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Face Recognition using Eigenface

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Abstract- To recognize an image from a database is typical task due to the image of a face changes with facial expression, age, viewpoint, illumination conditions, noise etc. With the help of Facial expression we can read the emotion, intention etc these are the most powerful, natural, and immediate means for human beings to communicate. Facial expression carries crucial information about the mental, emotional and even physical states of the conversation. This paper proposes an Eigen based face recognition algorithm for recognize an image from the database. Eigen face has proven to be a useful and robust cue for face recognition, localization and tracking.

Keywords- Face Recognition, Eigenface, Eigen-values, Pose Invariance and Illumination Invariance.

I. INTRODUCTION

Different aspects of human physiology are used to authenticate a person's identity. The science of ascertaining the identity with respect to different characteristics trait of human being is called biometrics. The characteristics trait can be broadly classified in to two categories i.e. physiological and behavioral. Face biometrics belongs to physiological characteristic and Face biometrics is used by everyone every day. The face is the first defining characteristic which, we use to identify persons. Face is only the characteristic which is used to recall person, when trying to remember what person looks like. We use it, and eventually come to depend on it, for recognition. We carry photo IDs that we show as proofs of identity. On the cards are pictures of our face. Our trust in our ability to judge if we know someone by his/her face can also fool us as well. We have all at one time or another thought we recognized person face, only to have it not be the person we thought. For many people, including parents, twins present a unique problem. Some twins can be so similar that even the parents may need to identify them by some other means. Human face recognition has been studied for more than twenty years. Face biometrics always surprisingly questionable biometrics for identified person. Face recognition is a non-intrusive method, and facial attributes are probably the most common biometric features used by humans to recognize one another.

II. FACE RECOGNITION SYSTEM

Face recognition is an interdisciplinary field which integrates different techniques such as (i) image processing, (ii) pattern recognition, (iii) time attendance system, (iv) access control, (v) physiology, and (vi) Visitor management system. In general, the computerized face recognition includes four steps. Generalized Face recognition system is given in figure 1, which have different, modules sensor, pre-processing, feature extraction, template generator, post-processing etc and discussed step by step in followings way (i) A biometric system is essentially a pattern recognition system that acquires raw biometric data from a person using single or multi sensor, (ii) Face image is acquired, enhanced and segmented. (iii) Face boundary and facial features are detected. (iv) the extracted facial features are matched against the features stored in the database. (iv) the classification of the face image into one or more persons is achieved.

M. Kirby and L. Sirovich [1, 2] have shown that any particular face could be economically represented in terms of a best coordinate system that they termed "eigenfaces". Turk and Pentland [3] proposed and successfully implemented a eigenface based face recognition which is motivated by information theory. Nayar and Murase [4] utilized an eigen-space approach to represent and recognize general 3D objects at various poses, formulating object and pose recognition as parameterized appearance matching. Lu et.al [5] used parallel neural network for face recognition. Zhao et.al [6] proposed Linear Discriminant Analysis (LDA) for face recognition. Rabia Jafri et.al, [7] proposed a survey of face recognition technique, in which they discussed three methods; (i) that operate on intensity images, (ii) those that deal with video sequences, and (iii) those that require other sensory data such as 3D information or infrared imagery.

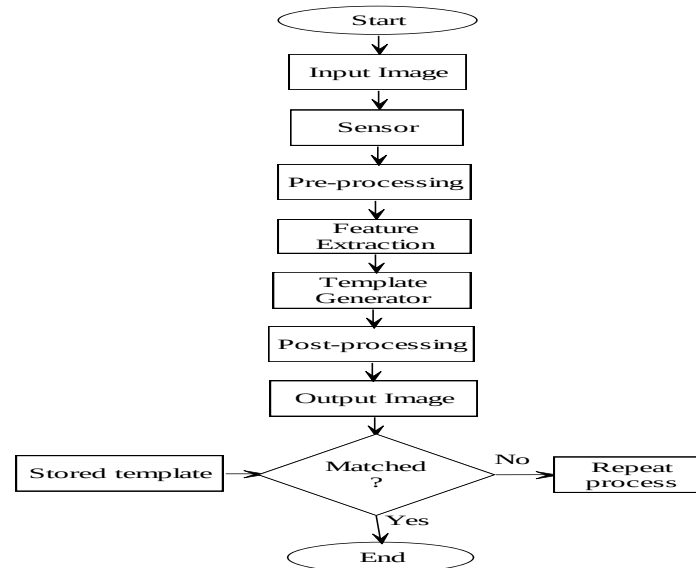


Figure 1: Block diagram of face detection/face recognition system

III. RELATED WORK

Face Databases

There are different standard face databases available in internet. This section shows some of the standard face databases.

Yale Database [8]: It consists of a set of standard 165 black and white images of 15 different people (11 Images per Person) taken from Yale university standard database for use in facial algorithm. All the images are properly aligned and taken in same and good lighting and background conditions. Resolution of each image is taken as 320x243 pixels. Figure 2 shows some of the faces of Yale database.

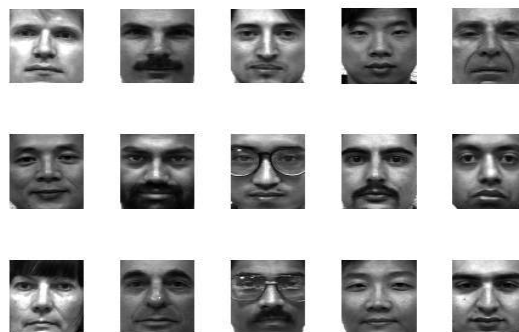


Figure 2: Faces of Yale Database

Extended Yale Database [9]: It contains 16128 images of 28 human subjects under 9 poses and 64 illumination conditions.

FERET Database, USA [10]: The database contains 1564 sets of images for a total of 14,126 images that includes 1199 individuals. All the images are of size 290x240. This database was cropped automatically and segregated into sets of 250 female and 250 male faces. Figure 3 shows some of the images of the FERET database.

Eigen face method for human face recognition is remarkably clean and simple. 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. The Eigenface approach is considered by many to be the first working facial recognition technology, and it served as the basis for one of the top commercial face recognition technology products. Consider face images (X, Y) , in 2-dimesional (2-D) of size $N \times N$ array with 8-bit intensity values. These images can be

thought of as a vector of dimension N^2 , or a point in N^2 -dimensional space. Basis vector is of length N^2 , and is the eigenvector of the covariance matrix corresponding to the original face images.



Figure 3: Faces of FERET database

IV. EIGEN BASED FACE RECOGNITION

An $N \times N$ matrix A is said to have an eigenvector X , and corresponding eigen-value λ , if

$$AX = \lambda X \quad (1)$$

Evidently, Eq. (1) can hold only if

$$\text{Det}[A - \lambda I] = 0 \quad (2)$$

This, if expanded out, is N_{th} degree polynomial in λ whose roots are the eigenvalues. This proves that there are always N (not necessarily distinct) eigenvalues. Equal eigenvalues coming from multiple roots are called "degenerate".

Let the training set of face images are $\Gamma_1 \Gamma_2 \dots \Gamma_M$, the average of the set is given by eqn. (3);

$$\Psi = \frac{1}{M} \sum_{n=1}^M \Gamma_n \quad (3)$$

Each face differs from the average by the vector $\Phi_i = \Gamma_i - \Psi$. The Co-variance matrix

$$C = \frac{1}{M} \sum_{n=1}^M \Phi_n \Phi_n^T \quad (4)$$

has a dimension of $N^2 \times N^2$. Determining the eigenvectors of C for typical sizes of N is intractable. Fortunately, we determine the eigenvectors by solving a $N \times N$ matrix. An example training set is shown in Figure 7, with the mean face Ψ shown in Figure 9.

A new face image (r) is transformed into its eigenface components (projected onto "face space") by a simple operation,

$$W_k = u_k^T (\Gamma - \Psi) \quad (5)$$

for $k = 1, \dots, M$. This describes a set of point by point image multiplications and summations, operations performed at approximately frame rate on current image processing hardware.

The weights form a feature vector,

$$\Omega^T = [W_1 \ W_2 \dots W_M] \quad (6)$$

Describes the contribution of each eigenface in representing the input face image, treating the eigenfaces as a basis set for face images.

Classification is performed by comparing the feature vectors of the face library members with the feature vector of the input face image. This comparison is based on the Euclidean distance between the two members to be smaller than a user defined threshold ϵ_k . This is given in Eq. (7) (figure 13 shows).

$$\frac{\|\Omega - \Omega_k\|}{\|\Omega_k\|} \leq \epsilon_k \quad (7)$$

If the comparison falls within the user defined threshold, then face image is classified as "known", otherwise it is classified as "unknown" and can be added to face library with its feature vector for later use, thus making the system learning to recognize new face images.

V. THE PROPOSED ALGORITHM

The eigen-face based algorithm is applied on a wide variety of images taken under different lighting conditions and with different backgrounds. The images of face also changes with facial expression, age, viewpoint,

illumination conditions, noise, pose variation, hair, growing beards, glasses and cosmetics etc. The task of a face recognition system is to recognize a face in a manner that is as independent as possible of these image variations. Furthermore, the human face is not a unique, rigid object. Indeed, there are numerous factors that cause the appearance of the face to vary. Facial expression carries crucial information about the mental, emotional and even physical states of the conversation. The complete flow chart of proposed face recognition is shown in figure 4.

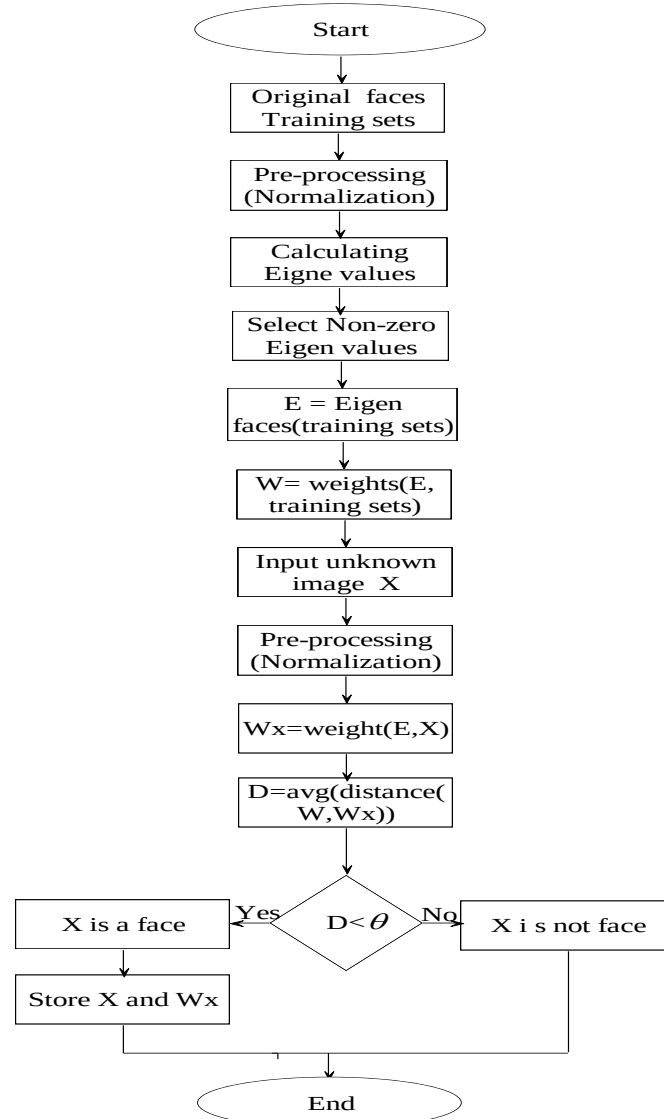


Figure 4: Flow-chart of Eigen based proposed algorithm

VI. RESULTS

The Face recognition algorithm is applied on a wide variety of images taken under different lighting conditions and with different backgrounds. The images also have pose variation, emotions etc. For a 180×200 size of image, the total time taken by the algorithm was 4.545611 seconds. The training set contained different set of people belonging to different races.

The various stages in the algorithm are explained using the training set of RGB images (Fig. 5). Now convert RGB image into gray image for preprocessing steps as shown in figure 6. First of all train the gray size image shown in figure 7. Now normalized the training set using many pre-processing steps as shown in figure 8. Figure 9 shows the mean image of normalized training sets. Eigen faces of normalized training set shown in figure 10. Figure 11 show the reconstructed image from input image for recognizing, it is in database or not. Figure 12 shows the weight of input image and Euclidean distance of input image for calculating or computing the features of input image and compare them with database, if features match from the database then image in database and

recognize them with the database. It is to be noted that the face has been correctly located and almost at the right scale.



Figure 5: RGB Image database with different condition and illumination & Figure 6: Gray size database of Original Image



Figure 7: Training Set of original Image

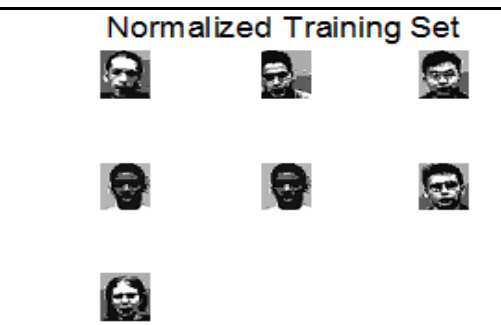


Figure 8: Normalized Training Set



Figure 9: Mean Image of normalized Training Set & Figure 10: Eigenfaces of Training Sets

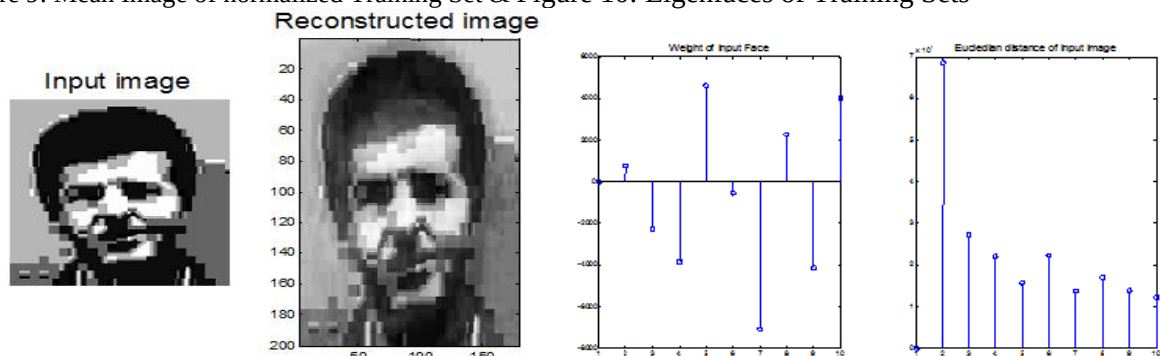


Figure 11: Input image and reconstructed Image & Figure 12: Weight and Euclidean Distance of Input image

VII. CONCLUSION

In this research paper, the authors propose eigen based automatic face recognition algorithm. Though there are some cases of false positives, the overall performance of the proposed algorithm is quite satisfactory. The training images on which the algorithm is tested are natural images taken under uncontrolled conditions. The efficiency of the face recognition was found good.

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