Efficient Iris and Fingerprint Fusion for Person Identification

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ABSTRACT
Security of information is one of the most important factors of information technology and communication. So systems need strong procedures to protect data and resources access from unauthorized users.Biometric-based authentication systems represent a valid alternative to conventional approaches. Multimodal biometric system is used in order to improve the accuracy. A multimodal biometric identification systems aims to fuse two or more physical or behavioral traits. Multimodal biometric identification system based on iris & fingerprint trait is proposed. Typically in a multimodal biometric system each biometric trait processes its information independently. The processed information is combined using an appropriate fusion scheme. A template level fusion algorithm results in a homogeneous biometric vector by integrating iris & fingerprint data. Successively, the comparison of data base template and the input data is done with the help of hamming-distance matching algorithm. If the templates are matched we can allow the person to access the system. The proposed multimodal biometric system will improve system accuracy & dependability.

General Terms
Identification, Security, Biometric system.

Keywords
Biometric, multimodal, iris and fingerprint traits, identification system, fusion techniques.

1. INTRODUCTION
The word biometrics is basically a Greek word; it is a combination of two words bio and metric. Bio means a living thing and metric means a measurement. This word has been used since 20th century. Basically biometric technology uses two types of characteristic which are physiological or behavioral. Common physiological characteristics are fingerprints, hand geometry, retina, iris, facial images etc. while common behavioral characteristics are signatures, voice recordings, keystroke rhythms etc. Small variation in the measured biometric characteristics occurs because of the existence of background noise, signal distortion, change in biometric feature and environmental variation. Biometric technology is used to provide security for different application as well as for identify a person.

Basically biometric systems are classified in to traditional/unimodal biometric system and multimodal biometric system. Biometric systems operating on a single biometric feature called as unimodal biometric system. It has many limitations like trouble with data sensors, distinctiveness ability, lack of universality etc. Identification based on a single biometric feature may not be sufficiently robust and it has a limited ability to overcome spoofing. With an increasing importance of security, there is a need to assure that only authenticated users have access to the system. Multimodal biometric system is a recent approach developed to overcome the problems occurs in traditional biometric system. Multimodal biometric systems give significant improvements over traditional biometric systems, in terms of higher accuracy and high resistance to spoofing [1].

The paper is organized as follows. Section 2 present the over view of existing approaches. Section 3 gives information about multimodal biometric authentication system. Section 4 describes the proposed multimodal biometric system. Section 5 contains the results obtained from the proposed system. In section 6 the conclusions of the system are discussed.

2. EXISTING APPROACHES
There are various approaches for traditional/unimodal and multimodal biometric systems. Traditional biometric systems have many limitations.

S. Prabhakar, A. K. Jain, and J. Wang presented a unimodal fingerprint verification and classification system. The system is based on a feedback path for the feature-extraction stage, followed by a feature-refinement stage to improve the matching performance. This improvement is illustrated in the contest of a minutiae-based fingerprint verification system. The Gabor filter is applied to the input image to improve its quality [2]. N. K. Ratha, R. M. Bolle, V. D. Pandit, and V. Vaish proposed a unimodal distortion-tolerant fingerprint authentication technique based on graph representation. Using the fingerprint minutiae features, a weighted graph of minutiae is constructed for both the query fingerprint and the reference fingerprint. The proposed algorithm has been tested on a large private database with the use of an optical biometric sensor [3].

Y. Zhu, T. Tan, and Y. Wang proposed a system for personal identification based on iris patterns. The algorithm for iris feature extraction is based on texture analysis using multi-channel Gabor filtering and wavelet transform [4]. L. Ma, Y. Wang and D. Zhang proposed Efficient Iris Recognition by Characterizing Key Local Variations. Multichannel and Gabor filters have been used to capture local texture information of the iris, which are used to construct a fixed-length feature vector [5]. V. Conti, G. Milici, P. Ribino, S. Vitabile and F. Sorbello proposed a multimodal biometric system using two different fingerprint acquisitions. The matching module integrates fuzzy-logic methods for matching-score fusion [6]. F. Yang and B. Ma proposed a mixed mode biometric information fusion based on fingerprint, palm print, and hand geometry. These three biometric features can be taken from the same image. They implemented matching score fusion at different levels to establish identity. First feature fusion of the fingerprint and palm-print. Successively a matching-score fusion of the multimodal system and the palm-geometry unimodal system [7]. F. Besbes, H. Trichili and B. Solaiman proposed a multimodal biometric system using fingerprint and iris features. They use a hybrid approach based on fingerprint minutiae extraction and iris template encoding through a mathematical representation of the extracted iris region. This approach is based on two recognition modalities and every part provides its own decision. The final decision is taken by considering the unimodal decision through an "AND" operator [8]. G. Aguilar and his colleagues proposed a system which uses the fingerprints of both thumbs. Each fingerprint is separately processed. Successively the unimodal results are compared in order to give the final fused result [9].Comparing the approaches found in literature and detailed earlier, we introduces an innovative idea to unify and homogenize the final biometric descriptor using two different strong features—the fingerprint and the iris. This idea shows the improvements by adopting the fusion process at the template level as well as the related comparisons against the unimodal elements. We are going to use the official fingerprint verification competition (FVC) 2002 DB2 fingerprint database [10] and the University of Bath Iris Image Database (BATH) iris database [11].

3. BIOMETRIC SYSTEM

Biometric systems that utilize more than one physiological or behavioral characteristic for identification are called multimodal biometric systems. Multimodal biometric identification system is a new approach. Biometric fusion is generally classified in terms of both categories and levels. The categories define what inputs or processes are being used for fusion and the levels define how the fusion performed [12].

Categories of fusion:

1. Multi-sample 2. Multi-instance
3. Multi-modal 4. Multi-algorithm

Levels of fusion:

1. Data-sensor level 2. Feature-extraction level
3. Matching-score level 4. Decision level

Fusion at template level is very difficult to obtain because biometric features have different structures and distinctiveness [13]. Multimodal biometric system can implement any of these fusion schemes to improve the performance of the system. We are going to do fusion at feature extraction level to generate a homogeneous template for fingerprint and iris feature. The different levels of fusion are as shown in below Figure 1.

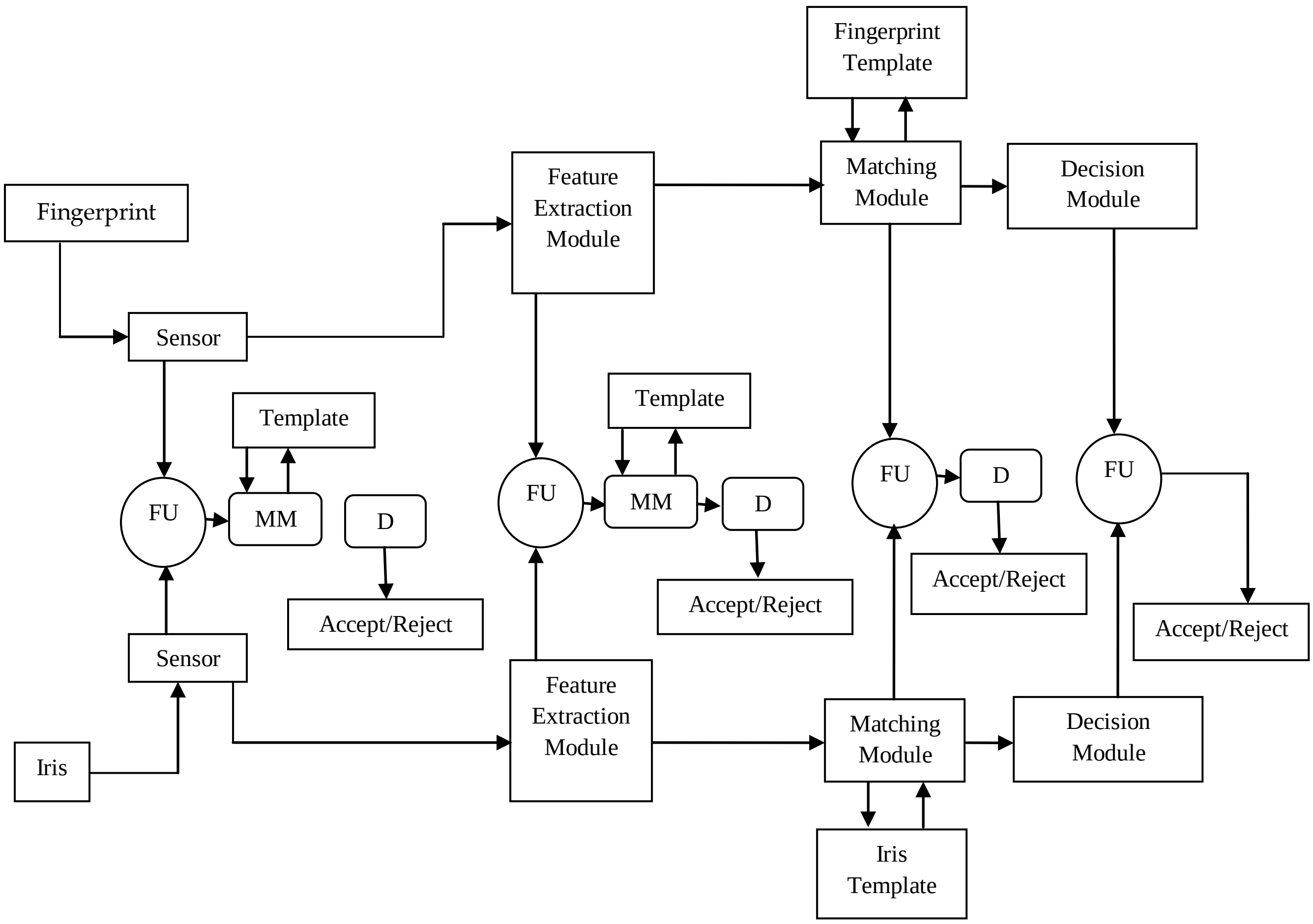

Fig1: Fusion levels in Multimodal Biometric Systems;

FU: Fusion Unit, MM: Matching Module, DM: Decision Module

4. PROPOSED BIOMETRIC SYSTEM

A multimodal biometric system based on fingerprint and iris characteristic is proposed. The proposed multimodal biometric system consists of two main stages: the preprocessing stage and matching stage.

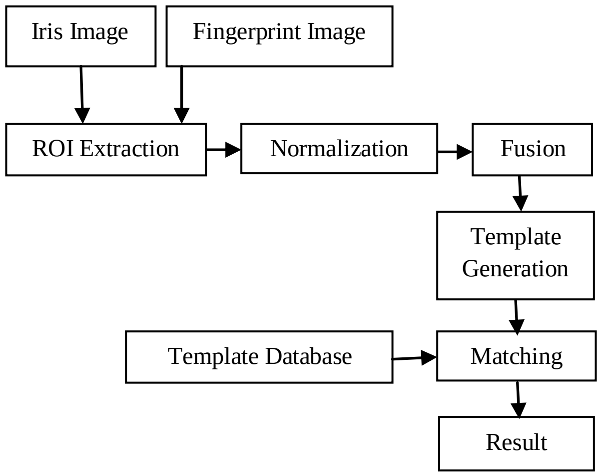

Fig 2: Schematic of the proposed multimodal system.

Iris and fingerprint images are preprocessed to extract the ROIs (Regions of Interest). The fingerprint singularity regions based approach requires a low execution time, since image analysis is based on a few points (core and delta) rather than 30–50 minutiae. Iris image preprocessing is performed by segmenting the iris region from eye and deleting the eyelids and eyelashes. The extracted ROIs are used as input for the matching stage. They are normalized and then processed in order to generate a homogeneous template. A matching algorithm is base on the HD (Hamming Distance) to find the degree of similarity. The proposed multimodal system is as shown in above Figure 2.

4.1 Preprocessing Stage

The preprocessing steps are carried out on the image, which increases the quality of image. In preprocessing the fingerprint singularity region extraction process and the iris region of interest extraction process are described. A region of interests is a selected part of an image used to perform particular task.

4.1.1 Iris Region of Interests Extraction

This process includes different tasks which are shown in Figure 3. Histogram equalization are usually increases the global contrast of an image. This approach is used to detect the circumference, center and radius of the pupil and iris region even if the circumferences are usually not concentric [14]. The pupil-identification phase consists of two steps. The first step is an adaptive thresholding and the second step is a morphological opening operation [15]. The first step is able to identify the pupil but it cannot eliminate the presence of noise due to the acquisition phase. The second step is based on a morphological opening operation performed using a structural element of circular shape. The morphological opening operation reduces the pupil area to approximate the structural element. Successively the pupil center and radius are identified. The edge is detected using canny edge detector. It has very low error rate and there is almost zero response to non-edges when giving an appropriate threshold. This algorithm uses horizontal and vertical gradients in order to deduce edges in the image. After running the canny edge detection on the image a circle is clearly present along the pupil boundary. In iris segmentation phase the iris boundary is detected. Eyelids and eyelashes are considered to be "noise" which degrades the system performance. Initially the eyelids are isolated by fitting a line to the upper and lower eyelid using the linear Hough transform.

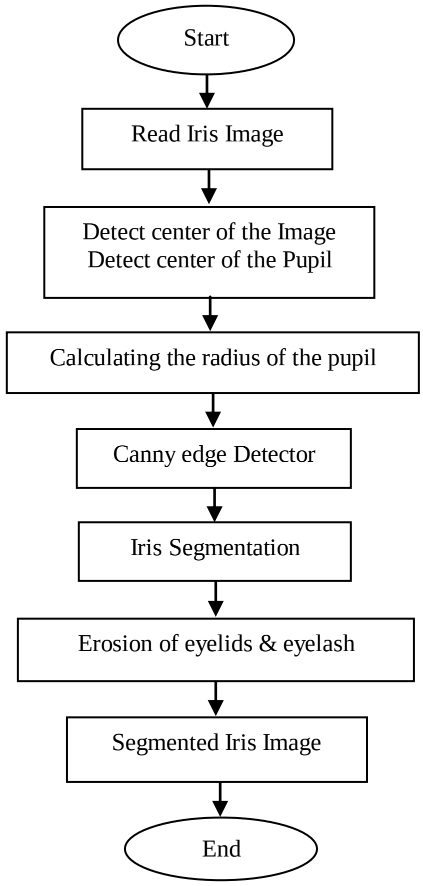

Fig 3: Flowchart for ROI extraction from iris image

4.1.2 Fingerprint Singularity Region Extraction

This process includes different tasks which are shown in Figure 4.

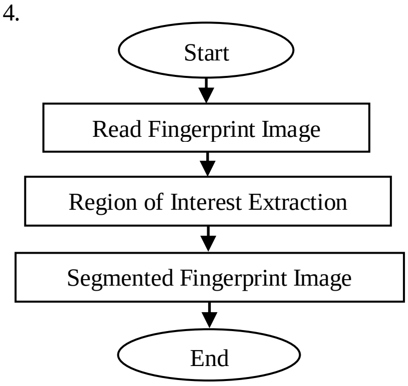

Fig 4: Flowchart for ROI extraction from fingerprint image

First we read the fingerprint image. A fingerprint image can be enhanced by remapping the intensity values using the histogram equalization. Then we are going to extract the singularity region. Particular fingerprint zones surrounding singularity points namely the "core" and the "delta" is known as singularity region. After that we get the segmented fingerprint image.

4.2 Matching Stage

The region of interest (ROI) extracted from the original images are stored in different vectors. Successively, each vector is normalized in rectangular coordinates. The features are extracted using Gabor filter. Then fusion is performed by combining the biometric features extracted from pair of fingerprint and iris images. Finally HD is used for matching score computation.

4.2.1. ROI Normalization

The fingerprint and iris images of different people may have different size. A normalization operation must be performed after ROIs extraction. For a person biometric feature size may vary because of illumination changes during the iris acquisition phase or pressure variation during the fingerprint acquisition phase.

4.2.2. Gabor Filter

A Gabor filter is obtained by modulating a sinusoid with a Gaussian. For the case of one dimensional (1D) signals, a (1D) sinusoid is modulated with a Gaussian. This filter will therefore respond to some frequency, but only in a localized part of the signal. For 2D signals such as images, a (2D) sinusoid is modulated with a Gaussian [16]. The Gabor filter can be defined as follows

$$\varphi(x,y,\omega,\theta) = \frac{1}{2\pi\sigma^2} e^{-\left(\frac{x'^2+y'^2}{2\sigma^2}\right)} \left[e^{i\omega x'} - e^{-\left(\frac{\omega^2\sigma^2}{2}\right)}\right]$$

$$x' = x\cos\theta + y\sin\theta, y' = -x\sin\theta + y\cos\theta \quad (1)$$

where (x, y) is the pixel position in the spatial domain, ω the radial center frequency, θ the orientation of Gabor filter and σ is the standard deviation of the round Gaussian function along the x- axes and y-axes. In addition, the second term of the Gabor filter compensates for the DC value because the cosine component has nonzero mean while the sine component has zero mean. Gabor filter bank with five frequencies and eight orientations is used to extract the Gabor feature for iris & fingerprint representation [17]. The Gabor feature representation of an image I(x, y) is the convolution of the image with the Gabor filter bank $\psi(x, y, \omega_m, \theta_n)$ as given by:

$$O_{m,n}(x,y) = I(x,y) * \varphi(x,y,\omega_m,\theta_n) \quad (2)$$

Where * denotes the convolution operator. The homogenous biometric vectors from fingerprint and iris data are made. But we understand that the time require for Gabor feature extraction is somewhat more and the dimension of Gabor feature vector is large. Then from homogenous biometric vector the fused template has been generated. The real part of the Gabor filters with five frequencies and eight orientations is shown in Figure 5.

4.2.3. Hamming Distance (HD) Based Matching

The matching score is calculated through the HD calculation between two final fused templates. The template obtained in the encoding process will need a corresponding matching metric that provides a measure of the similarity degree between the two templates. The result of the measurement is then compared with an experimental threshold to decide whether or not the two representations belong to the same user.

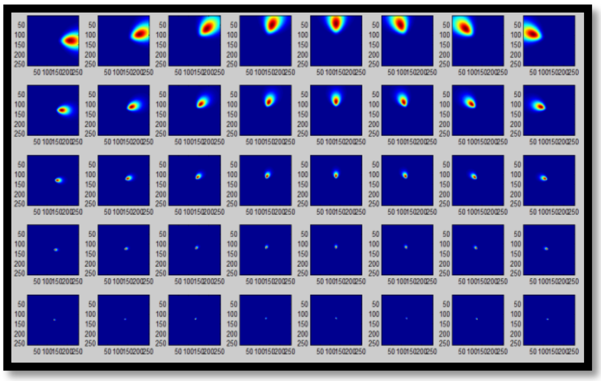

Fig 5: Real part of the Gabor filters with five frequencies and eight orientations

5. RESULTS

The original image is shown in Figure 6. Then after that we find the center of the pupil which is indicated with yellow color plus sign as well as we calculate the radius of the pupil which is shown in Figure 7. The pupil is detected using canny edge detector which is shown in Figure 8.After this polar to rectangular conversion is done which is shown in Figure 9. Gabor feature representation of the Iris image is shown in Figure 10. The original fingerprint image is shown in Figure 11. Then the ROI extracted fingerprint image is shown in Figure 12. Gabor feature representation of the Fingerprint image is shown in Figure 13. Then after that we can fuse these two Gabor features to form a template. This fused template is compare with stored one. Table 1 contains the comparison of the recognition rate of the proposed system and the unimodal system. Table 2 contains the recognition rate of proposed system for different threshold data based used are UBIRIS and FVC 2002 DB2.

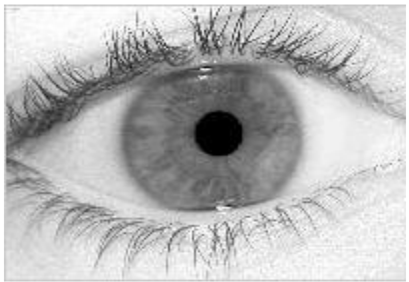

Fig 6: Downloaded Iris Image

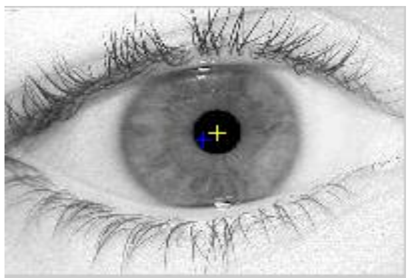

Fig 7: Center of the Pupil

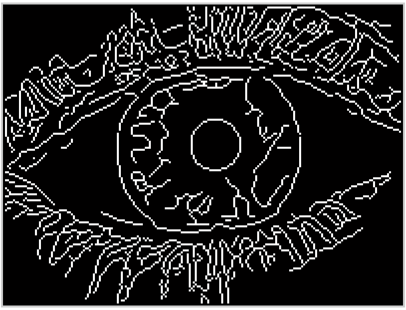

Fig 8: Canny edge detector

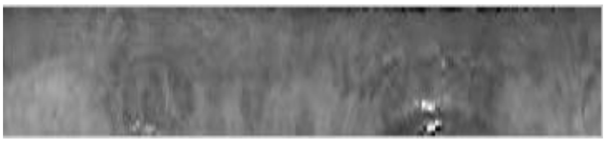

Fig 9: Polar to rectangular conversion

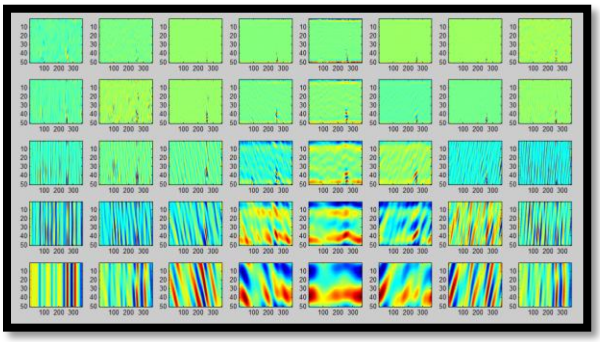

Fig 10: Gabor feature representation of the Iris image.

Fig 11: Downloaded Fingerprint Image

Fig 12: ROI Extracted Fingerprint Image

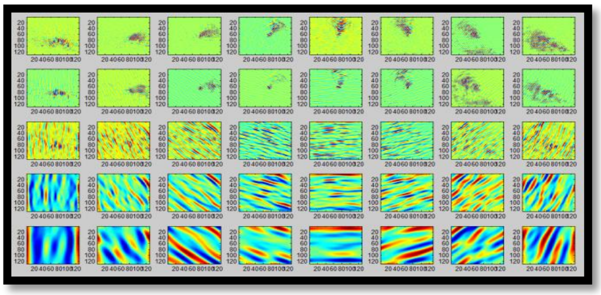

Fig 13: Gabor feature representation of the Fingerprint image

Table 1. Recognition rates of the proposed system compared to unimodal systems

Performance Measure	Unimodal		Multi-modal
	Iris BATH-S1	Fingerprint FVC2002_DB2B	Iris + Fingerprint
FAR	0.67%	1.35%	0%
FRR	9.98%	16.78%	5.71%

Table 2. Recognition rate of proposed system for different threshold

Performance Measure	Multimodal (Iris + Fingerprint)		
	Thresholds		
	0.1	0.5	1
FAR	0.5%	0.4%	0.3%
FRR	0.9%	0.7%	0.5%
EER	1.80	1.75	1.66
Accuracy	99.1%	99.3%	99.5%

6. CONCLUSIONS

In this paper we introduced an innovative multimodal biometric identification system based on iris and fingerprint traits. Iris is the unique organ and remains stable throughout the lifetime. Fingerprint is more selective as compare to palm. That's why we take these traits. The features are extracted using Gabor filter. Then template is formed & compare with stored one with the help of hamming distance. The proposed system works fine as it's FAR & FRR are 0% & 5.71% respectively. The accuracy of the multimodal system is 99.5% for threshold 1. So that multimodal biometric system has the potential to overcome the limitations of any individual biometric system. The multimodal biometric system provides more security to electronic data and resource access from unauthorized user.

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