Performance Study of Fusion in Multimodal Biometric Verification using Ear and Iris Features

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ABSTRACT
Multimodal biometric plays a significant role in human identification, which overcomes the issues of unimodal biometric system. The proposed approach is based on fusion of two unique traits, ear and iris and to study their performances. The features of both traits are extracted using common method, Principal Component Analysis (PCA) technique mainly for dimensionality reduction without information loss and used for identification. The similarity between the test data and the training set is measured using Euclidean distance by setting a threshold value for each system. It is found that this proposed work performs slightly better than the systems where only ear or iris trait is used.

General Terms
Image Processing, Pattern Recognition, Security.

Keywords
Ear, Iris, Segmentation, Principal Component Analysis, Fusion, Euclidean distance.

1. INTRODUCTION
Biometric authentication systems verify a person's claimed identity from behavioral traits (signature, voice) or physiological traits (face, iris, ear). Multimodal biometric system overcomes the limitations of unimodal biometric systems such as non-universality, noise in sensed data, spoofing, intra-class variability, inter-class variability [1]. Multimodal biometric system can be constructed using more than one physiological or behavioral characteristic for identification and verification purposes. These types of systems are developed for security purposes in various fields like crime investigation, e-commerce and military purposes. Multimodal biometric system developed using fingerprint, hand geometry, they required the concerned human to make physical contact with a sensing device.

Most of the existing biometric systems developed were based on single biometric features (fingerprint, ear, face, iris and so on). Each biometric trait has its own strength and weakness. Fig. 1 shows the different biometric traits popular recently.

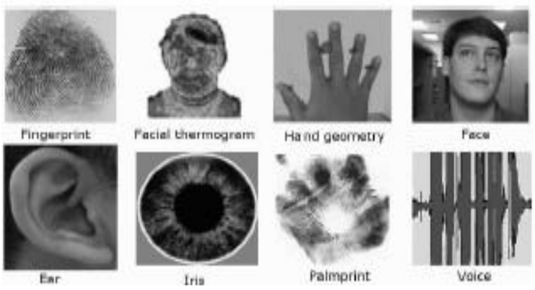


Fig 1: Examples of Biometric traits

Some of the problem with fingerprint recognition system is fingerprint images have been observed to have poor ridge details. Similarly, face recognition system fails due to variation in facial expression. Hence while developing biometric systems the choice of biometric traits is important in order to achieve better performance. Multimodal systems available are face and ear [2],[3],[7], face and fingerprint, palm print and face, etc. In this proposed work, two unique traits iris and ear are fused to obtain a better performance and high security.

The organization of this paper is as follows: section 2 describes the various levels of fusion in multimodal traits, section 3 gives the details of feature extraction of the traits using PCA, and section 4 explains the matching verification by fusion at different levels, finally section 5 discussions about results and section 6 concludes the work.

2. MULTIMODAL FUSION
Fusion in multimodal biometric system can be done at different levels of biometric verification process: feature extraction level, matching score level and decision level [4].

2.1 Fusion at Feature Extraction Level
Feature vectors obtained by extracting corresponding features from different traits are independent to each other. They are fused into a single vector for identification process. If the fused vector has high dimensionality, feature reduction techniques can be applied to reduce the dimensionality of the feature data.

2.2 Fusion at Matching Score level
When the feature vectors are compared with the template vector, a similarity score will be obtained. This measure indicates the proximity of the vectors for individual's identification.

2.3 Fusion at Decision level
Each acquired input trait is processed individually and the resultant feature vector is classified into two decisions, either accepted or rejected for each trait. Based on the major voting scheme, final decision will be made.

As our objective is to use iris and ear traits, the first step is to obtain the feature vectors of both traits individually and implement the fusion in it based on the necessity. Fig. 2 shows the different levels of fusion in bimodal biometric system.

3. FEATURE EXTRACTION
The region of interest for each trait, iris and ear is segmented by edge detection [9], Hough transform [10],[11],[13] and morphological operations [6] respectively. The features are

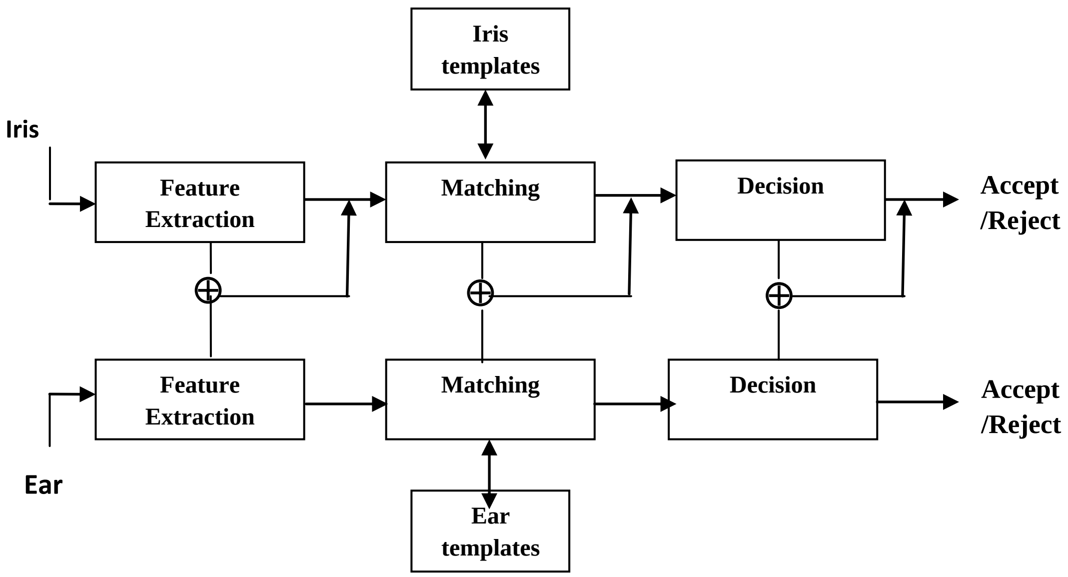


Fig 2: Levels of Fusion

extracted from both traits individually by suitable feature extraction technique. The feature extraction techniques can be chosen either classifier- based such as Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA) methods or wavelets such as Gabor wavelet, Haar wavelet depending on the requirements concentrated either on specific features [6] or general geometric features [5]. This process had been worked using wavelets earlier, hence in this proposed work, the same objective is tried using PCA method.

3.1 Principal Component Analysis (PCA)

Principal Components Analysis (PCA) is a dimensionality reduction technique to reduce a complex dataset into lower dimension. PCA found application in feature extraction, image compression. PCA is a method to identify patterns in data, and express the data in a way to highlight their similarities and dissimilarities. PCA make use of Eigen vectors for describing the features of an image. One of the advantages of PCA is that one can reconstruct any original image by combining the feature vectors. PCA reduces the dimensionality of data by having only the first few principal components [12].

The steps performed in PCA are as follows.

a) Reshape the normalized 2D image into 1D image vectors of size 1 X MN, simply by concatenating the rows of pixels in the original image.

b) The row-wise mean is calculated for entire dataset.

c) For PCA to work properly, subtract the mean from each dimension and place the result in matrix **A**.

d) To calculate the Eigen vectors and Eigen values, the matrix must be square. Construct an nxn covariance matrix by

$$A'*A \qquad (1)$$

f) Find the eigenvalues and eigenvectors of the dataset by solving

$$(A - \lambda)V = 0 \qquad (2)$$

Where λ is an eigenvalue and V is an eigenvector. The word "eigen" means that these quantities are characteristics of the correlation matrix A.

g) List the eigenvectors in order of decreasing Eigen value. That is, the first eigenvector corresponds to the largest Eigen value. This gives you the components in order of significance.

h) The eigenvector with the highest eigenvalue is the principle component of the data set.

i) To reduce the dimensionality, ignore the components that are less significant. Hence choose only the first **p** eigen vectors (p<n).

j) Feature vector is formed by taking the p eigen vectors and form a matrix with eigen vector as column.

$$f_v = (eig_1, eig_2, \ldots eig_n) \qquad (3)$$

k) This is the final step in PCA. Once the feature vector is formed, take the transpose of the vector and multiply it with the original data set. This will give the original data in terms of the vectors.

4. MATCHING

In this stage, the comparison is performed between testing and trained image. For the testing image processing steps such as segmentation, normalization and feature extraction are carried out. The generated feature vector from the testing image is then compared with training image feature vectors. The similarity between test images with the training set is measured by calculating Euclidean distance between their feature vectors. If the distance is higher than a threshold, the output is an imposter. Otherwise, the system outputs a match, meaning that person claimed for identity is verified.

The algorithm for verification is as follows:

a. First, the original images of the training set are transformed into a set of eigen features vectors **E1**.

b. For an unknown image, calculated the feature vectors **E2.**

c. Calculate the Euclidean distance **D** between the eigen feature vectors **E1** and eigen feature vectors **E2**.

d. If the distance **D** exceeds some threshold value, then the vector of the unknown image lies away from images in the dataset. In this case, person is rejected. Otherwise the person is considered as authenticated.

This algorithm is applied for both traits individually for verification.

4.1 Fusion

Fusion can be performed in three different levels, feature extraction level, matching level, and decision level. In this proposed work, fusion in matching module and decision level is performed as the initial start. Decision level fusion is performed at the end of both traits verification individually to obtain the final decision, accepted or rejected based on the majority voting scheme.

As next step, fusion at matching level is performed using score based matching. There are various methods available to perform score matching such as, Sum rule based fusion (transformation based), SVM (Classifier based), LR (Density based). Sum rule method is chosen to implement in this work at first.

4.1.1 Sum rule based fusion

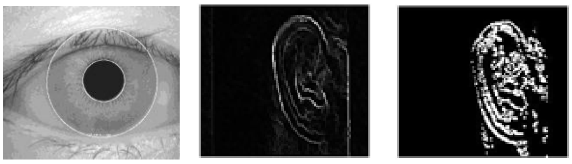
Obtain set of normalized scores (x_1, x_2,….,x_m) from a particular person, i.e., biometric matcher. The fusion score is evaluated by eq.4. Here weight is equal. Hence simplified fusion score is

$$f_s = x_1 + x_2 + \ldots + x_m \quad (4)$$

The fused score f_s will be compared to a pre-specified threshold *t*. We declare that a person to be a genuine user if $f_s \geq t$, otherwise, we declare that he or she is an impostor [14].

5. EXPERIMENTAL RESULTS

For experimental work, independent ear and iris datasets are been used containing sample size of 200. Test is conducted for the dataset individually at the beginning (Fig 3). The results of individual traits verification are shown in Table 1.



(a) (b) (c)

Fig 3:(a) Segmented Iris, (b) Morphological Ear Enhancement, (c) Processed Ear Image

Then decision level fusion based on individual matching result is determined using majority voting where we achieved 100% accuracy. Next for the evaluation of the sum rule-based score level fusion, we need to generate all possible genuine and impostor matching scores and then set a threshold for deciding whether to accept or to reject a match.

Table 1. Performance of individual trait verification

Model	FAR	GAR	FRR
Ear only	2.2	85	1.4
Iris only	3.3	84	1.4

A genuine matching score is obtained when two feature vectors corresponding to the same individual are compared, and an impostor matching score is obtained when feature vectors from two different individuals are compared. The false acceptance rate (FAR) value is the fraction of the number of false accepted impostor scores divided by the total number of impostor scores. The genuine acceptance rate (GAR) value is the fraction of the number of correctly accepted genuine scores divided by the total number of genuine scores. The result of score level fusion is shown in Table 2.

Table 2.Performance of fusion methods

Method	FAR	GAR	FRR
Decision Level	0	100	0
Score Level Matching	0	87.5	1.4

6. CONCLUSION

In this proposed work, iris and ear recognition system was developed separately first. Feature vectors of iris and ear region was extracted using Principal component analysis Technique and authenticated individually with 85% of accuracy for ear and 84 % for iris. Secondly, a recognition system is developed by fusion of iris and ear traits at matching score level with accuracy of 87.5% and 100% in decision level fusion. This improves the performance rate compared to single biometric authentication system and also increases the security level of authentication. But still performance can be improved by using other suitable feature extraction technique. Finally analyzed that this PCA method is not much suited for higher performance, especially with ear and iris.

7. FUTURE EXTENSION

To study the fusion of various traits at feature level and analyze its performances. Also to find some feature extraction techniques suitable for ear and iris other than wavelets.

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