An Invention Approach to 3D Face Recognition using Combination of 2D Texture Data and 3D Shape Data

Dr. Prashant P. Pittalia¹, Mrs. Kamini H. Solanki² (Ph.D Scholar)

¹Associate Professor, MCA Department, Programme Shri Jairambhai Patel Institute of Business Management & Computer Applications
²Lecturer, M.Sc. (IT) Department, ISTAR College, V.V. Nagar, Anand, Gujarat.

Abstract

Face recognition is one of the biometric methods, to identify given face using main feature of face. The 3D face recognition approach handles the challenges of 2D face recognition such as pose, illumination, expression etc. in better way. The exploration of 3D face recognition is used for security purpose at many places like airport, Organization, crime detection etc. Pose is a great challenge in real-world biometric application. This paper represents a method of face recognition using 3D images. First compensate the poses of 3D original facial images using geometrical measurement and extract 2D texture data and the 3D shape data from 3D facial images for recognition. Face recognition technique is based on Euler angle and principal component analysis (PCA) plus Linear Discriminate Analysis (LDA) algorithm. All the 2D texture images and the 3D shape images are normalized to 100 x 100 pixels. Here, GAVAB 3D face database is used for simulation and measured performance like Recognition rate, False Acceptance Rate (FAR), False Rejection Rate (FRR), Equal Error Rate (EER). Proposed technique is used to improve the recognition rate.

Keyword: Principal Component Analysis (PCA), Linear Discriminate Analysis (LDA), Eigenfaces, fisher faces, feature extraction, image representation, face recognition, 2D, 3D.

1. Introduction

The term “biometrics” originates from the Greek words “bios” (life) and “metric” (measure). The identity of an individual is called personal identification. A system requires reliable personal recognition schemes to either agree or disagree the identity of an individual. The purpose of such schemes is to ensure that the rendered services are accessed only by a legitimate user and no one else. In the absence of robust personal recognition schemes, these systems are exposed to the tricks of a fraud. Biometric recognition or, simply, biometrics refers to the automatic recognition of individuals based on their physiological and/or behavioral characteristics. Proposed face recognition system ensure the security of the whole system by using face features. A biometric recognition system that recognizes an individual based on his biometric traits. A biometric recognition system consists of four main modules:

(i) Image captures of a biometric trait
(ii) Feature extraction module that extracts certain features from the biometric data
(iii) System database that stores the features extracted from biometric data.
(iv) Matcher module that matches the features extracted from the biometric imputed data with the features stored in the system database.

Fig 1. Framework of Face recognition

2. Face as a Biometric Traits

The use of biometrics has been increased the personal security and access control. Fingerprint, face, iris and voice are commonly used in biometric traits. A fingerprint device has a risk of duplication and easily hacks. If the finger are wet or dirty it may deny access. Iris recognition devices are too interfering and expose the diseases. Voice recognition devices can fail to give results in certain condition. Face recognition system is advances then the others, and it is provides a more direct, friendly and convenient identification method. It is more acceptable to users compared to others. Biometrics face recognition system is considered the most efficient technology in biometrics.

3. 2D Vs. 3D Face Recognition

- 2D based approach, facial features recognized based on measurements such as distance between the eyes, width of the nose, and length of jaw while in 3D based approach, it used the contours of the nose, chin, eye sockets etc. to recognize the facial features.
In 2D based, face orientation accommodated up to around 15 to 20 degrees while in 3D based, face orientation up to 90 degrees can be accommodated.

- In 2D based, face need to be reasonably well illuminated otherwise Poor lighting can significantly impact performance but in 3D, Range camera with infrared light can be used in low light condition as well.
- Web camera or digital camera used in 2D Face recognition while Stereoscopic or range camera used in 3D Face recognition. [1]

4. Issues/Challenges of 3D Face Recognitions
Key technologies for distinguishing persons based on face appearances of different position, size, illumination, pose: face detection, feature location, size and grey level of face appearance normalization. The main issues are

4.1 Illumination Problem
Illumination problem occur when same image appear differently due to illumination condition. Person has to stay with fix lighting and fixed distance. Same person with the same facial expression and seen from the same view point, can appear significantly different when light sources illuminate the face from different direction.

4.2 Pose Problem
Face recognizes with different poses that is pose problem. If face rotation induced vary large changes in face appearance and recognition rate reduce significantly when one tries to match images from two different poses of same subject using any well known recognition technique.

5. Advantages of 3D Face Recognition
The motivation to use 3D face technology was to overcome the drawback of 2D face recognition systems that arise especially from significant pose, expression and illumination differences. PCA work well on 2D data and LDA work well at rotation Pose so hear use both and extract the feature using both algorithm so accuracy rate will be higher.

6. 3D Face Recognition
2D Texture data can easily be obtained by modern capturing devices. Combining shape and texture has the advantage that more accurate information is available for the face recognition, however the system becomes more complex and the texture data is dependent on lighting conditions. Using 3D shape data has another benefit: 3D has better normalization than in pure 2D, where unrestrained requirements like the unknown viewpoint, illumination and expression cause a lot of problems. 3D means three-dimensional, i.e. something that has width, height and depth (length). Our physical environment is three-dimensional and we move around in 3D every day. Humans are able to perceive the spatial relationship between objects just by looking at them because we have 3D perception, also known as depth perception. As we look around, the retina in each eye forms a two-dimensional image of our surroundings and our brain processes these two images into a 3D visual experience. 3D graphics defines 3D space with a system of three axes,[1]

- X, which is represents to width,
- Y, which is represents to height and
- Z, which is represents to depth.

7. Gavab Database
GavabDB contains 549 three-dimensional image with 61 persons (45 male & 16 female) and 9 different images per person. Most of them are aged between 18 to 40 years. There are different pose and different expression of each person. There are 2 front, 4 rotated image without expression and 3 frontal image with different facial expression.[1]

8. PCA Algorithm
An Efficient method for face recognition is Principal Component Analysis (PCA). The PCA has been extensively employed for face recognition algorithms. It is one of the most popular representation methods for a face image. It not only reduces the dimensionality of the image, but also retains some of the variations in the image data. The system functions by projecting face image onto a feature space that spans the significant variations among known face images. The significant features are known as “Eigen faces”, because they are the eigenvectors (Principal Component) of the set of faces they do not necessarily correspond to the features such as eyes, ears, and noses. The projection operation characterize an individual face by a weighted sum of the Eigen faces features and so to recognize a particular face it is necessary only to compare these weights to those individuals. The Eigen Object Recognizer class applies PCA on each image, the results of which will be an array of Eigen values that a Neural Network can be trained to recognize. PCA is a commonly used method of object recognition as its results, when used properly can be fairly accurate and resilient to noise. The method of which PCA is applied can vary at different stages so what will be demonstrated is a clear method for PCA application that can be followed. It is up for individuals to experiment in finding the best method for producing accurate results from PCA. To perform PCA several steps are undertaken: [2]

Stage 1: Subtract the Mean of the data from each variable (our adjusted data)
subtraction of the overall mean from each of our values as for covariance we need at least two dimensions of data. It is in fact the subtraction of the mean of each row from each element in that row.

Stage 2: Calculate and form a covariance Matrix

\[ cov(x, y) = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{n-1} \]

Stage 3: Calculate Eigenvectors and Eigen values from the covariance Matrix

Eigenvalues are a product of multiplying matrices however they are as special case. Eigenvalues are found by multiples of the covariance matrix by a vector in two dimensional space (i.e. a Eigenvector). This makes the covariance matrix the equivalent of a transformation matrix.

Stage 4: Chose a Feature Vector (a fancy name for a matrix of vectors)

Once Eigenvectors are found from the covariance matrix, the next step is to order them by Eigenvalue, highest to lowest. This gives you the components in order of significance. Here the data can be compressed and the weaker vectors are removed producing a lossy compression method, the data lost is deemed to be insignificant.

Stage 5: Multiply the transposed Feature Vectors by the transposed adjusted data

The final stage in PCA is to take the transpose of the feature vector matrix and multiply it with the transposed adjusted data set (the adjusted data set is from Stage 1 where the mean was subtracted from the data).

9. Proposed PCA Algorithm

Stage 1. The faces in the training set are preprocessed by taking the co-ordinates of eyes, mouth, noise for 2D, and chin, noise, mouth, eye for 3D and then applying cropping and aligning on these distances.

Stage 2: Subtract the Median of the data from each variable because median is better than min.

Stage 3: Calculate and form a correlation/covariance Matrix

Stage 4: Calculate Eigenvectors and Eigen values from the correlation/covariance Matrix into the face database

Stage 5: Chose a best feature from Feature Vector.

Stage 7: Take an input image which has to be identified and apply the same preprocessing steps.

Stage 8: Find the weight pattern of the Eigen faces by projecting the input image into Eigen faces using Eigenvectors and Eigen values.

Stage 9: Chose a best feature from Feature Vector from inputted image.

Stage 10: Determine if it is a face at all and if so, either known or unknown.

10. Linear Discriminant Analysis (LDA)

LDA also known as Fisher’s Discriminant Analysis, is another dimensionality reduction technique. It is an example of a class specific method i.e. LDA maximizes the between – class scatter matrix measure while minimizes the within – class scatter matrix measure, which make it more reliable for classification. The ratio of the between – class scatter and within – class scatter must be high [7]
For an M-class problem, the between and within class scatter matrices $S_b$ and $S_w$ are defined as:[8]

$$S_b = S_b = \sum_{i=1}^{M} Pr(C_i)(\mu_i - \mu)(\mu_i - \mu)^T = \Phi_b\Phi_b^T, \quad (1)$$

$$S_w = \sum_{i=1}^{M} Pr(C_i)\Sigma_i = \Phi_w\Phi_w^T, \quad (2)$$

Where $Pr(C_i)$ is the prior probability of class $C_i$ and usually is assigned to $1/M$ with the assumption of equal priors; $\mu$ is overall mean vector; $\Sigma_i$ is the average scatter of the sample vectors of different classes $C_i$ around their representative mean vector $\mu_i$:

$$\Sigma_i = E[(x - \mu_i)(x - \mu_i)^T | C = C_i].$$

The class separability can be measured by a certain criterion. A commonly used one is the ratio of the determinant of the between-class scatter matrix of the projected samples to the within-class scatter matrix of the projected samples:

$$J(A) = \arg \max_A \frac{|AS_bA^T|}{|AS_wA^T|} \quad (3)$$

Where $A$ is an $m \times n$ matrix with $(m < n)$. A solution to the optimization problem of Equation (3) is to solve the generalized Eigen value problem

$$S_bA^* = \lambda S_wA^* \quad (4)$$

For classification, the linear discriminate functions are:

$$D_i(X) = A^*(X - \mu_i), \quad i = 1, 2, \ldots, m. \quad (5)$$

A solution to Equation (4) is to compute the inverse of $S_w$ and solve a eigen problem for matrix $S_w^{-1}S_b$. But this method is numerically unstable because it involves the direct inversion of a likely high-dimensional matrix. The most frequently used LDA algorithm in practice is based on simultaneous diagonalization. The basic idea of the algorithm is to find a matrix $A$ that can simultaneously diagonalizable both $S_w$ and $S_b$, i.e.

$$AS_wA^T = I, \quad AS_bA^T = \Lambda. \quad (6)$$

Where $\Lambda$ is a diagonal matrix with diagonal elements sorted in a decreasing order. If we want to reduce dimension of the matrix from $n$ to $m$, we can simply use first $m$ rows of $A$ as the transformation matrix, which corresponds to the largest $m$ Eigen values of $\Lambda$. The simultaneous diagonalization algorithm also involves inversion of matrix. To our knowledge, most algorithms require that the within-class scatter matrix be $S_w$ non-singular, because the algorithms diagonalizable $S_w$ first. Such a procedure breaks down when the within-class scatter matrix $S_w$ becomes singular. This can happen when the number of training samples is smaller than the dimension of the sample vector. This is the case for most face recognition tasks.

### 11. Feature matching for proposed technique

The transformation metrics [4] is applied for feature vector of non frontal query image to obtain the feature vector of its frontal view. This frontal feature is match with frontal feature of subject in database. Transformation metrics is applied on the feature vector of non frontal query image to obtain the feature vector of its corresponding front face feature. Hence existing technique use classifier based on discriminate analysis or support vectors may perform well. Best result found for distance is Euclidean distance based on distance based classifier. Here both algorithm PCA and LDA are used for dimension reduction in better way so accuracy rate will be increased.

![Fig 5 3D Face Recognition System](image-url)
12. Impact & Output of Proposed Technique
In preprocessing stage, it resize the face and removes noise using median filter then feature extraction is done by the Principal component analysis (PCA), Linear Discriminant Analysis (LDA) and at the last Euclidian distance is used for classification. We have used GAVAB 3D dataset for testing purpose and measures parameter like recognition rate (RR). We have used training images from one to five per subject and testing images is two for all train cases. 18 subject is used for simulation so total we have tested 90 3D images. Proposed technique will get up to 1.50 % improvement in Recognition Rate, dimensionality reduction, and generalization.

13. Conclusion
The use of principal components analysis and Linear Discriminant Analysis to generate the feature vector of 3D face from the given face image. The proposed system will be tested on GAVAB database. It has been observed that the system performs better recognition rate when we increase the no of training images and further improvement we can get after correcting pose into frontal face.

REFERENCES
[2.] AN EFFICIENT METHOD FOR FACE RECOGNITION USING PRINCIPAL COMPONENT ANALYSIS (PCA) Gunjan Dashore, Dr. V.Cyril Ra, International Journal of Advanced Technology & Engineering Research (IJATER), ISSN NO: 2250-3536 VOLUME 2, ISSUE 2, MARCH 2012.
[8.] An Efficient LDA Algorithm for Face Recognition Jie Yang, Hua Yu, William Kunz School of Computer Science Interactive Systems Laboratories Carnegie Mellon University Pittsburgh, PA 15213
[14.]P.Latha and L.Ganesan,“Face Recognition using Neural Networks,” Signal Processing (SPIJ),2010