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Principle Component Analysis to Recognize Face, Iris and Finger Print Image

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Abstract: ***Mono modal biometric systems have a variety of problems such as noisy data, inter & intra class variations of freedom, non-universality, spoof attacks and non acceptable errors . These limitations can be addressed by using multi modal biometric systems that integrate the evidence presented by multiple information sources . Multi instance biometrics for persons authentication improves recognition rate. These systems are to improve its recognition rate, reduce spoofing and be avoid to fault tolerance of different mono modal biometric systems. In this paper present a multi modal biometric authentication method using face, iris and fingerprint based on Principle Component Analysis. This methods prevents the drawback of the common mono modal biometric systems. It allow to creating a flexible general-purpose and design for multi modal biometric systems.***

Keywords: Biometric, PCA, Multi Modal, FAR, FRR and EER

1. Introduction

In traditional cryptosystems, user authentication is based on possession of secret keys[1], which falls apart if the keys are not crypted. Bio metric authentication systems depends on physiological and behavioral characteristics of persons , such as fingerprints, Face & Iris. This provide solutions to many of these problems and may replace the authentication component of the traditional cryptosystems. Various methods that monolithically bind a cryptographic key with the biometric template of a user stored in the database in such a way that the key cannot be revealed without a successful biometric authentication have been defined. The accuracy of one of these biometric key binding/generation algorithms using the fingerprint biometric is assessed. The challenges involved in biometric key generation primarily due to drastic acquisition variations in the representation of a biometric identifier and the imperfect nature of biometric feature extraction and matching algorithms.

Inherent properties in each biometric and external manufacturing constraint in the sensing technologies, to date, no single biometric method can warrant 100% authentication accuracy by itself. This problem can be alleviated by combining multiple biometric methods[2][3] without resorting to the use of a conventional password system. The importance of multimodal biometrics thus need not be overemphasized. The biometric verification problem[4] can be considered to be a classification problem wherein a decision is made upon whether or not a claimed identity is genuine with inference to some matching criteria using principal component analysis.

2. Limitations of Mono Model Biometrics

Most biometric systems deployed in real-world applications are mono modal, i.e., they use a single source of information for authentication (e.g. Face/Iris). These systems have number of problems such as:

a) Noise in sensed data: A fingerprint image with a scar is examples of this. Noisy data could be result from defective sensors or unwanted ambient conditions.
b) Intra-class variations: These variations are typically caused by a user who is incorrectly interacting with the sensor.
c) Inter-class similarities: In a biometric system comprising of a large number of users, there may be inter-class similarities (overlap) in the feature space of multiple users.
d) Non-universal: The system may unable to acquire meaningful biometric data from a subset of users
e) Spoof attacks: These attack is e relevant when behavioral traits such as signature or voice are used.

Mono modal biometric systems can be overcome these by including multiple sources of information for authentication. Such systems, known as multi model biometric systems, are be more reliable due to the presence of multiple evidence.

3. Multi-Biometric Categories

To further the understanding of the distinction among the multi-biometric categories[5],

1) Multimodal biometric systems take input from single or multiple sensors measuring two or more different modalities of biometric characters. For example, a system matching Iris, face and fingerprint features for biometric recognition would be considered a "multimodal" system regardless of whether face and iris images were captured by different or same imaging equipments. It is not important that the various measures be mathematically gained in anyway.
2) Multialgorithmic biometric systems take a single sample from a single sensor and process that sample with two or more different algorithms.. Maximum output would be given from algorithms that are based on distinctly different and independent principles.
3) Multiinstance biometric systems use one sensor or multiple sensors to capture samples of two or more different instances of the same biometric features. i.e., systems capturing images from multiple fingers are considered to be multi instance rather than multimodal.
4) Multi sensorial biometric systems sample the same instance of a biometric trait.
5) Multi model: system take multiple sample from multiple sensor process it by using single algorithm

4. Principal Component Analysis

Principal component analysis (PCA)[6] was invented in 1901 by Karl Pearson. PCA is a variable reduction procedure and useful when obtained data have some redundancy. This will result into reduction of variables into smaller number of variables which are called Principal Components which will account for the most of the variance in the observed variable.

This paper gives the simple implementation of Biometric recognition using principal component analysis give results, based on information theory , it required a computational model that explains a Biometric, by extracting the most relevant information contained in this system. This technique is old one, but in this paper the implementation is given with very simple manner. Eigenvalues approach is a principal component analysis approch, in this a small set of features pictures are used to describe the variation between biometric images. Eigenvalues approach looks to be an proper method to be used for Biometric recognition due to its user friendly ness, execution speed and learning ability. Results using MATLAB are presented in this paper to demonstrate the ability of the proposed Biometric recognition method.

Problems arise when we wish to perform recognition in a high-dimensional space. Goal of PCA is to reduce the dimensionality of the data by retaining as much as variation possible in our original data set. On the other hand dimensionality reduction implies information loss. The best low-dimensional space can be determined by best principal components.

The major advantage of PCA is using it in eigenface approach which helps in reducing the size of the database for recognition of a test images. The images are stored as their feature vectors in the database which are found out projecting each and every trained image to the set of Eigen faces obtained.

1.PCA Implementation [17]

- Step 1: Lets Subtract the Mean of the data from each variable (our adjusted data)
- Step 2: Lets Calculate and form a covariance Matrix
- Step 3: Lets Calculate Eigenvectors and Eigenvalues from the covariance Matrix
- Step 4: Lets Chose a Feature Vector (a fancy name for a matrix of vectors)
- Step 5: Lets Multiply the transposed Feature Vectors by the transposed adjusted data

Step 1: Mean Subtraction
This data is fairly simple and makes the calculation of our covariance matrix a little simpler now this is not the sub-traction of the overall mean from each of our values as for covariance we need two dimensions of calculated data. It is required for the subtraction of the mean of each row from each element in that row.

Step 2: Covariance Matrix
The Covariance equation for two dimensional is:

$$\mathrm{cov}(x,y)=\frac{\sum_{i-1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{n-1} \quad \text{(Eq.01)}$$

Which is similar to the formula for dirrence. In this equation x represents the pixel value and $\bar{x}$ is the mean of all x values, and n the total number of values. The covariance matrix that is formed for the sample image data represents how much the dimensions differ from the mean with respect to one another. The definition of a covariance matrix is:

$$c^{n*n}=(\mathrm{c}_{i,j},\mathrm{c}_{i,j}=\mathrm{cov}(\mathrm{Dim}_i,\mathrm{Dim}_j)) \quad \text{(Eq.02)}$$

Now the easiest way to explain this is but an example the easiest of which is a 3x3 matrix.

$$cmat=\begin{pmatrix}\mathrm{cov(x,x)} & \mathrm{cov(x,y)} & \mathrm{cov(x,z)}\\ \mathrm{cov(y,x)} & \mathrm{cov(y,y)} & \mathrm{cov(y,z)}\\ \mathrm{cov(z,x)} & \mathrm{cov(z,y)} & \mathrm{cov(z,z)}\end{pmatrix} \quad \text{(Eq.03)}$$

Now with larger matrices this can become more complicated and the use of computational algorithms essential.

Step 3: Eigenvectors and Eigen values[8] Eigen values are a product of multiplying matrices how-ever they are as special case. Eigen values are found by multiples of the covariance matrix by a vector in 2 dimensions. This defines the covariance matrix the equivalent of a transformation matrix. This system shows in a Eigenvectors can be scaled so ½ or x2 of the vector will still produce the same type of results. A vector is a direction and all you will be doing is changing the scale not the direction

Step 4: Feature Vectors Now a usually the results of Eigen values and Eigenvectors are not as clean as in the example above.

Step 5: Transposition The final stage in PCA is to take the transpose of the feature vector matrix and multiply it on the left of the trans-posed adjusted data set. The Eigen Object Recognizer class performs all of this and then feeds the transposed data as a training set and data is passed to an image to recognize it performance PCA and compares the generated Eigen values and Eigenvectors to the ones from the training set the Euclidian distance then produces a match if one has been found or a negative match if no match is found.

5. Implementation of PCA Algorithm

This is the step wise algorithm used for image matching by considering above formulations [7].

1) All training set images are resized and converted in to a single vector.
2) The test image is resized and converted in to a single vector.
3) The mean image of all training set images plus test image is calculated.
4) Then the mean image is subtracted from each image of the training set as well as from the test image. After subtraction we will get new images called as difference images..

5) Then using covariance matrix the eigenvector and eigenvalues are calculated. Each eigenvector belongs to one of the eigenimage.
6) Using product of each eigenimages with the difference images will get the weight vector of each class as well as the weight vector of the test image.
7) Then the weight of the test image is subtracted from each weight vector of the difference image.
8) Then the distance of each class of the images in the database is calculated.
9) The class having the least distance, the input test image belongs to that class.

6. Result Analysis

In imaging science, image processing is any form of signal processing for which the input is image and the output of image processing may be image or a set of characteristics or parameters related to the image.In image-processing techniques which involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

Image processing usually refers to digital image processing.

The performance of verification system is measured in certain standard terms i.e. eucledian distance which gives False Acceptance Rate (FAR), False Rejection Rate (FRR) and Equal Error Rate (EER). FAR is the ratio of number of unauthorized user's attempts accepted by the biometric system to the total number of verification attempts made.FRR is the ratio of number of authorized user's attempts rejected by the biometric system to the total number of verification attempts made. EER is a point where FAR and FRR are same.

This requires effective feature extraction and feature matching algorithm to return results which are near matches to the characteristic given and hence the need of proper threshold .

6.1 System Graphical User Interface

This is system GUI used for testing performance of system. Following GUI is used for recognizing face image form the input and it is compared with database image, output of this process is shown.

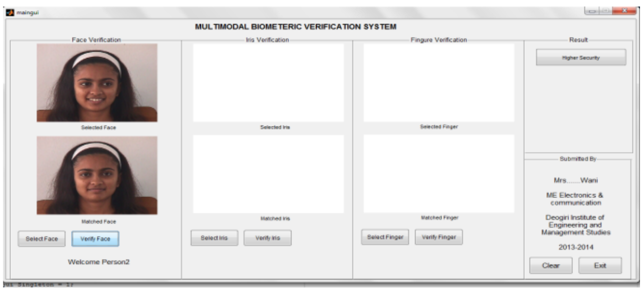

Figure 2: Face Recognition output

Following GUI is used for recognizing Iris image form the input and it is compared with database image, output of this process is shown.

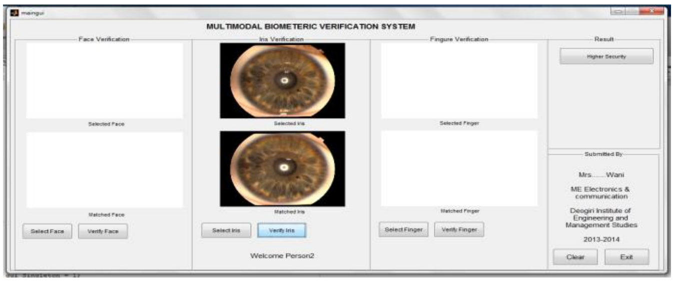

Figure 3: Iris Recognition Output

Following GUI is used for recognizing Fingerprint image form the input and it is compared with database image, output of this process is shown.

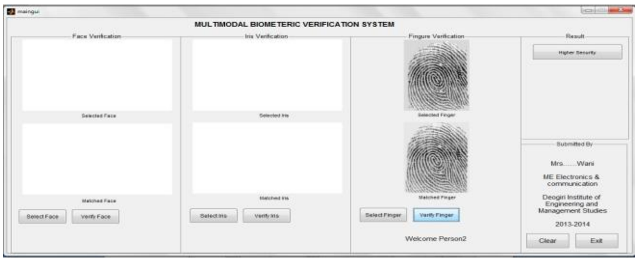

Figure 4: Fingerprint Recognition Output

In this process we have used Matlab 2013a is used for coding. A colored face image is converted to grey scale image as grey scale images are easier for applying computational techniques in image processing. A grey scale face image is scaled for a particular pixel size as 512x512 because many input images can be of different size whenever we take a input face for recognition. Database for different set of conditions is maintained. Four different expressions for five different people which creating a 4x5 that is equal to 20 different set of face images. Rotated images in left and right direction and different illumination conditions are also considered while making the training set. Size variations in a input face image can also change the output therefore input images by varying their size are also taken for recognition.Following is final system Output.

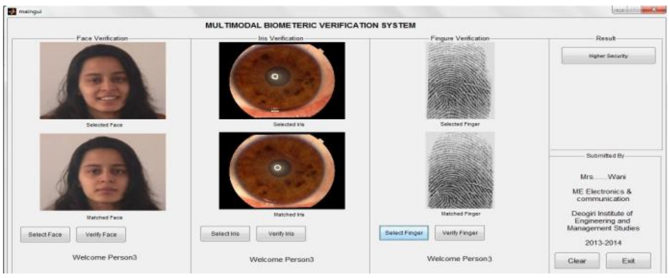

Figure 5: Final System Output

6.2 Database for Proposed System

Table 1: Database Properties

Parameter	Description
Required Database	Face, Iris & Fingerprint Image
Types of Images	PNG,JPEG,JPG
Database Name	Indian Faces, Standard Iris data,FVC2004
Number of persons	5
Total Images	5*4*3=60

These are biometric Images and are taken from good resolution 5 Mp webcam. We have taken total of 60 images. This is the data base used in this system

Figure 6: Face Image With Different Expressions

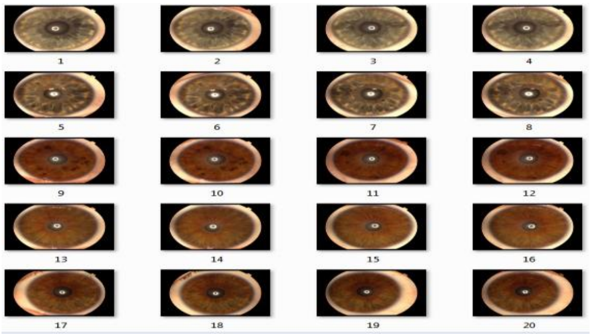

Figure 7: Iris image with variation

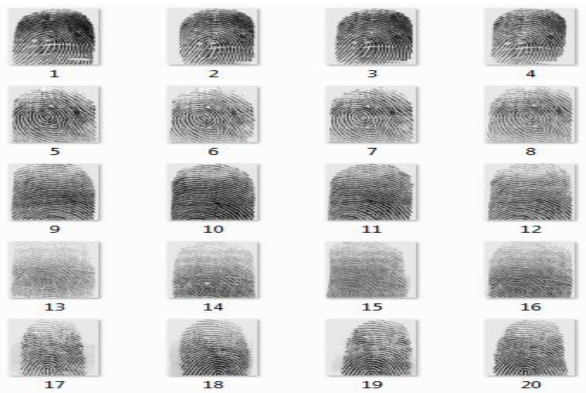

Figure 8: Finger Print Images with Variation

Fourvariation for five different people thus creating a 4x5 that is equal to 20.and same for iris and finger print.

6.3 Performance Parameter Evaluation

The performance of system is determined based on the accuracy of classification between the genuine and forged fingerprint. Evaluation parameters for any fingerprint verification system are FAR and FRR.Standard definitions of performance evaluation parameters i.e. False Acceptance Rate, False Rejection Rate is as follows:

$$\text{FAR}=\frac{\text{Number of Forged Sample Accepted}}{\text{Total Number of Verification Attempt Made}} \quad (1)$$

$$\text{FRR}=\frac{\text{Number of Genuine Sample Accepted}}{\text{Total Number of Verification Attempt Made}} \quad (2)$$

Following graph gives false rejection rate against threshold variance for proposed fingerprint recognition system.

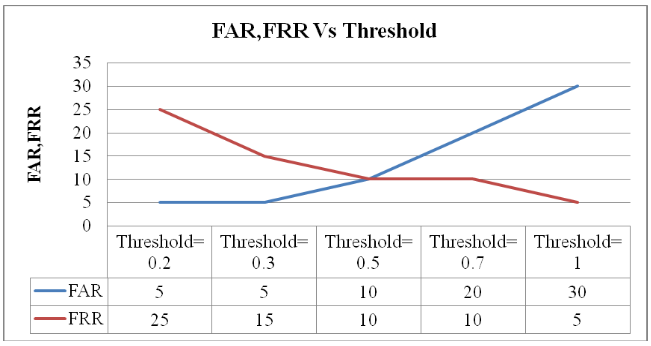

Figure 9: FAR,FRR(%) vs. Threshold variance for Face Image

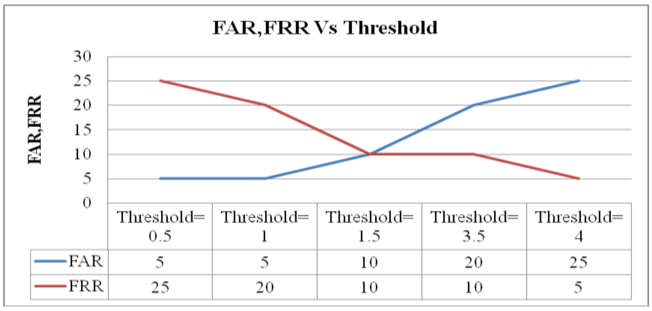

Figure 10: FAR,FRR(%) vs. Threshold variance for Iris Image

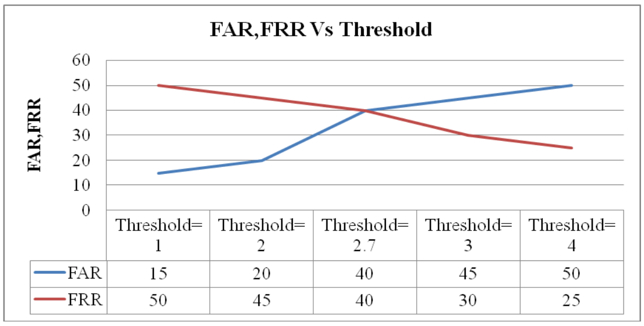

Figure 11: FAR,FRR(%) vs. Threshold variance for Finger Print

6.4 Accuracy of PCA for Face ,Iris & Finger

Accuracy is calculated for 60 images against various threshold values. Following graph shows that accuracy of the system for different threshold variance values.

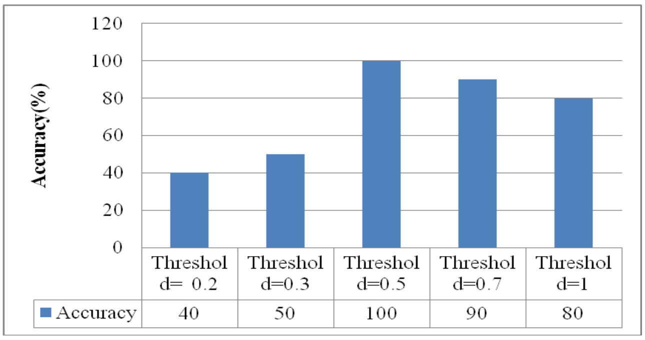

Figure 12: PCA Accuracy for Face Image

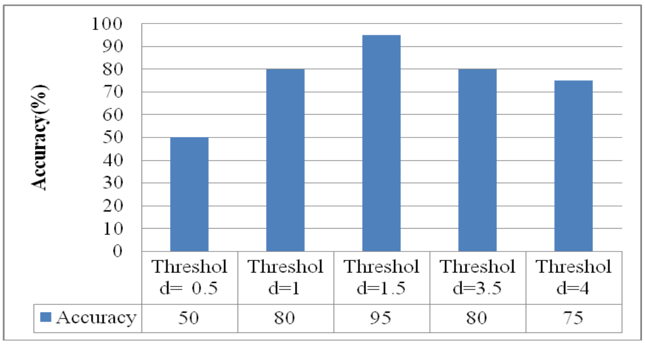

Figure 13: PCA Accuracy for Iris Image

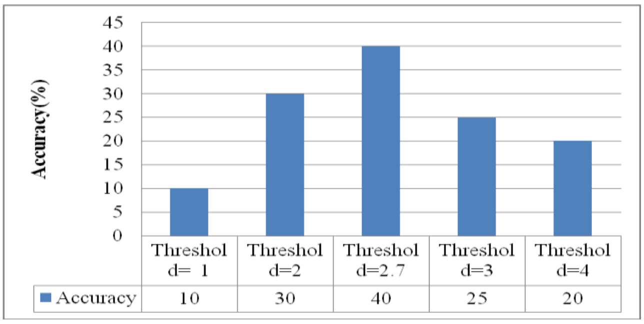

Figure 14: PCA Accuracy for Finger Print Image

Table 2: Best Accuracy for Various Threshold Values

Sr.No	Image	Threshold Value	Accuracy (%)
1	Face	0.5	100
2	Iris	1.5	95
3	Finger Print	2.7	40

Sixty different images for mentioned condition were taken to test for five different people. Light intensity is tried to keep low. Size variation of a test image is not altered to much extent. We can observe that normal expressions are recognized as face efficiently because facial features are not changed much in that case and in other cases where facial features are changed efficiency is reduced in recognition.

7. Conclusion

In above experiment the test image given for recognize is proved , which are shown in the Table 2. The algorithm developed works finely and gives 100% recognition rate for Face, 95%, recognition rate for Iris but due to Similar characteristics and incorrect difference of covariance matrix not able to give good result for Finger Print recognition i.e. only 40%. In this experiment it is observed that the images taken in the training set has different conditions like illumination, orientation and face expressions. . We can conclude that the output of this algorithm is gives better results.

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