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Multibiometrics System Design Based on Feature Level Fusion

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Abstract: ***An efficient multimodal biometric system which combines biometric data originated from face, iris and signature biometrics has been presented. Proposed feature extraction algorithm for unimodal and multimodal system has been based on discrete wavelet transform. Among the various biometrics face and iris based human authentication system are proved reliable and efficient. Signature as a behavioral biometrics is very important in financial transaction. Signature has highest variability among all biometrics. This research work proposes an approach to combine signature biometrics with face and iris biometric. Proposed method fuses biometric information originated from face, iris and signature at feature level. Hamming distance based classifier has been used for classifying feature vector as a genuine or imposter. Proposed multibiometrics system has been evaluated on chimeric databases. It has been shown by the reported results that proposed multimodal system outperforms unimodal system performance. Proposed system has been analyzed for recognition rates and error rates. Performance of proposed multimodal system shows improvement in recognition rate and reduction in error***

Keywords: ***feature fusion; face; iris; signature; wavelet transform.***

I. INTRODUCTION

Multimodal biometrics system makes use of several biometric characteristics for person authentication. Unimodal biometric system relies on physiological or behavioral traits of an individual. Unimodal system has to cope with various problems during identification of an individual such as noisy sensor data, non-universal biometric traits, vulnerable to spoof attacks, failure in enrollment. We can overcome some of the problems raised due to unimodal biometrics with the help of multimodal biometrics [1]. In situations such as when a person cannot be authenticated because of unavailability biometric trait, multimodal system can be very good solution. Sometimes unimodal system may not correctly recognize the identity of a person due to insufficient information or by spoofing. Multimodal systems are more difficult to forge than unimodal systems, as they are based on different traits of the person. Design of multimodal system aims at development of robust system which can perform good against forgeries. Multimodal biometrics also allows a person who does not possess a particular biometric trait to still become part of system and identified using other traits. Multimodal biometrics system integrates information obtained from multiple biometrics traits of an individual. Information determined from various biometric traits can be fused together at different levels such as feature level, score level, decision level. Feature level fusion combines features obtained from multiple biometric traits for formation of feature vector. Score level fusion allows for generation of feature vectors for different traits individually. Individual match scores of various biometrics modalities are combined which results into generation of final score. This score is further passed to decision module. Decision level fusion works at decision module. By combining decisions obtained from multiple biometrics traits subject is declared either genuine or imposter [1-2].This paper aims at analyzing performance of multimodal biometrics system over unimodal biometrics system. We have proposed approach for combination of biometric information originated form face, iris and signature biometrics. Paper is organized as follows. Section 2 presents related work, Section 3 discusses proposed multimodal biometrics system design. Section 4 presents feature extraction algorithm. Section 5 discusses feature level fusion algorithm. Section 6 describes feature matching algorithm. Experimental setup and results are discussed in section 7 and 8.Finally conclusion has been discussed in section 9.

II. RELATED WORK

Several researchers have carried out their work with different approaches. Face, fingerprint and hand-geometry based multimodal biometrics system has been presented by Jain et al [3]. An enhanced multimodal personal authentication system using face, teeth and voice modalities has been proposed by Dong-Ju Kim et al [4]. Ross and Govindarajan [5] proposed a multimodal system at feature level employing fusion of hand and face biometrics. Hong et al [6] investigated performance of multibiometrics. Poonguzali and Ezhilarasan [7] presented design of multimodal system based on fingerprint and iris. Conti et al [8] proposed biometric identification system using iris and fingerprint traits at feature level. Suryanti Awang et al have presented face and signature based multimodal system at feature level. Presented approach for feature level fusion is based on correlation pattern recognition [9].Heng Fui Liau [10] et al proposes multimodal biometric system using face and iris biometrics fusion at score level using support vector machine (SVM).Feature level fusion based bimodal system has been designed and presented by Yong Xu [11].

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Proposed work employs matrix-based complex PCA (MCPCA) algorithm where both biometrics modalities are represented in form of complex matrix.
Subbarayudu and Prasad [12] proposed system using iris and palmprint biometrics. Waheeda Almayyan et al. [13] have designed and presented various multimodal biometrics fusion methods. Proposed work fuses biometric information originated from iris and online signature at feature level. Imran et al. [14] has presented design of multimodal system based on signature and fingerprint biometrics.

III. PROPOSED MULTIMODAL BIOMETRICS SYSTEM

Proposed work presents an efficient approach for combination of three important biometrics characteristics of an individual such as offline signature, face and iris biometrics. Presented multimodal system has been designed to fuse biometric features. Template level fusion algorithm is difficult to obtain since different biometric traits have different characteristics and distinctiveness. Goal of proposed algorithm is development of efficient multimodal identification system in presence of outliers. For homogenous features, feature fusion is very much simple. Original features extracted are in similar form so they can combine as single feature vector. Feature-level fusion is complex fusion problem because of challenges such as heterogeneous relationship between different feature spaces, incompatibility between different biometrics feature spaces and the high computational cost to process the resultant vector [1,8].Proposed multimodal biometrics system performs information fusion at feature level. Wavelet based feature extraction algorithm has been designed for all three selected biometrics traits of an individual. Wavelet based features of face, iris and signature has been fused together to form homogenous feature vector. Hamming distance based classifier has been employed to perform feature classification. Proposed system architecture is as shown in fig.1. Proposed work presents wavelet transform based feature extraction algorithm. The wavelet transform is emerging as popular tool to perform variety of signal and image processing applications. Wavelet transform provides time-frequency representation of signal. Wavelet transform performs analysis of different frequencies at different resolutions. In case of wavelet transform an image is expressed in terms of translations and dilations of a scaling function and a wavelet functions. These functions are derived from 2D filter bank consisting of low-pass and high-pass filters. After 2D decomposition, the given image is decomposed into several frequency components at multiple levels of resolution. Decomposition of an image results into sub bands HHk, HLk, LHk , LLk, k = 1. . . J where k is the scale, with J being the largest scale in the image decomposition. The low pass information represents smoothed version of original image. Main information of the original data represented by low pass filtered data. High pass filtered information represent sharper variations and details of image [21,22].

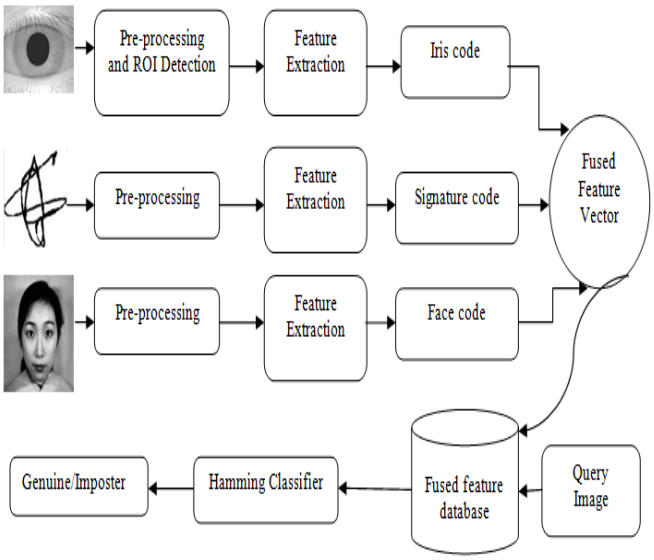
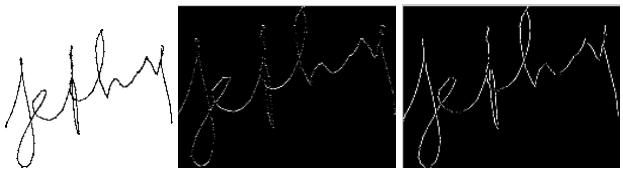


Fig. 1. Proposed Multimodal Biometric system architecture

IV. FEATURE EXTRACTION ALGORITHM

A. Signature feature extraction algorithm

Signature is an important behavioral biometrics of a person in legal transactions. For authenticity of documents in every sector signature is considered as main evidence. It is most common biometrics universally accepted both by governmental, private organizations and for commercial transactions as a mean of identification. Signature can compromised with certain degree of effort the user can change his signature and also can be affected by physical and emotional conditions. Signature as a behavioral biometrics is having large variation as compared to other biometrics. There are two signature based authentication system, online and offline signature authentication system. In proposed method offline signature recognition system has been presented. Proposed feature extraction algorithm consist of two important steps first is signature pre-processing and second is wavelet based feature extraction. Wavelet transform based feature extraction algorithm for signature modality has been presented by Suvarna Joshi 2013[22].Signature has been represented in the form high frequency coefficients obtained from second level wavelet decomposition of preprocessed image as shown in figure 2. After decomposition of sub-images at each level, different number blocks are obtained. Further sub-image CH, CD, CV i.e. wavelet coefficients are coded.



(2a) (2b) (2c)

(2d)

Fig. 2a) Original Signature image 2b), 2c), 2d) High Frequency Coefficients of signature image

B. Face feature extraction algorithm

Face is most common biometrics to identify persons in our social life. We can recognize a number of faces which are seen by us in our lifespan. Face is very popular and widely accepted biometrics in the past two decades. Automated face based authentication system plays important role in wide variety of practical applications including forensic applications, criminal identification, security systems, identity verification, financial transactions etc. Face based human authentication is used in many places surveillance monitoring system, forensic application in websites hosting images and social networking sites. Face recognition system should be able to handle face variations occurred due to various factor such as facial poses, illumination, image backgrounds, facial expressions, human ageing. Proposed multimodal system employs the DWT based feature extraction algorithm for face authentication designed by S .Joshi 2014 [23]. Proposed algorithm consists of two steps face image pre-processing and second DWT based feature extraction. Face images are decomposed upto fifth level as shown in figure 3. In case of face biometrics structural details plays important role during process of recognition. Proposed algorithm fuses binary encoded detail coefficient obtained from wavelet decomposition of preprocessed face image. Wavelet decomposition and binary encoding achieves decrease in size of face feature vector.

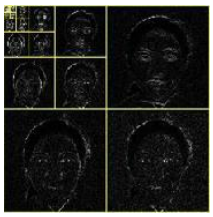


Fig. 3. a) Original Face image **Fig. 3.b) Fifth level wavelet decomposition**

C. Iris feature extraction algorithm

Iris is the most popular, highly reliable, accurate biometrics which doesn't change throughout life of an individual. Iris as a complex pattern consists of many distinctive features and also can't be duplicated. Proposed iris feature extraction algorithm consists of 3 important steps such as iris ROI detection, feature extraction and feature encoding. ROI detection requires different stages of processing as iris boundary detection, segmentation of iris, normalization, encoding. By application of canny edge detection algorithm [16] edge map of iris is detected which results in determination of boundary. It is a multi-stage algorithm which aims at finding a wide number of edges in images. Exact boundary of pupil and iris is determined from edges using Hough transforms [15,13].For iris images from database, the value of the iris radius lies in the range of 80 to 150 pixels, while the pupil radius is in between 20 to 75 pixels. In case of iris recognition system segmentation is one of the most important step. After performing segmentation of iris pattern, iris image should undergo the normalization process for making ROI of iris of same size for probe and query templates. Segmented iris and normalized iris images are as shown in figure 4b and figure 4c resp. along with original image in figure 4a.Normalization is nothing but process of conversion iris ROI into rectangular block with constant dimensions. Daugman's rubber sheet model has considered as base for ROI normalization. The detected circular iris ROI region was normalized to a 24X240 rectangular image. Normalized Iris pattern images are decomposed at several level of resolution by using discrete wavelet transform. Normalized iris pattern core is represented in terms of wavelet coefficient obtained from fifth level wavelet decomposition. Iris feature vector can be represented by fusing fourth and fifth level horizontal, vertical, diagonal wavelet components. Further feature vector has been encoded into Boolean form.

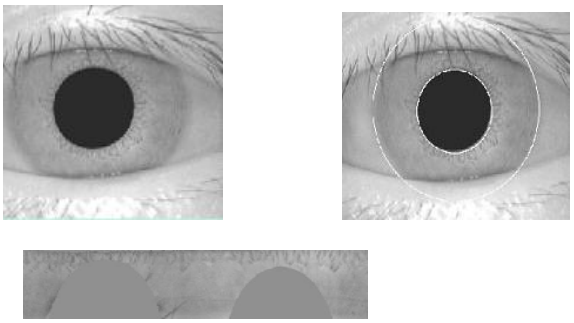


Fig. 4.a)Original iris image Fig. 4b) Segmented image Fig. 4c) Normalized iris ROI

V. FEATURE LEVEL FUSION

Any individual trait can't provide 100% accuracy. Proposed feature level fusion based multimodal system relies on three biometric traits i.e. face, iris, signature. Main aim behind selection of these three biometric traits arises from their strength points. We have obtained fused feature vector from encoded feature templates of face iris, signature. Feature vectors obtained from all three modalities consists of wavelet based features. The resulting vector obtained from homogenous fusion is composed of binary encoded biometric pattern. Feature vector of query sample images is matched with the feature vector of training sample stored in the database. Fused feature vector obtained from handwritten signature, iris and fingerprint images consist of 0's and 1's. So Proposed work performs feature matching using hamming distance algorithm which results into dissimilarity score in between fused feature vector of query and fused feature vector form database. The Hamming distance (HD) between two Boolean vectors can be defined in equation 1 as follows [17]:

$$\text{Hamming Distance} = \frac{1}{N}\sum_{j=1}^{N} H_A(j) \oplus H_B(j) \quad (1)$$

Where, HA and HB are wavelet coefficients and N is the size of the feature vector.

The symbol ⊕ is the known Boolean operator that gives a binary 1 if the bits at position j in HA and HB are different and 0 if they are similar [21].

VI. EXPERIMENTAL SETUP

Because of unavailability of real and publicly multimodal databases having face, iris and signature samples proposed work has been evaluated on chimeric database of virtual persons using face, iris and signature samples originated from different databases. Caltech university database [18] and UCOER database has been used for signature modality. Caltech database consists of two sets of data. Set 1 is having collection of signatures of 56 individuals with 25 genuine and 9 skilled forged signatures of each subject and Set 2 is having of signatures of 50 different individuals with 30 signatures of each subject. Dataset-1 has been used for evaluation of proposed algorithm. Another real time signature database has been collected from 30 individuals of universal college of engineering. There are 5 sample signatures for every individual in the Ucoer database. For iris modality we have chosen CASIA database provided by the National Laboratory of Pattern Recognition (NLPR) in China, i.e. CASIA[19].This database consists of 7 different images of each unique eye captured in two sessions with total 756 grayscale eye images with 108 unique eyes or classes. Proposed face authentication algorithm has been evaluated on ORL database [20]. This database consists of total 400 gray scale images of size 112×92 pixels corresponding to 40 distinct individuals. It consists of 10 images of each individual taken in various sessions varying the lighting, facial expressions (open/ closed eyes, smiling/ not smiling) and facial details (glasses/ no glasses); taken against a dark homogeneous background in an upright, frontal position(with tolerance for some side movement).

VII. RESULT

In order to test our proposed multimodal authentication algorithm, experiments has been carried out on two chimeric multimodal databases considering random 30 individuals. First chimeric database has been obtained by combination of CASIA iris images, ORL face images with Caltech signature images. While second chimeric database consist of CASIA iris images, ORL face images with UCOER signature images. Also we have evaluated performance of unimodal biometrics systems for all three biometrics. Performance has been analyzed to determine recognition rate, various error rates for both unimodal and multimodal system. Experimental results are summarized in table 1. Receiver operating characteristics of unimodal and multimodal system are as shown in figure 5 and fig.6.

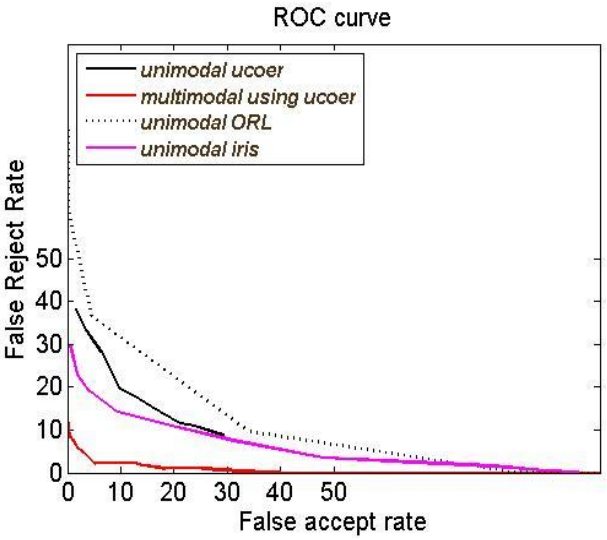


Fig. 5. ROC curve for ORL and UCOER

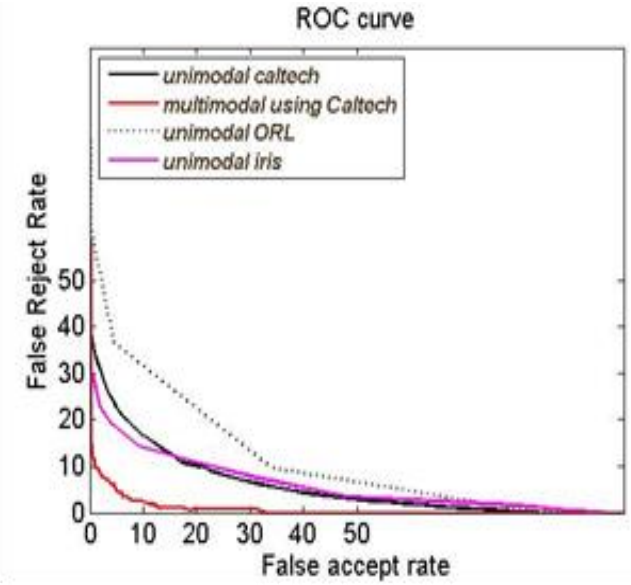


Fig. 6.ROC curve for ORL and Caltech

Table 1. Performance Analysis of Proposed System

Biometric System	Database	No of Training images	No. of Testing images	Recognition Accuracy	FAR	FRR
Unimodal Iris	Casia	5	2	93.33%	9.42%	14.33%
Unimodal Face	ORL	6	4	95.50%	9.46%	28.19%
Unimodal Signature	Caltech	16	8	88.39%	9.80%	33.64%
Unimodal System	Ucoer	3	2	85%	9.65%	20%
Multimodal System	Caltech,Casia,ORL	4	3	97.88%	2.11%	8.33%
Multimodal System	Ucoer,Casia,ORL	3	2	98.77%	0.613	8.33%

VIII. CONCLUSION

Multimodal biometrics system combing biometrics information obtained from face, iris and signature modalities of a person at feature level has been presented. Signature is most commonly biometrics required in all financial transactions and having highest variability while face and iris most commonly acceptable biometric traits. Proposed work has implemented multimodal system with an objective of performance improvement of unimodal system in term of recognition rates and various error rates. Wavelet based feature extraction algorithm has been presented for all three biometric traits. Proposed feature extraction algorithm is very efficient, robust and less complex. It has been observed that there is considerable improvement in performance of multimodal system as compared to that of unimodal system. Proposed multibiometrics system has achieved maximum accuracy of 98.77 % for chimeric database. The obtained results show that the proposed template-level fusion technique carries out an enhanced system showing interesting results in terms of FAR and FRR. In this paper we have presented design of multimodal system which consists of signature as one of important biometrics. Performance of multimodal system has been outperformed unimodal system.

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