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Wavelet and PCA based Multimodal Biometric System

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Abstract: ***Unimodal systems using single biometric trait often suffer from a lot of problems like noise in sensed data, intra-class variability, non-universality, spoof attacks, less population coverage and restricted degrees of freedom. Also, they are much less accurate as compared to multimodal systems. These problems can be resolved by using a multimodal biometric system. In this paper, a multimodal biometric fusion system is presented that fuses results from both Wavelets transform and PCA. This system is using three biometric traits like face, fingerprint and iris. Also, pre-processing of individual trait is done to improve the performance of the system using various techniques and algorithms. The overall performance of the system is shown in the form of ROC curve. The comparative study shows that multimodal systems are much more accurate than unimodal systems.***

Keywords: ***Unimodal, multimodal, fusion, pre-processing, threshold.***

1. INTRODUCTION

Biometrics refers to metrics related to human characteristics. Biometrics authentication (or realistic authentication) is used in computer science as a form of identification and access control. It is also used to identify individuals in groups that are under surveillance. Biometric identifiers are the distinctive, measurable characteristics used to label and describe individuals. Biometric identifiers are often categorized as physiological and behavioral characteristics.

Types of Biometrics: Biometric system is broadly categorized in two types:

*** Physiological Biometrics** that are related to shape of the body. E.g. Finger print, facial Recognition, hand geometry, IRIS Recognition, DNA

***Behavioural Biometrics** that are related to pattern of behaviour of a person. E.g. Voice Recognition, signature, keystroke, walking style.

Unimodal and multimodal systems: Systems that make use of single biometric trait are called unimodal systems while the systems making use of more than one biometric trait are called multimodal systems.

Working Principle of Biometrics: The first time an individual uses a biometric system is called *enrolment.* During the enrolment, biometric information from an individual is captured and stored. The first block (sensor) is the interface between the real world and the system; it has to acquire all the necessary data. The second block performs all the necessary pre-processing: it has to remove artefacts from the sensor, to enhance the input (e.g. removing background noise), to use some kind of normalization, etc. In the third block necessary features are extracted. A vector of numbers or an image with particular properties is used to create a *template*.

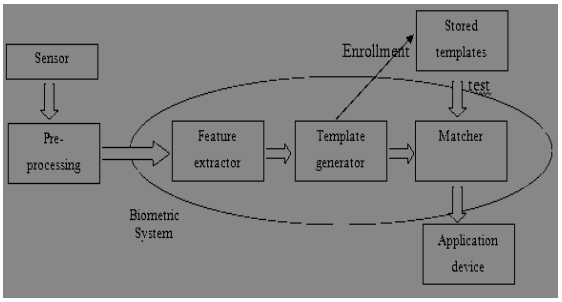

Fig1: logical block of biometric system

2. LITERATURE SURVEY

Dinakardas CN *et al* [1] They discuss a multimodal system in which they use PCA (Principal component analysis), Fisher face projection, minutia extraction and LBP (Local Binary Pattern) for Face, Fingerprints and Iris traits. They use two different methods to compare the results. In first method PCA is used to extract the features of fingerprint and iris, and fisher face is used for the face image. In second method fisher face is used for face, minutiae extraction for fingerprints and LBP feature for iris image. The performance of the system was tested on real time database which consists of 500 images of iris, fingerprints and face. They compare PCA and PCA with Fisher face technique in terms of sensitivity and from there results it shows that PCA with Fisher face works more efficiently than PCA.

Archana S. Badve Mahajan *et al* [2] There is a distinctive approach of the authenticity of biometric system, improving the robustness with the help of multiple traits such as, face and ear using Discrete Wavelet Transform (DWT) and Principle Component Analysis (PCA). The wavelet coefficients are being extracted by using 'Haar' and 'Daubechies' wavelets. The proposed method is tested on the self-created database containing a set of facial images taken in different illumination of light and with different moods. There are 9 different facial images of each person and 2 ear images (right ear and left ear) stored in the database.

Le Hoang Thai *et al* [8] They discuss the standardized fingerprint model which is used to synthesize the template of fingerprints. The synthesizing fingerprint model consists of four steps. These are, a) Pre-processing b) Finding and adjusting parameter sets c) Synthesizing fingerprints d) Post processing. They used FVC2004(DB4) fingerprint database for their research. They have done 800 synthesizing, 2800 matching between consistent and 79200 matching between inconsistent pairs to estimate the distribution of genuine and imposter matching respectively. The experiment results are compared to another results based on approach of Xiping Luo, 2000.FAR (fault acceptance ratio) of this model is very less as compares to Xiping luo's model.

Prateek Verma *et al* [4] Daugman proposed the first Iris Recognition algorithm in 1990s and got US patent for his work. His algorithm comprises of four steps – 1) Segmentation of the Iris, Pupil in the Eye image using Integro Differential Operator. 2) Normalization by Rubber Sheet Model. 3) Feature Extraction using the 2-D Gabor Filter. 4) Code Matching using the XOR Operation and Hamming Distance calculation. He used 592 images taken from the database provided by Ophthalmology Associates of Connecticut to test his algorithm. His results showed that it can search and match 4000 images in just 1 second including the decision making.

S.Anith *et al* [5] They deals with a forensic face recognition which is robust to changes with age, pose, expression and illumination. It has a pre-processing stage in which all the background information including the hairy parts in the face is removed by thresholding. After pre-processing, the thresholded image is divided into macro blocks. The scale invariant feature points are extracted from all the blocks by means of Scale Invariant Feature Transform. These extracted feature points are further refined by Taylor transformation technique and dominant orientation is assigned to every feature point.

Ahilandeswari *et al* [3] They presented a new personal identification system using multimodal biometrics. In this paper, the methods of feature extraction, fusion and decision used and their advantages over other biometric systems are discussed. This system aims at combining the features from three biometrics namely the fingerprint, face and speech. This fusion is aimed to be achieved at the match score level. A face recognition method using Eigen faces is used in this system. The minutiae based approach is used in this system for fingerprint recognition. The system is very much useful for reducing time in identifying an individual.

Mohamad Abdolahi *et al* [9] Two unimodal biometrics, iris and fingerprint are used as multi-biometrics and show using this biometrics has good result with high accuracy. Decision level is used for fusion and each biometric result is weighted for participate in final decision. Fuzzy logic is used for the effect of each biometric result combination.

3. PROPOSED WORK

The process starts with pre-processing of acquired images. Further features are extracted for training and testing images and matched to find similarity between feature sets. The matching scores generated from individual recognizers are passed to decision module where a person is declared as genuine or an imposter.

Iris recognition

Each eye has unique iris because two irises are never having same mathematical details. The identical twins and triplets also have different iris' patterns. Even one's own left and right eye irises are different. From this, it shows the uniqueness of the iris and hence it can be used for the identification purposes. The various steps involved in iris recognition are:

1. **Pre-processing** (segmentation using Canny's edge detection algorithm [17] and Hough's circular transform, and normalization using Daugmans's rubbersheet modal [16]).
2. **Feature extraction** using wavelet and PCA.
3. **Matching.**

Segmentation: Segmentation is done to find the inner and outer edge of iris region. The proposed system uses Canny Edge Detection algorithm to find the edge of the given person's eye. Canny in 1986 proposed an edge detection algorithm. This optimal detector has simple approximate implementation in which edges are marked at maxima in gradient magnitude of a Gaussian-smoothed image. The raw image is convoluted with a Gaussian filter to remove noise in the image due to lighting effects produced during capture process. The result obtained is a slightly blurred version of the original image which is not affected by a single noisy pixel to any significant degree of freedom. The further step is finding the gradient of the image. Edge gradient (E) and direction; (D) is determined from eqn. (1) and eqn. (2).

$$\textit{Edge Gradient } E = \sqrt{Ea^2 + Eb^2} \qquad (1)$$

$$\text{Direction, } D = \arctan\frac{Ea}{Eb} \qquad (2)$$

As a result of suppression of non-maximum, different set of edge points in the form of a binary image is obtained. Finally edge is traced in this non maximum suppression. Two thresholds are chosen to trace the edges. Applying a high threshold value of thresh H, the system marks out the genuine edges. After starting from these edges, using the directional information derived from Eqn. 3, edges can be traced throughout the image.

$$MS_{iris} = \frac{1}{N}\sum_{i=1}^{N} A_i + B_i \qquad (3)$$

Inner edge of iris can be obtained by selecting two appropriate numbers that are indicated to two upper and lower thresholds (L, U). The intensity of each pixel is converted to 0 if the intensity is lower than L+K, convert it to 255 if the intensity is bigger than U – K. Otherwise the intensity is filtered to lower one by use of scaling factor. The process is verified and the inner boundary is located. Morphological operator, Extended Minima (EM) transform is used to detect outer boundary of the iris detection region. EM transform is always the region of minima of the H-minima transform. H-Minima transform suppresses all minima in the intensity image whose depth is less than a scalar. By choosing an appropriate scalar in EM transform, a perfect edge of outer boundary is gotten.

Normalization remaps the each point of iris region to a polar coordinates, (r) where r is in the range of [0,1] and $\boldsymbol{\theta}$ is of range [0,2pi]. The remapping of coordinates is done from circle's x and y coordinates it converts the co-ordinates into the polar coordinates.

$$R= xh \pm xh2 - x - r2 \text{ , where } x=\sigma_{a^2} + \sigma_{b^2} \quad (4)$$

$$h= \cos\{\rho i - \tan g - (\sigma x2 - \sigma x1)\} \quad (5)$$

Feature Extraction: After segmenting and normalizing the iris pattern, necessary features are extracted fom the iris using wavelet and principal component analysis

Matching: The comparison is done between iris codes (IC) generated for database and query images using hamming distance approach. In this hamming approach the difference between the bits of two codes are counted and the number is divided by the total number of comparisons where A is the binary vector (iris code) for database image and B is the binary vector for query image while N is the number of elements. This matching score (MSi) is used as input for the fusion module where the final matching score is generated.

Fingerprint recognition

Fingerprints are distinct to each person because of unique papillary features which are different even in twins. Fingerprint patterns remain unchanged throughout the entire adult life and that's why easily used for identification. In any case if a finger is damaged, other fingers that are previously enrolled into the system can also be used for identification. The various steps involved are:

1. **Pre-processing**(enhancement using thinning algorithm [18] and segmentation using canny's algorithm)
2. **Feature extraction** using wavelet and PCA.
3. **Matching**

Enhancement and segmentation: the acquired image is corrupted due to presence of noise, smudges and holes. So to improve the quality of image and to reduce the presence of noise, an enhancement algorithm is required. In thinning algorithm, the ridgelines of the fingerprint image are transformed to a one pixel thickness. Thinning does not change the structure of the fingerprint image.

Feature extraction and Matching: After enhancing the image, matching score is calculated to get the final output.

Face recognition

A face recognition device is the one that views an image of a person and compares it with the one that is stored in the database. The comparisons are made by means of structure, shape and proportions of the face; distance between the eyes, nose, mouth and jaw; the sides of the mouth; location of the eyes; and the cheek bones surrounding area. The various steps involved in recognition of face are:

1. **Pre-processing** (enhancement using histogram equalization).
2. **Feature extraction** using wavelet and PCA.
3. **Matching.**

Enhancement: This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of bone structure in x-ray images, and to better detail in photographs that are over or under-exposed. A key advantage of the method is that it is a fairly straightforward technique and an invertible operator.

4. EXPERIMENTAL RESULTS

The proposed multimodal biometric system is implemented in MATLAB R2012a. The values of various parameters like FAR, FRR and EER are calculated and it is clear from the results that performance of the proposed system is improved as compared to the existing systems. The proposed system has values as FAR 0.0025%, FRR as zero and EER as 0.0025%. ROC curve is plotted using true positive rate against false positive rate and the area under ROC curve is found to be 0.992% which makes the system much efficient than the

Table 1: Comparison with existing research

	Dinakardas CN [1]	**Proposed method**
Az	0.9609	0.9992
S.D	0.0139	0.0012
CI	0.9336	0.9901

Table 2: Parameters calculated in proposed work

Parameter	**Value**
FAR	0.0025%
FRR	0
EER	0.0025

A threshold value is chosen that reaches EER where FAR=FRR. This is shown with the help ROC curve as:

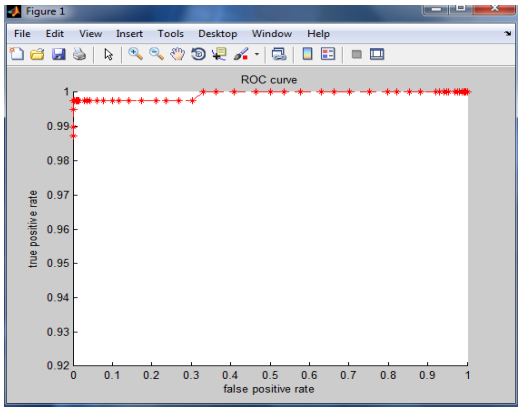

Fig 2: Receiver operating characteristic curve

The threshold curve defines the distribution of genuine, imposter and genuine-imposter both with respect to hamming distance along with density.

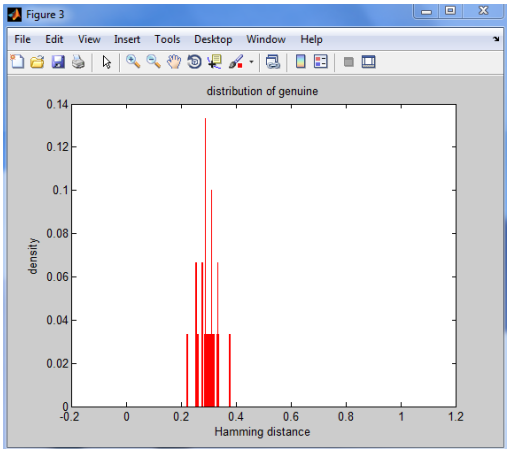

Fig 3: Threshold curve for Genuine

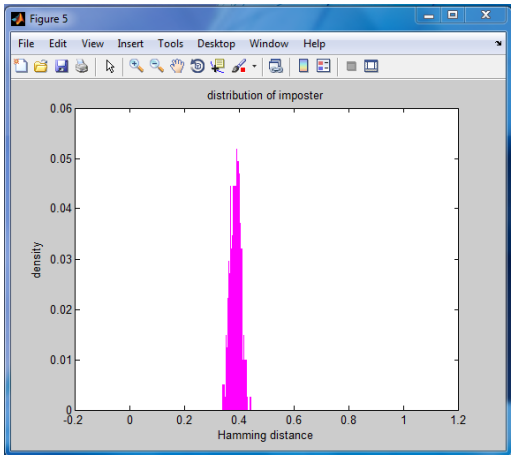

Fig 4: Threshold curve for Imposter

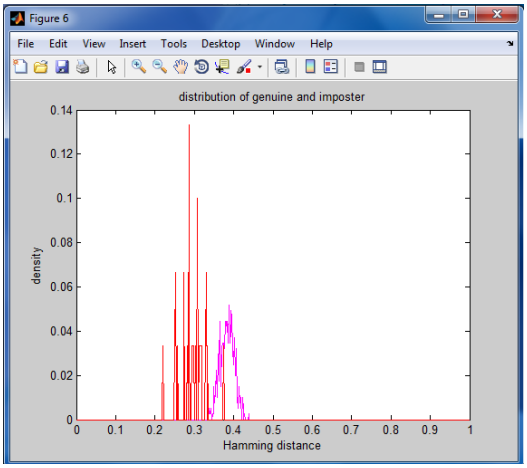

Fig 5: Threshold curve for genuine-imposter

The overall performance of the system increases as clear from the improved values of FAR, FRR and EER as shown:

Table 3: Comparison of FAR and FRR

	FAR (%)	FRR (%)
Mohamad Abdolahi *et al* [9]	2	2
Sheetal choudhary *et al* [11]	2	2
HunnyMehrotra *et al* [15]	1.58	6.34
Nageshkumar M *et al* [14]	2.4	0.8
R. Gayathri *et al* [13]	1.6	0.8
Le Hoang Thai *et al* [8]	3.57	2.5
Proposed system	0.0025	0

5. CONCLUSION

From the research, it is clear that multimodal systems are able to give better performance in terms of accuracy, recognition rate, false acceptance rate, false rejection rate etc. Also multimodal systems are giving better performance when the various biometric modalities are pre-processed individually to remove the artefacts and noise which are responsible for degrading the overall performance of the system. As per the research done in the proposed system, various segmentation and normalization algorithms are used to pre-process the iris and fingerprint images. Enhancement algorithms are also used to improve the contrast of the images taken in the database. All the techniques under pre-processing are responsible for enhancing the performance of the system. Features are extracted using the wavelet family and principle component analysis.

6. FUTURE SCOPE

In near future, we can expect more reliable, accurate and effective biometric system by implementing it in real time environment. In real time environment, much more robust techniques can be used so that this biometric system can be used in practice to enhance security in various areas.

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