Integrated Biometrics (Face, Fingerprint, Iris, Palmprint & Ear) using PCA

Khushboo¹ Sat Pal²
¹,²Baba Mastnath University, India

Abstract—Integrated Biometrics is a rising domain in biometric technology where more than one biometric trait is combined to improve the performance. Integrated biometrics has much higher efficiency than unimodal biometrics. Integrating the biometric system results in enlarge the user database but increase the level of security. In this paper, a study of integrated biometrics has been done with five biometrics considered face, iris, ear, palm and finger respectively. In biometric system, Problems arise when integrated performing recognition in a high-dimensional space. Significant improvements can be achieved by mapping the data into a lower dimensional space. This can be done by PCA approach. PCA method reduces memory requirement of the system and computation time. This paper presents a method for face, iris, fingerprint, palm print and ear recognition based on Principal Component Analysis (PCA). I have applied the same PCA algorithm for all these biometric traits.

Key words: PCA, Applications, Face Recognition, Iris Recognition, Fingerprint Recognition, Palm Print Recognition, Ear Recognition

I. INTRODUCTION

Biometrics refers to the use of physiological or biological characteristics to measure the identity of an individual. These features are unique to each individual and remain mostly stable during a person’s lifetime.

Fig. 1: these features make biometrics a promising secure solution to the society. The access to the secured area can be made by the use of ID numbers or password. But such information can easily be accessed by intruders and they can breach the doors of security. The problem arises in case of monetary transactions and highly restricted to information zone. Thus to overcome the above mentioned issue biometric traits are used. The biometrics possesses unique, time invariant, consistent and not able to be forgotten or lost features. These features made biometrics an important component in security-related applications such as: logical and physical access control, airport/sea security, border control, forensic investigation, IT security, identity fraud protection, and terrorist prevention or detection, etc.[3].

Biometric systems work by first capturing a sample of the feature, such as recording a digital sound signal for voice recognition, or taking a digital color image for face recognition or taking the print for the palmprint recognition. The sample is then transformed into a biometric template using some sort of mathematical function. The biometric template will provide a normalized, efficient and highly discriminating representation of the feature, which can then be objectively compared with other templates in order to determine identity.

Most biometric systems allow two modes of operation [5]. First one is an enrolment mode for adding templates to a database, and second one is a verification/identification mode, where a template is created for an individual and then a match is searched for in the database of pre-enrolled templates [40].

Enrollment Process

The new template is matched against the stored template and a measure M is calculated. The Decision module accepts or rejects the claimed user using the measure M [40].

Verification Process

The new template is matched against all the templates in the database producing a score S for each template. Depending on the score the Decision module decides who the user is [40].

Identification Process

The new template is matched against all the templates in the database producing a score S for each template. Depending on the score the Decision module decides who the user is [40].

The various biometrics traits available are face, fingerprint, iris, palm print, hand geometry and ear, thumb. The reliability of several biometrics traits is measured with the help of experimental results. In this study, Among the available biometric traits some of the traits have been considered namely face, iris, ear, palm and finger.

Fig. 2: Enrollment Process

Fig. 3: Verification Process

Fig. 4: Identification Process
respectively. Research groups around the world are developing algorithms and systems based on face, iris, fingerprint, palm print and ear. But I have used here PCA algorithm for all these biometric traits.

PCA was invented in 1901 by Karl Pearson. Principal component analysis (PCA) is a classic technique used for compressing higher dimensional data sets to lower dimensional ones for data analysis, visualization, feature extraction, or data compression. The Principal Component Analysis (PCA) is one of the most successful techniques that have been used in image recognition and compression. The purpose of PCA is to reduce the large dimensionality of the data space to the smaller intrinsic dimensionality of feature space which is needed to describe the data economically. The PCA is a technique that allows, from extracting the eigenvectors and eigenvalues of the covariance matrix of images, to create a space of reduced images, which contains the “main components” of the images for subsequent recognition. Although PCA is widespread adopted in the recognition of face images, we apply here this technique also as a part of the face, iris, fingerprint, palmprint and ear recognition [5].

It is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analyzing data. PCA is applied on Eigen face approach to reduce the dimensionality of a large data set. The advantage of PCA is that once we have found these patterns in the data, and we compress the data, by reducing the number of dimensions, without much loss of information. This technique used in image compression. When the original data is reproduced, the images have lost some of the information. This compression technique is said to be lossy because the decompressed image is not exactly the same as the original, generally worse.

PCA is the concept of Eigenvalues and Eigenfaces. PCA is a method of transforming a number of correlated variables into a smaller number of uncorrelated variables. PCA can be applied to the task of face recognition by converting the pixels of an image into a number of eigenface feature vectors, which can then be compared to measure the similarity of two face images. PCA involves the calculation of the eigenvalue decomposition of a data covariance matrix or singular value decomposition of a data matrix, usually after mean centering the data for each attribute [2]. After feature extraction, the image is represented as a feature vector. We used Euclidean Distance similarity measures to measure the similarity of test and training images feature.

II. EARLIER WORK

Three algorithms - Artificial Neural Network, Eigenfaces and Active Appearance Model based methods for face recognition. Eigenfaces for face representation was used first used by Sirovich and Kirby which was later developed by Turk and Pentland for face recognition. Different techniques have been developed using neural networks. The implementation by Lawrence, Giles, Tsoi and Back showed good results. Taylor and Cootes used Active Appearance Model to design a system for face identification. Some comparison has been done between eigenfaces vs. fisherfaces, eigenfaces vs. feature based techniques and likewise. [34] Have proposed approach to replace the Gabor features by a graph matching strategy and HOGs (Histograms of Oriented Gradients). [35] Have proposed the FERET Evaluation Methodology for Face Recognition Algorithm. [36] Have proposed Robust Facial Feature Tracking methodology for tracking the facial features of human face.


In fingerprint recognition, [18] proposed multilayer perceptrons and use the elements of the orientation image as input features. [19] Proposed a neural network as decision stage and the fingerprint features were extracted using the discrete wavelet transform, [13] Proposed a method using the 2D hidden Markov model. [10] The orientation image is partitioned into regions by minimizing a cost function that takes into account the variance of the element orientations within each region. An inexact graph matching technique is then used to compare the relational graphs with class-prototype graphs.

In palmprint recognition, [23] have used Principal Component Analysis (PCA), Fisher Discriminant Analysis (FDA) and Independent Component Analysis (ICA) for the feature extraction from the raw images. [24] Used the approach of compact extraction of principle lines from the palmprint images by using filtering operations consecutively. Here, the image is first smoothed and then worked upon. The palmprint images are passed through several filters.[26] have used the two dimensional Gabor for the development of a high performance palmprint identification. [27] Proposed an approach which makes use of the multispectral analysis of the hybrid features to improve the performance of the palm print recognition system. [29] Have proposed an online palm print identification system. This system was developed to make authentication possible in the real time also. [30] have proposed a novel preprocessing technique for DCT domain palmprint recognition in which the task of feature extraction is carried out in local zones using 2 dimensional Discrete Cosine Transform (2D-DCT). [65] Proposed a dynamic selection scheme by introducing global texture feature measurement and the detection of local interesting points.

In ear recognition [31] have propose force field transformation for the force field feature extraction, [32] have proposed local surface patch comparisons using range data , Voronoi diagram matching, neural networks, and genetic algorithms. [33] Have proposed geometric feature extraction and 2D, 3D data, ICP. [37] Detected image regions with a large local curvature with a technique called step edge magnitude. [38] Use weak classifiers based on Haar-wavelets in connection with AdaBoost for ear localization. [39]
developed an ear detection method which fuses range images and corresponding 2D color images.

Here is the table shows the different algorithms used by researchers in different biometric traits.

<table>
<thead>
<tr>
<th>Algorithms used</th>
<th>Face</th>
<th>Fingerprint</th>
<th>Iris</th>
<th>Palmprint</th>
<th>Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Component Analysis (PCA)</td>
<td>[48]</td>
<td>[52]</td>
<td>[10]</td>
<td>[16]</td>
<td>[33]</td>
</tr>
<tr>
<td>Independent Component Analysis</td>
<td>[48]</td>
<td>[52]</td>
<td>[10]</td>
<td>[16]</td>
<td>[77]</td>
</tr>
<tr>
<td>Discrete Cosine Transform(DCT)</td>
<td>[49]</td>
<td>[78]</td>
<td>[79]</td>
<td>[30]</td>
<td>[119]</td>
</tr>
<tr>
<td>Linear Discriminant Analysis(LDA)</td>
<td>[50]</td>
<td>[52]</td>
<td>[41]</td>
<td>[81]</td>
<td>[82]</td>
</tr>
<tr>
<td>Locality Preserving Projections(LPP)</td>
<td>[50]</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Discrete wavelet transform(DWT)</td>
<td>[87]</td>
<td>[83]</td>
<td>[88]</td>
<td>[89]</td>
<td>[90]</td>
</tr>
<tr>
<td>Neural networks</td>
<td>[50]</td>
<td>[110]</td>
<td>[111]</td>
<td>[112]</td>
<td>[75]</td>
</tr>
<tr>
<td>Wavelet-Curvelet Technique</td>
<td>[58]</td>
<td>[93]</td>
<td>[94]</td>
<td>[95]</td>
<td>[91]</td>
</tr>
<tr>
<td>2D wavelet transform</td>
<td>[49]</td>
<td>[97]</td>
<td>[98]</td>
<td>[99]</td>
<td>[100]</td>
</tr>
<tr>
<td>Neural networks with Gabor filters</td>
<td>[50]</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Novel Thinning Algorithm</td>
<td>-----</td>
<td>[55]</td>
<td>-----</td>
<td>[113]</td>
<td>-----</td>
</tr>
<tr>
<td>MERIT</td>
<td>-----</td>
<td>[56]</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Image Segmentation</td>
<td>[118]</td>
<td>[60]</td>
<td>[117]</td>
<td>[115]</td>
<td>[116]</td>
</tr>
<tr>
<td>Cluster Algorithm</td>
<td>[121]</td>
<td>[61]</td>
<td>[122]</td>
<td>[123]</td>
<td>[120]</td>
</tr>
<tr>
<td>Weighted Linear Embedding (WLE)</td>
<td>-----</td>
<td>[52]</td>
<td>-----</td>
<td>[124]</td>
<td>-----</td>
</tr>
<tr>
<td>local discriminant embedding analysis (LDE)</td>
<td>-----</td>
<td>[124]</td>
<td>-----</td>
<td>[124]</td>
<td></td>
</tr>
<tr>
<td>LGIC technique</td>
<td>-----</td>
<td>[52]</td>
<td>-----</td>
<td>[52]</td>
<td>-----</td>
</tr>
<tr>
<td>Gabor filter</td>
<td>[104]</td>
<td>[86]</td>
<td>[103]</td>
<td>[124]</td>
<td>[101]</td>
</tr>
<tr>
<td>Edge detection</td>
<td>[125]</td>
<td>[52]</td>
<td>[127]</td>
<td>[126]</td>
<td>[76]</td>
</tr>
<tr>
<td>Gabor Wavelet Transforms</td>
<td>[96]</td>
<td>[105]</td>
<td>[42]</td>
<td>[68]</td>
<td>[106]</td>
</tr>
<tr>
<td>Log gabor wavelets</td>
<td>[107]</td>
<td>[59]</td>
<td>[10]</td>
<td>[108]</td>
<td>[109]</td>
</tr>
<tr>
<td>Circular Symmetric Filters</td>
<td>-----</td>
<td>-----</td>
<td>[43]</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Haar Wavelet transform</td>
<td>[49]</td>
<td>[128]</td>
<td>[46]</td>
<td>[129]</td>
<td>[38]</td>
</tr>
<tr>
<td>Self-organizing map neural network</td>
<td>[130]</td>
<td>[132]</td>
<td>[47]</td>
<td>[131]</td>
<td>[133]</td>
</tr>
<tr>
<td>M-ICA</td>
<td>[136]</td>
<td>[137]</td>
<td>[44]</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Phase Based Image Matching</td>
<td>[134]</td>
<td>[85]</td>
<td>[22]</td>
<td>[80]</td>
<td>-----</td>
</tr>
<tr>
<td>Indexing technique</td>
<td>-----</td>
<td>[139]</td>
<td>[138]</td>
<td>[63]</td>
<td>-----</td>
</tr>
</tbody>
</table>

Table 1: Shows the Different Algorithms used in Different Biometric Traits

### III. Applications

#### A. Applications of Biometrics

Applications of biometric system are: Security (access control to buildings, airports/seaports, ATM machines and border checkpoints, computer/network security, email authentication on multimedia workstations), Surveillance (a large number of CCTVs can be monitored to look for known criminals, drug offenders, etc.). General identity verification (electoral registration, banking, electronic commerce, identifying newborns, national IDs, passports, drivers' licenses, employee IDs), Criminal justice systems (mug-shot/booking systems, post-event analysis, forensics). Image database investigation, Smart Card applications, Multimedia environments with adaptive human computer interfaces, Video indexing, Witness face reconstruction [25].

#### B. Applications of PCA

PCA is a useful statistical technique that has found application in fields such as face recognition and image compression. The jobs which PCA can do are prediction, redundancy removal, feature extraction, visualization and data compression, etc. PCA is a common technique for finding patterns in data of high dimension. It covers standard deviation, covariance, eigen vectors and eigen values. These are mathematical concepts that will be used in PCA. Now a day, PCA is using for most of the biometric traits like face, hand, fingerprint, iris, ear, palmprint, thumb etc.

### IV. HOW PCA WORKS

Suppose $\Gamma$ is an $N_2 \times 1$ vector, corresponding to an NxN face image $I$ [1].

1. Step 1: obtain face images $I_1, I_2, ..., I_M$ (training faces)
2. Step 2: represent every image $I_i$ as a vector $\Gamma_i$
3. Step 3: compute the average face vector $\Psi$:

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

All rights reserved by www.tjsrd.com 643
4) Step 4: subtract the mean face:
\[ \Phi_i = \Gamma_i - \Psi \]

5) Step 5: compute the covariance matrix C:
\[ C = \frac{1}{M} \sum_{i=1}^{M} \Phi_i \Phi_i^T = AA^T \quad (N^2 \times N^2 \text{ matrix}) \]
Where \( A = [\Phi_1 \Phi_2 \ldots \Phi_M] \) (\( N \times M \) matrix)

6) Step 6: compute the eigenvectors \( u_i \) of \( AA^T \)
   - Step 6.1: consider the matrix \( A^T A \) (\( M \times M \) matrix)
   - Step 6.2: compute the eigenvectors \( v_i \) of \( A^T A \)
   \[ A^T A v_i = \mu_i v_i \]
   \[ \Rightarrow A A^T A v_i = \mu_i A v_i \]
   \[ \Rightarrow C A v_i = \mu_i A v_i \quad \text{or} \quad C u_i = \mu_i u_i \]
   where \( u_i = A v_i \)
   Thus, \( AA^T \) and \( A^T A \) have the same eigenvalues and their eigenvectors are related as follows: \( u_i = A v_i \)
   - Step 6.3: compute the \( M \) best eigenvectors of \( AA^T : u_i = A v_i \)

7) Step 7: keep only \( K \) eigenvectors (corresponding to the \( K \) largest eigenvalues)
   Each face (minus the mean) \( \Phi_i \) in the training set can be represented as a linear combination of the best \( K \) eigenvectors:
\[ \hat{\Phi}_i - \text{mean} = \sum_{j=1}^{K} w_j u_j \quad (w_j = u_j^T \Phi_i) \]

Each normalized training face \( \Phi_i \) is represented in this basis by a vector:
\[ \Omega_i = \begin{bmatrix} w_1^T \\ w_2^T \\ \vdots \\ w_K^T \end{bmatrix}, \quad i = 1, 2, \ldots, M \]

Image recognition using Euclidean distance in PCA:
Given an unknown face image \( \Gamma \), follow these steps:
1) Step 1: normalize \( \Gamma : \Phi = \Gamma - \Psi \)
2) Step 2: project on the eigenspace
\[ \hat{\Phi} = \sum_{j=1}^{K} w_j u_j \quad (w_j = u_j^T \Phi) \]
3) Step 3: represent \( \hat{\Phi} \) as:
\[ \Omega_i = \begin{bmatrix} w_1^T \\ w_2^T \\ \vdots \\ w_K^T \end{bmatrix}, \quad i = 1, 2, \ldots, M \]

4) Step 4: find \( e_r = \min ||\Omega - \Omega_i|| \)
5) Step 5: if \( e_r < \text{Tr} \), then \( \Gamma \) is recognized as face \( \Gamma \) from the training set.
The distance \( e_r \) is called distance within the face space. We use the common Euclidean distance to compute \( e_r \).

A. Flowchart of PCA

Here is the flowchart to present how the MATLAB software program works for all Biometrics:

B. Flowchart of Proposed System

V. DESCRIPTION OF BIOMETRICS USING PCA

A. Face Recognition using PCA
The task of recognition of human faces is quite complex. The human face is full of information but working with all the
information is time consuming and less efficient. It is better to get unique and important information and discards other useless information in order to make system efficient. Face recognition systems can be widely used in areas where more security is needed. M.A. Turk and Alex P. Pentland developed a near real time Eigen faces system for face recognition using Euclidean distance.

The eigenfaces approach is now largely superceded in the face recognition literature. A set of eigenfaces can be generated by performing a mathematical process called principal component analysis (PCA) on a large set of images depicting different human faces. eigenfaces can be considered a set of "standardized face ingredients", derived from statistical analysis of many pictures of faces. Any human face can be considered to be a combination of these standards faces [6].

There are two phases in the identification phase: training and testing. In the training phase the eigenvalues and eigenvectors of the training set are extracted and the eigenvectors are chosen based on the top eigenvalues. Training set is a set of clean images without any duplicates. In the testing phase the algorithm is provided a set of known faces and a set of unknown faces as the probe set. The algorithm matches each probe to its possibly identity in the gallery [14].

I have used Frontal face dataset which is Collected by Markus Weber at California Institute of Technology, 450 face images with resolution 896 x 592 pixels in the Jpeg format. Belongings to 27 or so unique people under with different lighting/expressions/backgrounds. In our experimental result, we have used 5 individuals with different 5 face images. So, we have 25 training face images and 10 test images (5 individuals with different 2 face images). By using PCA, we reduced the dimensions from (896 x 592) to (56 x 56). First largest 21 eigen values are selected for 21 eigen face instead of 25 eigenface. The Euclidean distance is used to find out the distance between the test image and training images. The training image which has the minimum distance with the test image is supposed to be an individual with perfect match. The proposed matlab program works in jpeg format images.

I have applied the MATLAB program on 10 test images, and all are recognized with exact individual. One result with proper match is shown below:

Table showing the distance between test image and all training images. The test image has the minimum distance with image 2 by minimum distance 1.619653077917682

<table>
<thead>
<tr>
<th>Image</th>
<th>Minimum Distance</th>
<th>Image</th>
<th>Minimum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.663115222775505</td>
<td>14</td>
<td>3.645981684653634</td>
</tr>
<tr>
<td>2</td>
<td>1.619653077917682</td>
<td>15</td>
<td>7.52631066744526</td>
</tr>
<tr>
<td>3</td>
<td>3.106194071506731</td>
<td>16</td>
<td>6.219968621163678</td>
</tr>
<tr>
<td>4</td>
<td>4.275033088620918</td>
<td>17</td>
<td>3.539672055488723</td>
</tr>
<tr>
<td>5</td>
<td>3.439825085959034</td>
<td>18</td>
<td>3.816293895709851</td>
</tr>
<tr>
<td>6</td>
<td>2.59407488093842</td>
<td>19</td>
<td>3.97046579459104</td>
</tr>
<tr>
<td>7</td>
<td>2.264743936721611</td>
<td>20</td>
<td>4.354268671985382</td>
</tr>
<tr>
<td>8</td>
<td>4.458852993560516</td>
<td>21</td>
<td>3.156992254685193</td>
</tr>
<tr>
<td>9</td>
<td>4.914985547364522</td>
<td>22</td>
<td>5.417743402897436</td>
</tr>
<tr>
<td>10</td>
<td>3.198207763331167</td>
<td>23</td>
<td>4.246053540007097</td>
</tr>
<tr>
<td>11</td>
<td>5.24126199905721</td>
<td>24</td>
<td>5.319743743942976</td>
</tr>
<tr>
<td>12</td>
<td>3.432940906969986</td>
<td>25</td>
<td>3.728909520833027</td>
</tr>
<tr>
<td>13</td>
<td>3.77668924617894</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Distance between Test Image and Training Images

The graph shows the distance found between the test images and training images. The distance is found by using the Euclidean distance method.

Fig. 8: shows the graph plot distance found with test image verses training images

B. Fingerprint Recognition using PCA

Fingerprints are currently emerging as the widespread biomedical identification method in both forensic and civilian applications. Fingerprint recognition is one of the most reliable and valid personal recognition method which has been in use of long time. Fingerprint probably is the most widely used as a personal identification tool. It has been used for many centuries, primarily because of its individuality and
uniqueness and reliability. Of all the Biometrics, fingerprint identification is one of the most famous and publicized biometrics and has been successfully used in security applications. Nowadays, the automatic fingerprint identification algorithms are very expensive on computations. Due to the large size of present day fingerprint databases, it is necessary to use methods to reduce the number of one-to one fingerprint comparisons when performing the fingerprint query execution. A fingerprint is believed to be unique to each person. Fingerprints of even identical twins are different [6].

The fingerprint image is made up of pattern of ridges and valleys; they are the replica of the human fingertips. The fingerprint image represents a system of oriented texture and has very rich structural information within the image. This flow-like pattern forms an orientation field extracted from the style of valleys and ridges called minutia. Now days, Many algorithms are used for feature extraction and pattern matching for fingerprint recognition. But we have used PCA for fingerprint recognition because of its simplicity and less computational work and require less space in the system because of its low dimensionality approach [7].

I have used fingerprint database. All images are in PNG format. There are 16 people with different 8 fingerprint images with different lighting/expressions/backgrounds and resolution is (248 x 338) pixels. In the experimental result, I have used 6 individuals with different 5 fingerprint images. So, I have 30 training fingerprint images and 12 test images (6 individuals with different 2 fingerprint images). By using PCA, I reduced the dimensions from (248 x 338) to (100 x 100). First largest 24 eigen values are selected. The PNG format of images has changed to jpeg. The proposed matlab program works in jpeg format images. The Euclidean distance is used to find out the distance between the test image and training images. The training image which has the minimum distance with the test image is supposed to be an individual with perfect match. If I am decreasing the dimensions and increasing the eigenvalues from 24 to 29 then the distance also decreases.

We have applied the MATLAB program on 12 test images, and all are recognized with exact fingerprint match. One result with proper match is shown below.

Table 3: Distance between Test Image and Training Images

<table>
<thead>
<tr>
<th>Images</th>
<th>Minimum Distance</th>
<th>Images</th>
<th>Minimum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.7344410007568</td>
<td>16</td>
<td>3.503113625998</td>
</tr>
<tr>
<td></td>
<td>68</td>
<td></td>
<td>504</td>
</tr>
<tr>
<td>2</td>
<td>2.885972196929</td>
<td>17</td>
<td>3.594705669296</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td></td>
<td>74</td>
</tr>
<tr>
<td>3</td>
<td>3.513940491032</td>
<td>18</td>
<td>3.673057093526</td>
</tr>
<tr>
<td></td>
<td>436</td>
<td></td>
<td>04</td>
</tr>
<tr>
<td>4</td>
<td>3.216849448116</td>
<td>19</td>
<td>3.126784655385</td>
</tr>
<tr>
<td></td>
<td>754</td>
<td></td>
<td>676</td>
</tr>
<tr>
<td>5</td>
<td>3.991457291484</td>
<td>20</td>
<td>3.549020399878</td>
</tr>
<tr>
<td></td>
<td>817</td>
<td></td>
<td>964</td>
</tr>
<tr>
<td>6</td>
<td>3.7082450605064</td>
<td>21</td>
<td>3.555739718306</td>
</tr>
<tr>
<td></td>
<td>285</td>
<td></td>
<td>333</td>
</tr>
<tr>
<td>7</td>
<td>3.419770405178</td>
<td>22</td>
<td>3.550843764682</td>
</tr>
<tr>
<td></td>
<td>713</td>
<td></td>
<td>72</td>
</tr>
<tr>
<td>8</td>
<td>5.226852140173</td>
<td>23</td>
<td>4.081427347616</td>
</tr>
<tr>
<td></td>
<td>81</td>
<td></td>
<td>82</td>
</tr>
<tr>
<td>9</td>
<td>3.4797088181246</td>
<td>24</td>
<td>3.725461203670</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td></td>
<td>826</td>
</tr>
<tr>
<td>10</td>
<td>4.988421390768</td>
<td>25</td>
<td>4.050210729967</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td></td>
<td>79</td>
</tr>
<tr>
<td>11</td>
<td>5.293181416094</td>
<td>26</td>
<td>4.363775111055</td>
</tr>
<tr>
<td></td>
<td>675</td>
<td></td>
<td>595</td>
</tr>
<tr>
<td>12</td>
<td>4.3699001142691</td>
<td>27</td>
<td>3.733278286868</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td></td>
<td>94</td>
</tr>
<tr>
<td>13</td>
<td>4.4212664157955</td>
<td>28</td>
<td>3.922315827005</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td></td>
<td>05</td>
</tr>
<tr>
<td>14</td>
<td>4.3156793504587</td>
<td>29</td>
<td>3.794260777240</td>
</tr>
<tr>
<td></td>
<td>965</td>
<td></td>
<td>568</td>
</tr>
<tr>
<td>15</td>
<td>3.7695229587313</td>
<td>30</td>
<td>3.432502303561</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td></td>
<td>925</td>
</tr>
</tbody>
</table>

Table 9: The graph shows the distance found with the test image and training images. The distance is found by using the Euclidean distance method.

C. Iris recognition using PCA

Iris pattern recognition is one of the most reliable, secure and promising approaches for individual authentication. Iris recognition is considered as a most reliable and accurate method because of its high recognition rate and uniqueness. Among all biometrics, iris recognition is the most consistent
one. The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. The pattern of the human iris differs from person to person; there are not even two irises alike, not even for genetically identical twins. The iris is considered one of the most stable biometric, as it is believed to not change. The iris is considered one of the most stable biometric, as it is believed to not change [8].

Various algorithms have been applied for feature extraction and pattern matching processes. These methods use local and global features of the iris. A great deal of advancement in iris recognition has been made through these efforts. Here, I have used PCA for feature extraction. In PCA, the aim of feature extraction is to find a transformation from an n-dimensional observation space to a smaller m-dimensional feature space [9]. Main reason for performing feature extraction is to reduce the computational complexity for iris recognition. Most existing iris recognition methods are based on the local properties such as phase, shape, and so on. However, iris image recognition based on local properties is difficult to implement. Principal component analysis can produce spatially global features [10]. The original data are thus projected onto a much smaller space, resulting in data reduction. Using PCA the feature vector is generated. The matching of test iris and database iris is performed using PCA.

I have used MMU iris database images with resolution 320 x 240 pixels in the bitmap format. Belongings to 46 unique people with different 5 left and 5 right iris images. In the experimental result, I have used 3 individuals with different 3 left iris images and 3 right iris images. So, I have 18 training iris images and 12 test images (3 individuals with different 2 left iris images and 2 right iris images). By using PCA, I reduced the dimensions from (320 x 240) to (56 x 56). First largest 15 eigenvalues are selected. The bitmap format of images has changed to jpeg. The proposed matlab program works in jpeg format images. The Euclidean distance is used to find out the distance between the test image and training images. The training image which has the minimum distance with the test image is supposed to be perfect iris match.

I have applied the MATLAB program on 12 test images, and all are recognized with exact iris match. One result with proper match is shown below.

Table showing the distance between test image and all training images. The test image has the minimum distance with image 6 by minimum distance 0.591262031613743.

<table>
<thead>
<tr>
<th>Images</th>
<th>Minimum Distance</th>
<th>Images</th>
<th>Minimum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.591262031613743</td>
<td>10.1</td>
<td>0.591262031613743</td>
</tr>
<tr>
<td>2.0</td>
<td>0.591262031613743</td>
<td>10.2</td>
<td>0.591262031613743</td>
</tr>
<tr>
<td>3.0</td>
<td>0.591262031613743</td>
<td>10.3</td>
<td>0.591262031613743</td>
</tr>
<tr>
<td>4.0</td>
<td>0.591262031613743</td>
<td>10.4</td>
<td>0.591262031613743</td>
</tr>
<tr>
<td>5.0</td>
<td>0.591262031613743</td>
<td>10.5</td>
<td>0.591262031613743</td>
</tr>
<tr>
<td>6.0</td>
<td>0.591262031613743</td>
<td>10.6</td>
<td>0.591262031613743</td>
</tr>
<tr>
<td>7.0</td>
<td>0.591262031613743</td>
<td>10.7</td>
<td>0.591262031613743</td>
</tr>
<tr>
<td>8.0</td>
<td>0.591262031613743</td>
<td>10.8</td>
<td>0.591262031613743</td>
</tr>
<tr>
<td>9.0</td>
<td>0.591262031613743</td>
<td>10.9</td>
<td>0.591262031613743</td>
</tr>
</tbody>
</table>

Fig. 12: shows the graph plot distance found with test image verses training images.

D. Palmprint recognition using PCA

Palmprint is one of the relatively new physiological biometrics because of its stable and unique characteristics. The rich texture information of palmprint offers one of the powerful means in personal recognition. Palmprint recognizes a person based on the principal lines, wrinkles and ridges on the surface of the palm. These line structures are stable and remain unchanged throughout the life of an individual. More importantly, no two palmprints from different individuals are the same, and people feel easy to have their palmprint images taken for testing. Therefore palmprint recognition offers promising future for medium-security access control system [16]. Palmprint recognition is a very interesting research area.

In Palmprint recognition, it is sometimes difficult to extract the line structures that can discriminate every individual well. Besides, creases and ridges of the palm are always crossing and overlapping each other which
complicates the feature extraction task [16]. An important issue in palmprint recognition is to extract palmprint features. Among the works that appear in the literature are eigenpalm, Gabor filters, Fourier Transform, and wavelets. I have used “eigenpalm” (PCA) in the study. Eigenpalm are just like the eigenface. It works with the same manner as for face recognition system. The features are extracted with PCA and then matching process is done [62].

I have used hand database with different 300 hand images with resolution 230 x 260 in the tif format. In the experimental result, I have used 5 individuals with different 4 palmprint images. So, I have 20 training images and 10 test images (5 individuals with different 2 palmprint images). By using PCA, I reduced the dimensions from (230 x 260) to (100 x 100). First largest 12 eigen values are selected for 12 eigenpalms instead of 20 eigenpalms. The tif format of images has changed to jpeg. The proposed matlab program works in jpeg format images. The Euclidean distance is used to find out the distance between the test image and training images. The training image which has the minimum distance with the test image is supposed to be perfect match.

I have applied the MATLAB program on 10 test images, and all are recognized with exact palmprint match. One result with proper match is shown below:

![matches 047.jpg min distance 1.0786033](image)

The left image is the test image and it is recognized by the right side image from the training images.

Table showing the distance between test image and training images. The test image has the minimum distance with image 14 by minimum distance 1.0786326202370273.

<table>
<thead>
<tr>
<th>Image</th>
<th>Minimum Distance</th>
<th>Image</th>
<th>Minimum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.80975829423400 2</td>
<td>11</td>
<td>4.94269604254555 35</td>
</tr>
<tr>
<td>2</td>
<td>6.44992519346678 9</td>
<td>12</td>
<td>5.87120416077242</td>
</tr>
<tr>
<td>3</td>
<td>6.73476982962015 75</td>
<td>13</td>
<td>5.72429021168663 2</td>
</tr>
<tr>
<td>4</td>
<td>6.73480009255091 7</td>
<td>14</td>
<td>1.0786326202370273 73</td>
</tr>
<tr>
<td>5</td>
<td>6.72736976435878 4</td>
<td>15</td>
<td>1.74444191962936 41</td>
</tr>
<tr>
<td>6</td>
<td>4.6767302502589 5</td>
<td>16</td>
<td>3.70912160631344 67</td>
</tr>
<tr>
<td>7</td>
<td>4.300995853018 2</td>
<td>17</td>
<td>1.91043167035315 99</td>
</tr>
</tbody>
</table>

Table 5: Distance between test image and training images.

![Fig. 14: shows the graph plot distance found with test image verses training images](image)

**E. Ear recognition using PCA**

The possibility of identifying people by the shape of their outer ear was first discovered by the French criminologist Bertillon, and refined by the American police officer Iannarelli, who proposed a first ear recognition system based on only seven features. The detailed structure of the ear is not only unique, but also permanent, as the appearance of the ear does not change over the course of a human life [12]. Additionally, the acquisition of ear images does not necessarily require a person’s cooperation but is nevertheless considered to be non-intrusive by most people. Ears have gained attention in biometrics due to the robustness of the ear shape. The shape does not change due to emotion as the face does, and the ear is relatively constant over most of a person’s life [13]. It has been suggested that the shape of the ear and the structure of the cartilaginous tissue of the pinna are distinctive. Matching the distance of salient points on the pinna from landmark location of the ear is the suggested method of recognition in this case.

Ears have several advantages: reduced spatial resolution, a more uniform distribution of color, and less variability with expressions and orientation of the face. In face recognition there can be problems with e.g. changing lighting, and different head positions of the person. There are some kinds of problems with the ear, but the image of the ear is smaller than the image of the face, which can be an advantage. In practice ear biometrics aren’t used very often. There are only some cases in the crime investigation area where the earmarks are used as evidence in court. However, it is still inconclusive if the ears of all people are unique. There are some researches done which favor that ear uniqueness is good enough [14]. The most interesting parts
of the ear are the outer ear and ear lobe, but the whole ear structure and shape is used.

In this paper, I have used principal component analysis, also known as “eigenfaces”, which is a dimensionality-reduction technique in which variation in the dataset is preserved. The classification is done in eigenspace, which is a lower dimension space defined by principal components or the eigenvectors of the data set.

I have taken IIT Delhi Ear Database version 1.0, This is touch less ear image database mainly. All the images are acquired from a distance (touch less) using simple imaging setup and the imaging is performed in the indoor environment. The currently available database is acquired from the 121 different subjects and each subject has at least three ear images. All the subjects in the database are in the age group 14-58 years. The database of 471 images has been sequentially numbered for every user with an integer identification/number. The resolution of these images is (272 x 204) pixels and all these images are available in jpeg format. In the experimental result, I have used 10 individuals with different 3 ear images. So, I have 30 training face images and 20 test images (10 individuals with different 2 ear images). By using PCA, I reduced the dimensions from (272 x 204) to (100 x 100). First largest 21 eigen values are selected for 21 eigenear instead of 30 eigenear. The proposed matlab program works in jpeg format images. The Euclidean distance is used to find out the distance between the test image and training images. The training image which has the minimum distance with the test image is supposed to be an ear with perfect match.

I have applied the MATLAB program on 20 test images, and all are recognized with exact ear match. One result with proper match is shown below:

![Image]

The left image is the test image and it is recognized by the right side image from the training images.

Table showing the distance between test image and training images. The test image has the minimum distance with image 8 by minimum distance 0.7625512875712156.

<table>
<thead>
<tr>
<th>Images</th>
<th>Minimum Distance</th>
<th>Images</th>
<th>Minimum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.6415662325106</td>
<td>16</td>
<td>2.0522029700881</td>
</tr>
<tr>
<td>2</td>
<td>3.5279409023380</td>
<td>17</td>
<td>2.3192799508064</td>
</tr>
<tr>
<td>3</td>
<td>3.5713602457148</td>
<td>18</td>
<td>2.7439082290819</td>
</tr>
<tr>
<td>4</td>
<td>3.6642828670141</td>
<td>19</td>
<td>2.231784315180</td>
</tr>
<tr>
<td>5</td>
<td>3.590377541068</td>
<td>20</td>
<td>2.7437715888705</td>
</tr>
<tr>
<td>6</td>
<td>3.4734443779222</td>
<td>21</td>
<td>2.663959952505</td>
</tr>
<tr>
<td>7</td>
<td>1.0825819993289</td>
<td>22</td>
<td>2.1621744146398</td>
</tr>
<tr>
<td>8</td>
<td>0.7625512875712</td>
<td>23</td>
<td>2.1134032073819</td>
</tr>
<tr>
<td>9</td>
<td>1.2458929317615</td>
<td>24</td>
<td>2.5232900947231</td>
</tr>
<tr>
<td>10</td>
<td>3.0159897078665</td>
<td>25</td>
<td>2.8456270277603</td>
</tr>
<tr>
<td>11</td>
<td>3.211648934801</td>
<td>26</td>
<td>2.8747147788553</td>
</tr>
<tr>
<td>12</td>
<td>3.2226047212110</td>
<td>27</td>
<td>2.4855933107944</td>
</tr>
<tr>
<td>13</td>
<td>2.8189486366466</td>
<td>28</td>
<td>3.3216860730778</td>
</tr>
<tr>
<td>14</td>
<td>2.6627780720555</td>
<td>29</td>
<td>3.503737925125</td>
</tr>
<tr>
<td>15</td>
<td>2.7557690319927</td>
<td>30</td>
<td>2.7363496713997</td>
</tr>
</tbody>
</table>

Table 6: Distance between test image and training images.

The graph shows the distance found between the test images and training images. The distance is found by using the Euclidean distance method.

![Graph]

VI. RESULT / CONCLUSION

In this paper, I have used PCA algorithm for all biometric traits such as face, iris, fingerprint, palm print and ear recognition. The same MATLAB software program is used for all biometrics. The results are obtained are discussed earlier. A short format of result is shown here of all biometric traits.
From the experimental results mentioned above, it has been proven that PCA is well suited for all biometrics and given better results. All test images (face, ear, iris, fingerprint, palmprint) found with perfect match in the training images. Main reason for using PCA is to reduce the computational complexity and reduce the large dimensionality of the data space to the smaller intrinsic dimensionality of feature space. PCA based method is computationally expensive and requires less time and therefore we considered the algorithm of PCA if the noise is not strong. The aim of working on the PCA is to develop a system with increased speed and accuracy. In comparison with other methods, our algorithm can be implemented without using hard mathematical computations.

REFERENCES


[6] Mohammed S. Khalil, Muhammad Imran Razzak, Muhammad Khurram Khan, “Fingerprint Classification Using PCA, LDA, L-LDA and BPN”, Center of Excellence in Information Assurance (CoEIA), King Saud University, Saudi Arabia.


[14] Hanna-Kaisa Lammi, “EAR BIOMETRICS”, Lappeenranta University of Technology, Department of Information Technology.


[16] Tee Connie, Andrew Teoh, Michael Goh, David Ngo, “Palmprint Recognition with PCA and ICA”.


[51] Fernando Alonso-Fernandez Josef Bigun, Julia Fierrez, Hartwig Fronhalter, Klaus Kollreider, “Fingerprint Recognition”.


[59] Nabanita Basu, “Comparative study of the different feature extraction algorithms used for fingerprint identification”.


[82] Zhang Xiaoxun, “symmetrical null space LDA for face and ear recognition”,

[83] Department of Computer Science and Engineering, Beijing Institute of Technology, Beijing 100081, PR China.


[119] KAMENCAY, Patrik; ZACHARIASOVA, Martina; HUDEC, Robert; JARINA, Roman; BENCO, Miroslav; UBIK, Jan HL, “A Novel Approach to Face Recognition using Image Segmentation Based on SPCA-KNN Method”, Radioengineering;Apr2013, Vol. 22 Issue 1, p92.


[128] U T Tania, S M A Motakabber, M I Ibrahimy “Edge detection techniques for iris recognition system”, 5th International Conference on Mechatronics (ICOM’13)
recognition using minutiae extraction for bank locker security”, national conference.


[144] V. Starovoitov, D. Samal, “A GEOMETRIC APPROACH TO FACE RECOGNITION”.


[149] Laurenz Wiskott, Jean-Marc Fellous, Norbert Krüger, Christoph von der Malsburg, “Face Recognition by Elastic Bunch Graph Matching”.
