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Human Face Recognition Using Eigen Vector-Based Recognition System

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Abstract: Face recognition is an algorithm that can recognize or verify a query face among a large number of faces in the enrollment database. Face recognition is a crucial and difficult area of computer vision. This study demonstrates a system that can recognize a human face by comparing the facial structure to that of another individual or a well-known individual, which is accomplished by the use of frontal several summarizations. Many researchers have done their work on face recognition and also applied it by using different methods. We made use of an eigenvector-based recognition system as a method for recognizing faces. The face recognition system is highly accurate and is one of the most powerful surveillance tools ever made. But this face recognition technology is quite costly for developing countries like Bangladesh. In this study, we have used a face recognition system for our security purpose using an eigenvector-based face recognition system with the help of MATLAB software and a Raspberry Pi camera for security purposes which minimizes the cost, and this process we have used is quite affordable.

Keywords: Face recognition, Eigenvector, Eigenvalue, Covariance matrix.

I. Introduction

Face recognition applications are affected by a variety of factors such as illumination, facial distance, expression, age group, hair color, facial wear, and so on. In social situations, the face is the primary center of attention, and it plays an important role in expressing identity and emotion. Although face recognition is difficult, the human ability to recognize faces is remarkable that you can recognize faces. Even after years apart, faces can be recognized at a look. This ability is despite significant alterations in the visual stimuli due to distractions such as lighting, emotion, and age such as spectacles, beards, or hairstyle changes. Face recognition has fundamental importance for our simple everyday activities. It is a very high-level task and has many applications. A facial recognition system is a technology capable of matching a human face from a digital image or a video frame against a database of faces, typically employed to authenticate users through ID verification services and works by pinpointing and measuring facial features from a given facial recognition systems are employed throughout the world today by governments and private companies. The strategy taken by Dubravka Jevtic et al., (2012) aims to Face Recognition Using Eigenface Approach [1]. Their effectiveness varies, and some systems have previously been scrapped because of their ineffectiveness. K Ravi, M Kttswamy, (2014) aim at Face Recognition using PCA and Eigenface Approach [2]. Manoharan, Samuel, (2019) Study on Hermitian Graph Wavelets in Feature Detection [3]. The use of facial recognition systems has also raised controversy, with claims that the systems violate citizens' privacy, commonly make incorrect identifications, encourage gender norms and racial profiling, and do not protect important biometric data securities. F Mahmud, M T Khatun, S T Juhori, M Akhter dan B Paul, (2015) aim to Face recognition using Principal Component Analysis and Linear Discriminant Analysis [4]. In this study, we are going to use a face recognition system using an eigenvector-based face recognition system with the help of MATLAB software and a Raspberry Pi camera for security purposes.

II. Methodology

Face Recognition

A straightforward approach to extracting the information contained in a face image is to capture the variation in a collection of face images, independent of any judgment of features, and then use this information to encode and compare individual face images. Treating a picture as a point (or vector) in a very high dimensional space, the major components of the distribution of faces, or the eigenvectors of the covariance matrix of the collection of face images, are sought. Each picture position contributes more or less to each eigenvector, allowing these eigenvectors to be displayed as a sort of ghostly face image known as an "eigenface." In our project work, we have decided to minimize our cost and use a face recognition system as our door security using an eigenvector-based face recognition system with the help of MATLAB software. We are going to use a Raspberry Pi camera board for using the MATLAB program.

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Basic steps involved in Face Recognition using Eigenfaces:

1) Acquire an initial set of face images known as Training Set (Γ_i).
2) The average matrix Ψ has to be calculated. Then subtract this mean from the original faces (Γ_i) to calculate the image vector (ϕ_i)

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

$$\phi_i = \Gamma_i - \Psi \quad (2)$$

3) Find the covariance matrix C by

$$C = \frac{1}{M}\sum_{i=1}^{M}\phi_i\phi_i^T = AA^T \quad (3)$$

where, $A = [\phi_1, \phi_2, \phi_3, \ldots \ldots \ldots \phi_i]$

4) Compute the eigenvectors and eigenvalues of C.
5) The M' significant eigenvectors are chosen as those with the largest corresponding eigenvalues
6) Project all the face images into these eigenvectors and form the feature vectors of each face Image

Calculation of Eigenfaces

An $N \times N$ matrix A is said to have an eigenvector x, and a corresponding eigenvalue λ if

$$Ax = \lambda x \quad (4)$$

Evidently, Equation (4) can hold only if

$$\det|A - \lambda I| = 0 \quad (5)$$

Which, if expanded out, is an nth-degree polynomial in λ whose roots are the eigenvalues. A matrix A is symmetric if $A = A^T$.

It is termed orthogonal if its transpose equals its inverse,

$$\text{i.e} \quad AA^T = A^T A = I \quad (6)$$

Finally, a real matrix is called normal if it commutes with its transpose

$$\text{i.e} \quad AA^T = A^T A \quad (7)$$

The covariance matrix C, however, is $N^2 \times N^2$ real symmetric matrix, and determining the N^2 eigenvectors and eigenvalues is an intractable task for typical image sizes. If the number of points in the image space is less than the dimension of the space ($M < N^2$) There will be only $M - 1$, rather than N^2 meaningful eigenvectors. The remaining eigenvectors will have associated eigenvalues of zero. Consider the eigenvectors v_i of $A^T A$ such that

$$A^T A \; v_i = \lambda_i v_i \quad (8)$$

where λ_i are eigen values

Pre multiplying both sides of equation (11) with A we get

$$A A^T A \; v_i = \lambda_i A v_i \quad (9)$$

Following this analysis, we construct the $M \times M$ matrix L

$$L = A A^T \quad (10)$$

Find the M eigenvectors, v_i of L.

These vectors determine linear combinations of the M training set face images to form the Eigenfaces u_i.

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$$u_i = \sum_{k=I}^{M} v_{ik}\phi_{k,} \quad i = 1,2,\dots M \tag{11}$$

The weight vectors

$$\Omega=[u_1, u_2, \dots \dots u_M]$$

The easiest way to determine which face best describes an unknown input facial image is to locate a representation of *k* that reduces the Euclidean distance ε_k.

$$\varepsilon_k = \|\Omega - \Omega_k\|^2 \tag{12}$$

where Ω_k is a weight vector describing the *kth* face from the training data set.

When ε_k is less than a certain threshold ε, a face is designated as belonging to person *k*; otherwise,

the face is listed as unidentified.

III. Data collection

We have created a database containing 400 images of 40 individual people. For preparing our database we have taken the images of 11 students of Mathematics Discipline, Khulna University, Khulna, Bangladesh with their consent, and the rest 29 person from the website [5]. Each student has been instructed to perform 10 different facial expressions. In our face database 400 (10 each of 40 images) images, 110 images from the students of Khulna University, and the rest of the 290 images have been collected from the website [5]. Each image is in RGB level which is normalized to gray level and has a dimension of 92×112 (pixels). Some sample images of one student among 400 images have shown in the figure given below:[6]

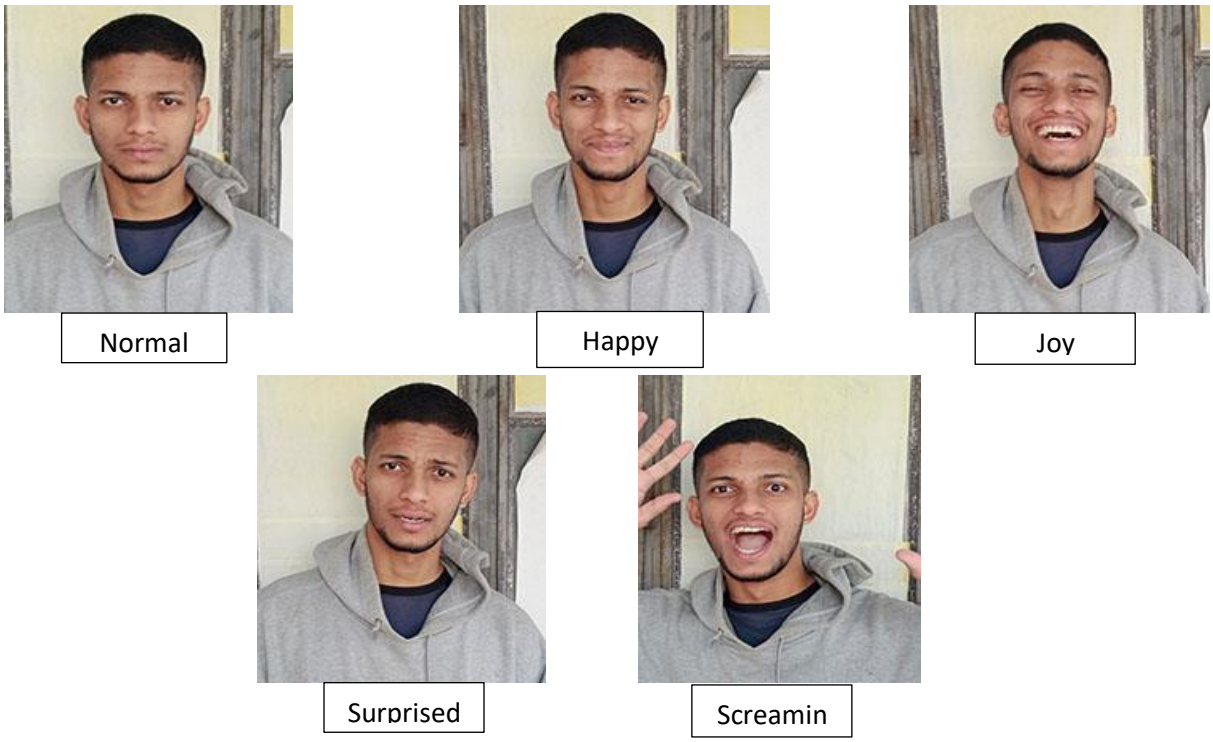

Fig.1 Sample dataset

IV. Experimental Result

In our dataset, 80% of images are used for training procedures and 20% of images are used for testing procedures.[7] By applying an eigenvector-based face recognition technique we have converted the face image of our dataset into eigenvectors. The eigenvectors have their individual eigenvalues.[8] We have stored the required eigenvalues. If we want to identify or recognize a specific image, this method first counts the eigenvalue of the given image and then compares the eigenvalue with stored eigenvalues.

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In our eigenvector-based face recognition technique we used MATLAB program and a Raspberry Pi camera for security purposes. The eigenvalues which match approximately in the percentage of 95 are considered to be recognized.

An implementation Procedure table is given below

Training procedure	80% image of the dataset *i.e.* 320 images used for training data
Testing procedure	20% image of the dataset *i.e.* 80 images used for testing data
Image size	Resize image is 92×112(pixels)
Testing outcome	76 images are matched with the data set *i.e.* 95%

Table:1 Experimental results

V. Conclusion

In our study, Face recognition is performed by obtaining feature vectors from the eigenvectors space.[9] We achieved a recognition accuracy of 95% for the tested images. Though it has succeeded to recognize 76 images out of 80, we could say that we have accomplished our goal to use it for security purposes.[10] There is a 5% chance that it could have failed to recognize this misrecognition happened due to the huge input of the database. But when we are going to put it as a door security lock there would be a minimal percentage of data for instance; if we want to set it to our own home door lock only then the dataset is a very small number of images. Then the chances of misdetection can be reduced to 0%-1%.

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