# Face Image Retrieval using Eigenfaces

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**Abstract—***Face image matching and retrieval has many important applications including forensic studies. Face retrieval process is combination of two stages: feature extraction and distance measurement. In our work we have utilized the Eigenface approach for defining a feature set (Eigen vectors) for the training set of face images. This paper presents a methodology for face image retrieval using Eigenface approach and a comparative study among various distance classifiers viz Manhattan distance, Euclidian distance, Bray-Curtis distance, Canberra distance and Squared-Chord distance applied for face retrieval.*

**Keywords***: Eigen Face, Distance classifier.*

## 1. INTRODUCTION

In recent years, face recognition is gaining a considerable attention in the field of biometrics. Human brain can remember a good number of faces and recognize any face even after a long period of time. This recognition process is immune to any changes in expression, age or any distraction such as glasses or change in hairstyle. The computational model for this recognition is very interesting topic and applicable in various fields viz forensic studies, security system etc. Developing such a model for face recognition is a quite difficult task.

Previously most of the face recognition methods involved detection of individual features such as eyes, nose, mouth and head outlines and defining a face model by the position, size and relationships among these features. Such approaches are dependent on precise features and are proved to be quite fragile.

The idea of using eigenfaces was motivated by a technique developed by Sirovich and Kirby in 1987 for efficiently representing pictures of faces using principle component analysis [2]. M.A.Turk and Alex **P.** Pentland in 1991 [1] developed eigenfaces which has some significant advantages over previous work.

Till date a great number of research works had been done on face recognition using eigenfaces [2-5]. This method had been proved to be a very helpful tool in the field of face image matching and retrieval.

In our work we have applied the Eigenface method of face recognition for retrieval of face images from database. Eigenfaces is one of the most simplest and old technique for recognition of face images. The simplicity of the process makes it easily understandable how the recognition and dimensionality reduction works. The method utilized in this paper doesn't focus on extracting features from individual parts of face like nose, eyes etc. Instead the whole face portion is considered and eigenvectors are calculated which represents the individualistic features of the face images.

## 2. ALGORITHM FOR IMAGE RETRIEVAL

Human face images can be described as combination of some basic face images. The basic faces which best account for describing the face images in database are called eigenfaces.

In this process the face images in the database are transformed into a set of basic faces (eigenfaces) represented by eigenvectors which characterize the variations among them. Each face in the database can be represented as a linear combination of theses eigenfaces. Dimensionality reduction is done by considering a threshold heuristically.

After dimensionality reduction the distance between the testing image and training set data is evaluated for image retrieval.

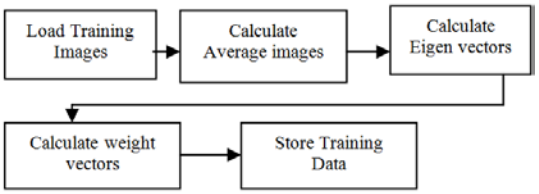


**Fig. 1: Learning stages of the training set of images**

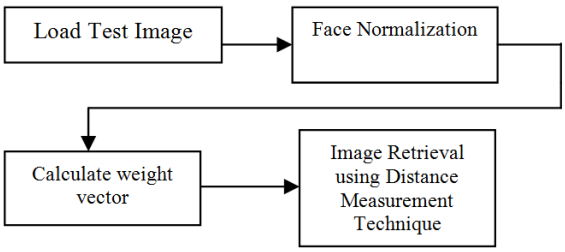


**Fig. 2: Processing of test image and retrieval flowchart**

## 3. MATHEMATICAL PROCEDURE

**Step 1**: A database of M face images is obtained and each face image is transformed into a vector Γ and placed into the set S.

$$S= \{\Gamma_1, \Gamma_2, \Gamma_3, \Gamma_4, \Gamma_5, \ldots . \Gamma_M\}$$

**Step 2**: Mean image ψ is calculated.

$$\Psi= \frac{1}{M}\sum_{i=1}^{M} \Gamma_i$$

**Step 3:** Third step is to find the difference between the input image and the mean image ψ. The purpose of subtracting the mean image is to obtain only the distinguishing features and remove the common information.

$$\Phi_i = \Gamma_i - \psi$$

**Step 4:** Calculate the covariance matrix.

$$C = AA^T \text{ where } A=\{\Phi_1, \Phi_2, \Phi_3 \ldots . \Phi_M\}$$

**Step 6:** Next step is to calculate the eigenvectors of the covariance matrix C. The practical procedure for obtaining the eigenvectors is to consider the matrix L= $A^T$A instead of $C = AA^T$ and find the eigenvectors of the matrix L ($u_i$).

**Step 7:** The eigenvectors of the covariance matrix is obtained by product of the matrix A with the eigenvectors of the matrix L.

$$v_i = Au_i$$

If these eigenvectors are converted into images, a ghost like face appearance will be formed. Hence these eigenvectors are called eigenfaces.

**Step 8:** Each face image in the database can be represented as weighted linear combination of these eigenvectors.

The weights can be calculated as:

$$w_j = {u_j}^T \Phi_i$$

**Recognition Procedure:**

**Step 1:** Normalization of the loaded test image $\Gamma$.

$$\Phi = \Gamma - \psi$$

**Step 2:** Second step is to multiply the normalized face image matrix with the eigenfaces of the matrix L.

$$w_j = {u_j}^T \Phi$$

**Step 3:** After obtaining the weight vector for the input test image, next step is to apply distance classifiers and sort the distances between the test image and the training set of images for retrieval purpose.

We have used five different distance classifiers viz Manhattan distance, Euclidian distance, Bray-Curtis distance, Canberra distance and Squared-Chord distance.

**Euclidian Distance**

$$d_e(x,y)=\sum_{i=1}^{d} \sqrt{|x_i - y_i|^2}$$

**Bray-Curtis distance:**

$$d_{BC}(x,y) = \sum_{i=1}^{d} \frac{|x_i - y_i|}{x_i + y_i}$$

**Canberra distance:**

$$d_C(x,y) = \sum_{i=1}^{d} \frac{|x_i - y_i|}{|x_i| + |y_i|}$$

**Squared-Chord distance:**

$$d_{SC}(x,y) = \sum_{i=1}^{d} \left(\sqrt{x_i} - \sqrt{y_i}\right)^2$$

**Manhattan distance:**

$$d_m = \sum_{i=1}^{d} |x_i - y_i|$$

## 4. EXPERIMENTAL RESULTS:

The database used in this paper is formed by the face images taken from the Face Recognition Data, University of Essex, UK [6]. The training set consists of 50 images, 10 images each from 5 individuals. The testing set of face database consists of 50 face images of 5 individuals. Dimension of each image of the database is 200x180x3.

The number of retrieved image is set to 10 for each testing image. The parameter considered for comparison among the distance classifiers is the retrieval rate. The average retrieval rate (ARR) of the retrieval system is calculated as;

$$ARR = \frac{\sum_{Z=1}^{Z} m_z}{F \times Z} \quad [7]$$

Z denotes the number of test images; F is the number of retrieved samples and $m_z$ is the number of correctly retrieved samples.

**Table 1: Result of face retrieval for different distance classifiers**

| Distance Classifier | Retrieval Rate |
|---|---|
| Euclidian Distance | 90% |
| Manhattan Distance | 90% |
| Bray-Curtis Distance | 60% |
| Canberra Distance | 73% |
| Squared-Chord Distance | 95% |

This methodology is implemented in Matlab environment on a 32 bit windows 8 system.

## 5. CONCLUSION

Face image retrieval using eigenface approach is implemented and comparisons among various distance classifiers is done. A database of 50 images of 5 persons is used as training set.

From the results it can be concluded that Squared-Chord distance is showing a better retrieval rate among all distance classifiers. On the other hand the Bray-Curtis and Canberra distance classifiers are not able to perform well in this methodology.

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