

# Hybrid Technique for Human Identification Using Information Theory

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**Abstract** – Humans can be individualized based on their facial characteristics. However, identifying a face becomes a challenging task due to the complexities involved. The visual models of face include many parameters. In this paper different algorithms and parameters are studied and computed for real time results. The combined PCA and geometric feature based algorithm is used to recognize age, gender and facial information. These holistic and geometric methods can be combined for decision making to reduce the error in recognition system.

**Keywords** – Face Recognition, PCA, Age and Gender classification, Eigen faces, Eigenvalues, Shape transformation, Decision method.

## I. INTRODUCTION

The face among other biological features is the most emerging research field in biometrics. The growing demands for surveillance, security and identification in societies have raised their search in this field. The change in structure and features on face makes it challenging for programmers and developers.

MD Malkauthekar and SDSapkal [1] showed experimental analysis of classification of facial images. G Mallikarjuna Rao [2] proposed a Neural Network-based frontal face detection system to classify the gender based on facial information. Anil Kumar Sao and B. Yegnannarayana [3] discussed analytic phase based face recognition to resolve the issue of illumination variation using trigonometric functions. Whereas in this paper the information theory is used on face images to decompose it into smaller set of Eigenfaces and principal component analysis is used to create an initial training set. The input image is then compared with the database of Eigenface sets by projecting it on the subspace of the Eigenfaces. The Euclidean distance is calculated and is compared with set threshold for recognition. The PCA gives efficient

and good results in lower dimensional space [4]. The geometric features on faces like distance between eyebrow, eyes and size of lips and nose etc. are located and computed using canny edge operator. The gender and age is determined considering region, size and density of mustache, wrinkle and total number of pixels of skin color.

The approaches in the paper for biometric face recognition enhances the existing processes by providing more accuracy and the new added decision method gives strength to used algorithm in identifying the person from the databases. The problems of the variation of light, size, partial occultation, partial noises and illumination during image capture are reduced to an extent during preprocessing of image for recognition system.

## II. FACE RECOGNITION SYSTEM

Face recognition system is a subset method of pattern recognition. The input face image is compared with the existing database and output is either a known or unknown identification. The outline for face recognition system is given in Figure 1. There are six main functional blocks.

### A. The acquisition module

The face image as the input to face the recognition system is given in this module in standard image formats like jpeg and bitmap etc.

### B. The preprocessing module

The preprocessing module enhances the quality of image by performing certain operations on it. The preprocessing steps implemented are as follows:

(i) *Color Conversion:* The red, green and blue components of a color (RGB) image at a specific spatial location are  $M \times N \times 3$  array. Three dimensional RGB is

converted into two dimensional gray scale images for easy processing of the face image.

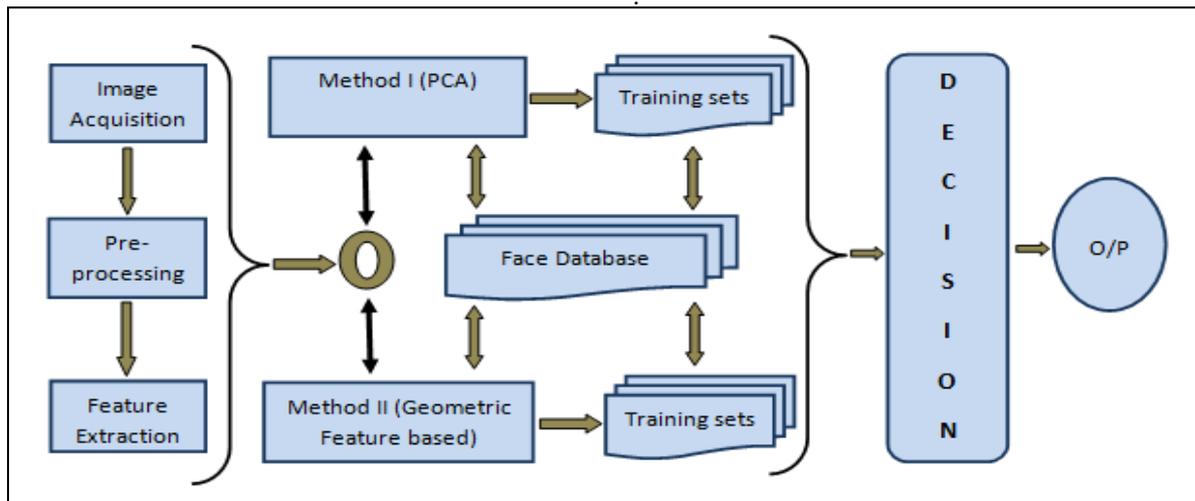


Fig. 1: Outline of face recognition system

(ii) *Noise reduction:* The dirt on hardware devices like cameras, scanner lighting, scanner lens etc. introduces the noise in the scanned face image. The noise on the scanned image is reduced using standard filtering method. The function replaces each pixel by its majority function.

(iii) *Edge detection method:* The discontinuities in the intensity of the image frame in the form of point or line can be detected and corrected to a certain extent by the Canny edge operator. The operator finds edge by looking for local maxima in the gradient  $f(x, y)$ .

The local gradient is given by Equations (1) and (2)

$$G(x, y) = [G_x + G_y]^{\frac{1}{2}} \quad (1)$$

$G_x$  and  $G_y$  are the first derivatives of function  $f(x, y)$ , digitally.

$$\alpha(x, y) = \tan^{-1} \left( \frac{G_x}{G_y} \right) \quad (2)$$

$\alpha(x, y)$  is the edge direction.

The image size adjustment and illumination nominalization is carried out using standard algorithms.

### C. The feature extraction module

This module composes a feature vector that is well enough to represent the face image. The grid feature explore the colors on face, moustache pixels, forehead region, canthus, lip area, eye tail, eyelid, and nose sizes on the face image and also wrinkle region. The Global features extracts the distances between lips and the nose

tip, the distance between nosetip to center between the eyes and width of lips.

### D. The computation module

#### I METHOD (EIGEN FACE APPROACH)

The  $N \times N$  pixels of image vectors are transformed to  $N^2$  dimensional space [5]. To enhance the speed of recognition and eliminate lengthy computation duration, images are represented into smaller number dimensions. The eigenvectors of the covariance matrix of the set of face images are computed and Eigenfaces are the principal components of it. The method describes the holistic approach in this module [6].

The vectors are assumed to be real numbers, a nonzero column vector  $X$  is an Eigenvector of a matrix  $A$  if there exists a number  $\lambda$  such that,

$$AX = \lambda X \quad (3)$$

Where 'A' is a Vector function, the number ' $\lambda$ ' is Eigen values corresponding to the above vectors. By using (3), we get the equation,

$$(A - \lambda I)X = 0 \quad (4)$$

$I$  is the  $n \times n$  Identity matrix. It is a homogeneous system of equations, and a nontrivial solution exists if and only if

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

Where  $\det()$  denotes determinant. When calculated, forms a polynomial of degree  $n$ . This is known as the characteristic equation of  $A$ , and the corresponding polynomial is the characteristic polynomial. If  $A$  is  $n \times n$

n, then there are n solutions or n roots of the characteristic polynomial. Resulting in n Eigen values of 'A' satisfying the equation,

$$AX_i = \lambda X_i \quad (6)$$

Where  $i = 1, 2, 3 \dots N$

If distinct values of eigenvector occur then there are n linearly independent eigenvectors, whose directions are unique and n dimensional Euclidean space is formed. The process can be studied under two parts. First the initial training set formation and second the recognition process.

The initial training sets have these steps:

- 1) The input face images are collected and Eigenfaces are formed keeping only the highest eigenvalues. The M images are the face space the figure 2 shows an example. The figure 3 Shows Eigenfaces image after calculation of figure 2.

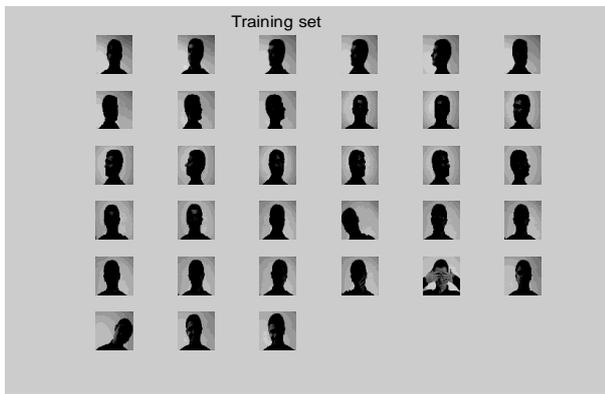


Fig. 2: Shows the training set of human faces.

- 2) The calculation is performed periodically to update databases. The face can be classified and stored for future references.



Fig. 4 : Mean Faces of train set

The below procedure is carried out for face recognition.

- 1) The training sets of images are formed from  $\Gamma_1, \Gamma_2, \dots, \Gamma_m$  with each image as  $I(x, y)$ . The selected image is converted into set of vectors and matrix (m

$\times p$ ) is computed, where m is the number of training images and p is  $(x \times y)$ .

- 2) The mean face is calculated using equation (7) and the mean-subtracted face is done by equation (8).

$$\Psi = \frac{1}{m} \sum_{i=1}^m \Gamma_i \quad (7)$$

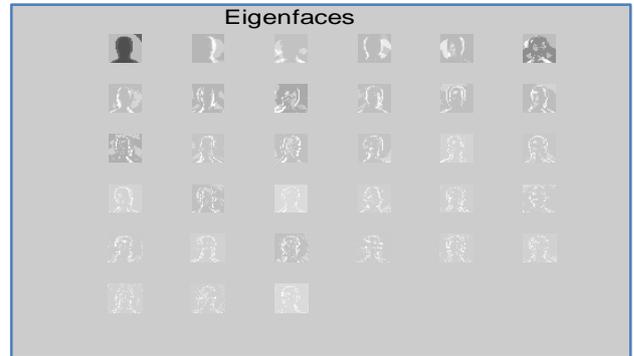


Fig. 3 : Describes about Eigen Faces

$$\Phi_i = \Gamma_i - \Psi, \quad i = 1, 2, \dots, m \quad (8)$$

$A = [\Phi_1, \Phi_2, \dots, \Phi_m]$  is the mean-subtracted matrix vector of size  $A_{mp}$ .

- 3) The covariance matrix C and its transpose matrix is computed using equation(9)

$$C_{mn} = A_{mp} * A_{pm}^T \quad (9)$$

- 4) The The eigenvectors,  $V_{mm}$  and eigenvalues,  $\lambda_m$  is calculated from C matrix using Jacobi method. Jacobi's method is selected for its accuracy and reliability as compared to the other methods.

- 5) The eigenvectors matrix,  $V_{mm}$  and matrix,  $\Phi_m$  these determine linear combinations of the training set images to form Eigenfaces,  $U_k$  by:

$$U_k = \sum_{n=1}^m U_k V_k n, \quad k=1,2,\dots,m \quad (10)$$

Each image have its face vector using Eigenfaces, by:

$$W_k = U_k^T (\Gamma - \psi), \quad k = 1,2,\dots,m' \quad (11)$$

- 6) The face can reconstructed using  $\Omega^T$  vector and previous Eigenfaces,  $U_{m'}$  as :

$$\Gamma' = \psi + \phi_f \quad (12)$$

The weights form a feature vector:

$$\Omega^T = [w_1 w_2, \dots, w_{m'}] \quad (13)$$

$$\text{Where } \phi_f = \sum_{n=1}^m w_i U_i \quad (14)$$

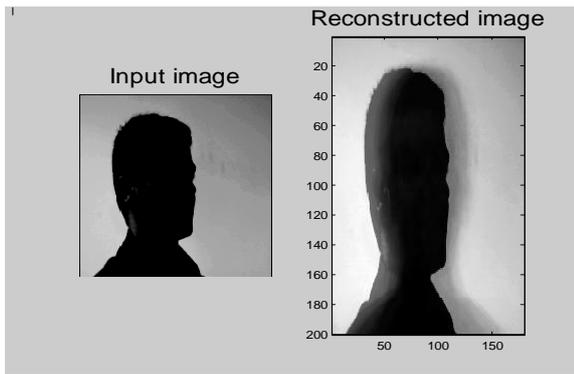


Fig. 5: Matched output and reconstructed image.

The Euclidean distance vectors are calculated. If this is within set threshold value, then image is said to be matching which means the person is identified. Depending on this result decision block further calculates values. In figure 6(a) and 6(b) the graph shows the Euclidean distance of input image and weight of it using histogram. Figure 5 shows input image and compared if validated then it is reconstructed from mean face.

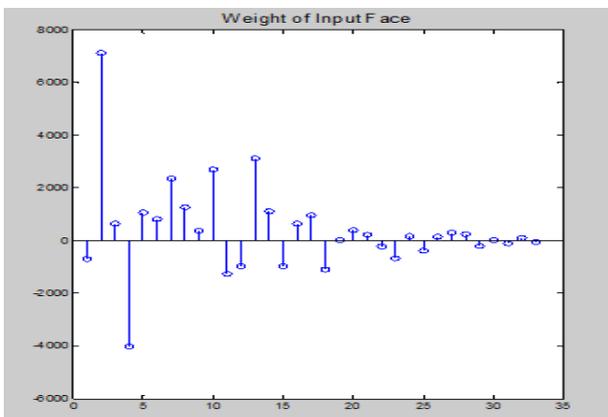


Fig. 6(a): weight of input image

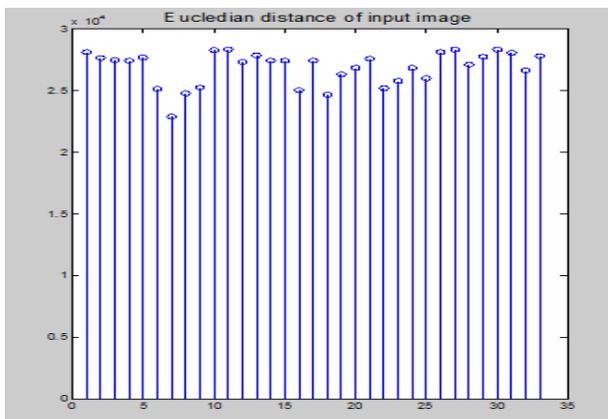


Fig. 6(b): Euclidean distance of input image

## II. METHOD (GEOMETRIC FEATURE BASED)

The geometric feature extracts information using edge detection where area and size are calculated. In figure 7(a) frontal face is operated with canny edge algorithm. The feature ratios are computed from facial face database comprising young aged, middle aged and old aged adults. Figure 7(b) shows the ratios of left eye to right eye distance, eye to nose distance, eye to lip distance, eye to chin distance for feature extraction and area and region by skin color pixels [7]. Some of the ratios are shown below.

- (a) Ratio 1 = (Left eye to Right eye distance) / (eye to nose distance)
- (b) Ratio 2 = (Left eye to Right eye distance) / (eye to lip distance)
- (b) Ratio 3 = (Eye to nose distance) / (eye to chin distance)
- (d) Ratio 4 = (Eye to nose distance) / (eye to lip distance)
- (e) Ratio 5 = (Size of lips / size of nose region)



Fig. 7(a): Canny edge of one image from database.

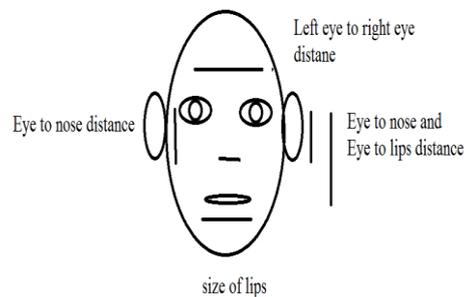


Fig. 7(b): Mustache area, Forehead area and white line indicating edges.

The age classifiers are trained with male and female database. The output for the gender classifier is also compared from experimental results gathered. The extracted feature of test image is observed in comparison to the faces of database. If the extracted features of the test face image matches with the sample

faces database then it is accepted as known or identified, otherwise, it is unknown matching.

*E. The classification module*

With the above methods and databases the image is classified individually in each method and output is processed by next module. The figure 8 shows complete classifier of hybrid technique for human identification for age estimation and corresponding gender. The age classifier has been trained with male and female data. Based on the output of the gender classifier, age classifier is processed. The extracted feature of test face image is compared with the database. If the features of the test face image match with the sample database then accepted as matching, otherwise, it is accepted as unmatched.

*F. The decision and verification module*

The decision over the identification of input image is decided by threshold values assigned in two modules, if decision is true from both modules then the person is said to be identified correctly. If decision is true for only one module it means possibility of similar or same person. In case both modules identifies wrong, it is clear chance of the person to be unknown. Using this module we can avoid false identification which in turn will improve recognition accuracy.

III. CONCLUSION

In this paper, a hybrid technique is proposed for human face identification. It uses a combination of PCA and Geometric feature extraction techniques. This holistic algorithm used recognizes age, gender and facial information. The decision and verification module further increases the accuracy of system by avoiding false identification. In future the algorithm may be modified for large faces database and more variations of faces can be processed.

IV. REFERENCES

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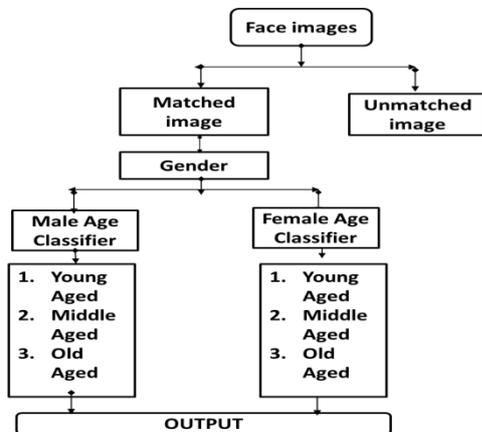


Fig. 8: Classifier flow for Hybrid Technique for Human Identification.