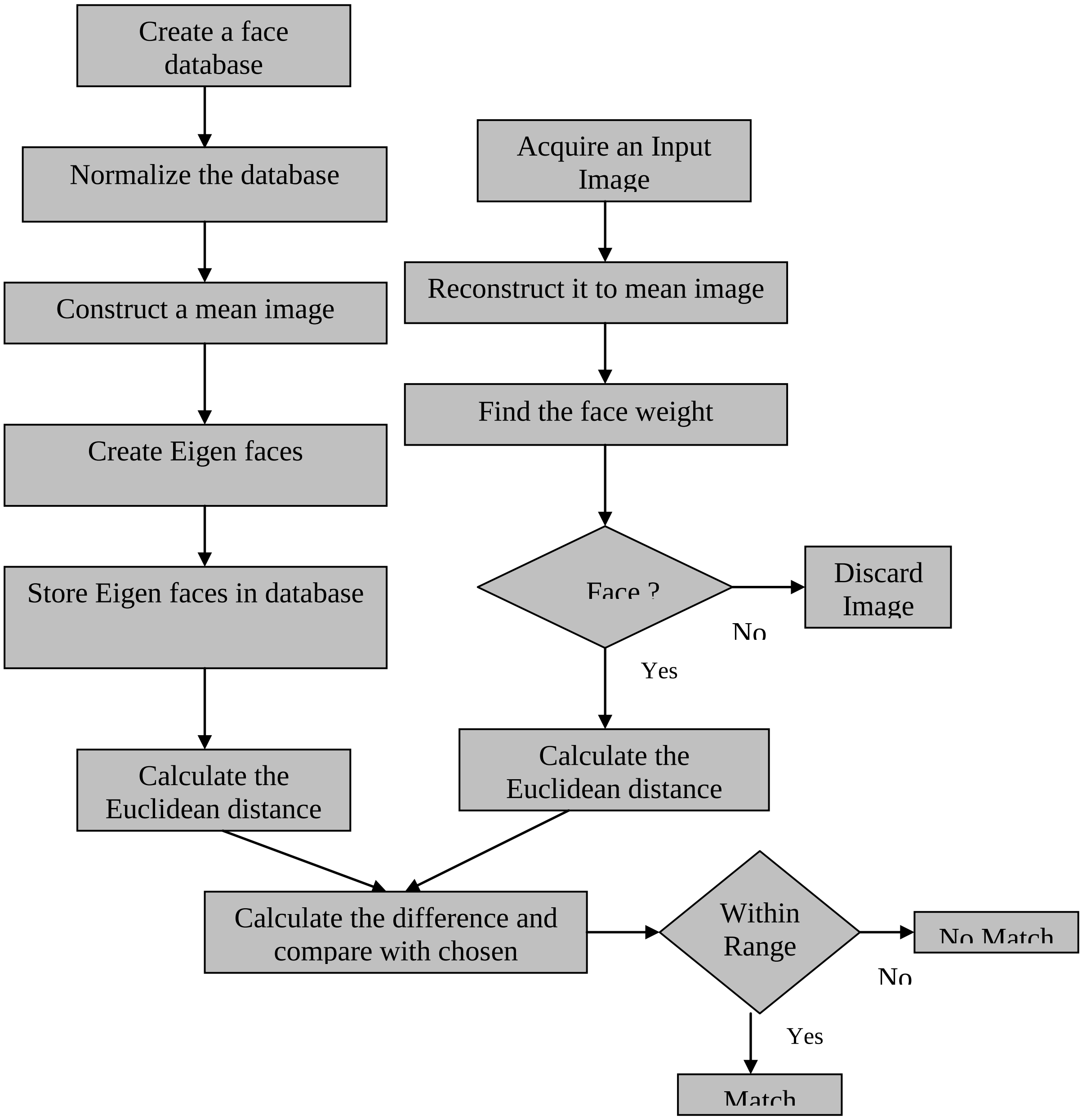
Procedure for Eigenface approach

1. Form a face library that consists of the face images of known individuals. This was a training set. A face image, I(x,y), is a two-dimensional N by N matrix of intensity values, which are usually quantized to 8-bit values. Each x and y pair denotes a position in the image. For the purpose of exposition, it is represented in the matrix of intensity values as a vector, where each row is concatenated. Now, instead of having a matrix of dimension N by N, we have a vector of dimension N^2.
2. Choose a training set that includes a number of images (M) for each person with some variation in expression and in the lighting.
3. Calculate the M x M matrix L, find its eigenvectors and eigenvalues, and choose the M' eigenvectors with the highest associated eigenvalues.

   To obtain the Eigenfaces for a training set, it is crucial to first determine the mean vector, deviation-from-mean vectors and the covariance matrix for the particular training set. Let the images in the training set be represented by $\{T_1, T_2, T_3, \ldots, T_M\}$, where each T_n is a vector of N^2-dimension. The value M is the number of images in the training set.

   The set of deviation-from-mean vectors, contains the individual difference of each training image from the mean vector.
4.
5. Combine the normalized training set of images to produce M' eigenfaces.

   The Eigenfaces are the set of principal components of the training set. To obtain the eigenface description of the training set, the training images are subjected to Principal Component Analysis (PCA), which seeks a set of vectors


Create a face database
Normalize the database
Construct a mean image
Create Eigen faces
Store Eigen faces in database
Calculate the Euclidean distance
Acquire an Input Image
Reconstruct it to mean image
Find the face weight
Face ?
No
Discard Image
Yes
Calculate the Euclidean distance
Calculate the difference and compare with chosen
Within Range
No
No Match
Yes
Match

(the principal components) which significantly describes the variations of the data. Mathematically, the principal components of the training set are the eigenvectors of the covariance matrix of the training set.

6. Form a face library that consists of the face images of known individuals. This was a training set. A face image, I(x,y), is a two-dimensional N by N matrix of intensity values, which are usually quantized to 8-bit values. Each x

7. and y pair denotes a position in the image. For the purpose of exposition, it is represented in the matrix of intensity values as a vector, where each row is concatenated. Now, instead of having a matrix of dimension N by N, we have a vector of dimension N^2.

8. Choose a training set that includes a number of images (M) for each person with some variation in expression and in the lighting.

9. Calculate the M x M matrix L, find its eigenvectors and eigenvalues, and choose the M' eigenvectors with the highest associated eigenvalues.

   To obtain the Eigenfaces for a training set, it is crucial to first determine the mean vector, deviation-from-mean vectors and the covariance matrix for the particular training set. Let the images in the training set be represented by $\{T_1, T_2, T_3, \dots, T_M\}$, where each T_n is a vector of N^2-dimension. The value M is the number of images in the training set.

   The set of deviation-from-mean vectors, contains the individual difference of each training image from the mean vector.

10. Combine the normalized training set of images to produce M' eigenfaces.

    The Eigenfaces are the set of principal components of the training set. To obtain the eigenface description of the training set, the training images are subjected to Principal Component Analysis (PCA), which seeks a set of vectors (the principal components) which significantly describes the variations of the data. Mathematically, the principal components of the training set are the eigenvectors of the covariance matrix of the training set.

11. Store these eigenfaces for later use.

12. For each member in the face library, compute and store a feature vector.

13. Choose a threshold e that defines the maximum allowable distance from any face class. Optionally choose a threshold f that defines the maximum allowable distance from face space.

14. For each new face image to be identified, calculate its feature vector and compare it with the stored feature vectors of the face library members.

    Recognition is performed by projection first; any image similar-sized can be fed into the system. Images of individuals not previously seen in the training set, as well as non-face images, can be projected onto face space, yielding the set of weights. Hence, a competent face recognition must be able differentiate between a face image and non-face image, and if a face image is received, whether it corresponds one or none of the individuals in the training set.

15. If the comparison satisfies the threshold for at least one member, then classify this face image as "known", otherwise a miss has occurred and classify it as "unknown" and add this member to the face library with its feature vector.

16. (Optional) For a test image with a previously unknown identity, the system was retrained by adding this image to the training set.

Conclusion and Future Scope

The Eigenface approach performs satisfactorily for our training set of faces. The method was found to be robust enough to account for changes in facial expressions and addition of accessories. It was capable of classifying known faces as well as discarding unknown face images. We developed a simpler but more effective method for the task.

Future Scope of Work:

- This project can be used to recognize the faces as well as buildings or other kind of images.
- System can be extended to include the matching of images of unequal size.

A. *References*

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